Construction Contract Risk Management: A Study of Practices in the United Kingdom

Dr. Francis K. Adams

ABSTRACT: Although formal analytical processes are applied to the management of economic risks in construction projects, very little is reported on the application of similar processes to the management of construction contract risks. Evidence from other industries however, point to the benefits that such rigorous approaches will offer the construction industry. This article presents the findings of a study conducted to assess the extent to which available techniques for identifying and analyzing risks are applied to construction contract risks by construction professionals in the United Kingdom. The study also sought to evaluate the appropriateness of the predominant techniques used by determining whether the techniques adequately address the nature of contract risks and the significant impact that personal perceptions and biases have on their analysis. The study employed a structured questionnaire survey to collect primary data collection for analysis in order to provide an empirical basis for the major conclusions of the research study. The study found that the predominant approaches to construction contract risks identification and analysis are inappropriate as they rely heavily on single expert assessments and as such do not address the effect of individual perception and biases on the subjective estimates used in their analysis.

KEY WORDS: Contract risks, analysis, identification and management

In terms of the broad approaches by which risks are analyzed, construction project risks can be broadly classified as either objective or subjective.

Risks that are purportedly analyzed by the actual observation or calculation of their occurrence and impact on a project are often described as objective risks. Analyzes of objective risks are quantitative in nature and often structured in probabilities. They involve experimental evidence, long-term experience, or complicated analytical calculations that describe actual or potential risks. Risks that are assessed based on beliefs about the risks rather than objective recorded risk data are often referred to as subjective risks.

Analyzes of subjective risks are often qualitative and based on the analyst's knowledge and experience of the risks and the process by which the analyst selects and organizes such knowledge and experiences into meaningful patterns.

The majority of construction contract risks are subjective; there are often insufficient historical data to enable their objective analysis. Therefore, their analysis will, at best, be based on the subjective predictions of the analyst(s).

The use of rigorous analytical techniques for objective risks in construction is well reported in the literature. However, reports of empirical work on the application of similar rigor to contract risks such as payment delays, adverse ground conditions, etc. is scant. Evidence suggests that such risks are often analyzed in a somewhat arbitrary manner.

Contractors tend to resort to the addition of a single arbitrary percentage cost contingency to give their overall impression of the total risk rather than assessing the risks that they are asked to carry. However, applications of analytical rigor to similar risks in other industries point to the potential benefits that such methods present to the construction industry. For example, subjective probability forecasting has been used reliably, in combination with classical methods involving objective probabilities, in short-range weather forecasting.

Elicitation of expert beliefs has been used in the development of probabilistic expert systems for the diagnosis of congenital heart disease, and in population projection [12, 18]. Elicitation of prior beliefs has also been successfully used in estimating the future maintenance costs of water treatment plants, in determining the hydraulic conductivity of rocks for nuclear waste repository development, and in uncertainty analysis for radiological protection [13, 14].

Subjective predictions made on the weather are based on the forecaster's knowledge and experience of weather patterns in much the same way as a construction expert's knowledge and experience of soil characteristics that lead to risks such as adverse ground conditions drive his predictions about such risks. Furthermore, unlike recurring events that are subject to the laws of large numbers, most contract risks represent rare event samples for which analysis of long-run frequency and traditional statistical approaches are often inapplicable.

A. Tversky argues that predictions and analysis of such subjective risks are often based on the intuitive judgements of the decision-maker [19]. These intuitive judgements and estimates are influenced by individual perceptions and biases that are often not addressed during the analysis. Appropriate analytical methods for construction contract risks are thus needed to enhance risk management efficiency. Bayesian methods, for example, enable subjective opinions about uncertainties to be combined with sample evidence about the risk to form posterior probability distributions of the risk. Such distributions can then be used as input variables in the systematic analysis of the uncertainty. The adjustment of the individual expert's estimate by the available sample information will lead to a more accurate representation of the probability of the risk.

J. Ansell (1992) argues that one of the major problems in evaluating the risk of a system is the identification of the full range of risks to which the system could be subject [3]. The identification process is made difficult especially since what is considered "risk" is significantly influenced by perceptions that are very dynamic in nature. A thorough identification of both internal and external project-related risks requires that the risks analyst is not only systematic and experienced, but also creative.

J. Raftery argues that the best way to gain access to such a range of qualities is to use a team of experienced construction professionals or experts [15]. Thus, a construction contract risk management approach that uses appropriate methods of eliciting and aggregating opinions from multiple experts will be better at reducing the impact of individual perceptions and biases on the estimates and enhancing risk management effectiveness [1].

Aims and Objectives of the Study

This article presents the findings of a study conducted to assess the extent and frequency with which available techniques for identifying and analyzing risks are applied to construction contract risks by the various professions within the UK construction industry.

The study also sought to evaluate the appropriateness of the predominant practices of contract risk identification and analysis in the UK. Appropriateness in this context was determined by whether the processes and techniques used adequately address the nature of contract risks and the significant personal biases and perceptions to which their analysis are subjected.

In essence, the study sought to test the following operational assertions:

- There is very little application, if any, of systematic and rigorous probabilistic methods to contractual risk in construction. And,
- Analytical methods currently used to manage contractual risks in construction do not adequately deal with the effect of perception on the subjective estimates used in these analytical techniques.

These assertions are theoretical constructs that needed testing with real life responses. The research therefore adopted a positivist approach, using structured standardized questionnaires as the main method of primary data collection. Major conclusions of the research are therefore empirically based; induced from the analysis of the data collected.

The Risk Management Process

Although opinions vary in the literature as to what constitutes the stages in the systematic process of project risk management, experts generally agree on the intended objectives, content, and outcomes of the total process.

Within the context of construction contract risks, the objectives of the risk management process can be summed up in the following.

- To gain a greater awareness and understanding of the types and nature of risks inherent in the project, and the likelihood of their occurrence.
- To assess the potential impact of the risks on the viability of the project and contract and to determine how best to eliminate or control the risks. And,
- To inform the development of the most appropriate contract strategies by helping to identify which of the project parties are best placed to take responsibility for the risks and the optimum premiums or contingencies to allow for the risks.

For the purposes of the study presented in this article, the following three-stage risk management system was adopted [2].

- Risk identification: 'the process of systematically and continuously identifying, categorizing, and assessing the initial significance of risks associated with a construction project'.
- Risk analysis and evaluation: 'the process which incorporates uncertainties in a quantitative manner, using probability theory, to evaluate the potential impact of risk.'
- Risk response management: 'strategies aimed at removing as much as possible the potential impact of risk or increasing control of risk.'

Methods for Identifying Project Risks

An effective risk identification technique would aim at answering the question: "What are the discrete features of the project or its general environment (risk sources) which might cause failure?"

The technique would therefore involve an investigation into all possible potential sources of project risks, the interrelationships among them, and the extent to which they can be controlled.

Methods for identifying risks in construction projects are also very well described in literature. J.E. Diekman and others, C. Chapman and S. Ward, for example, discuss the main range of techniques available for identifying risks [8, 10]. Those surveyed in the present study are summarized as follows.

Types of Assessments

- In-house individual expert assessment
- In-house multi-disciplinary/panel group assessment
- In-house synectic team assessment

Assessment Techniques

- pondering or "what can go wrong" analysis;
- free and structured brainstorming;
- synectics;
- checklists;
- risk records;
- prompt lists; and
- structured/expert interviews.

Techniques for Analyzing Contractual Risks in Construction

The risk identification process would have highlighted risks that may be considered by project management to be more significant and selected for further analysis.

The objective of a risk analysis technique is therefore to determine probability numbers that quantity beliefs about uncertainty and thereby quantify the effects on the project of the identified major risks. This analysis progresses from the collection of data relevant to the modeling of the uncertainty through the analyzes of the frequency, severity, and probability of the risk event, to the assessment of the consequences and impact of the risks on the risk targets.

The range of techniques available for analyzing and evaluating risks are also summarized in the following.

Techniques for Assessing Risk Likelihood

- quantitative probability assessments based on historical data.
- subjective probability assessments based on expert judgment. And,
- scaled assessments (e.g., high/medium/low) based on experience

Techniques for Assessing Risk Severity

- quantitative probability assessments based on historical data.
- subjective probability assessments based on expert judgment.
- scaled assessments (e.g., high/medium/low) based on experience. And,
- Individualized estimation of actual severity should risk occur. This approach differs from the three above in that detailed calculations of the cost to be incurred to time to be lost are done for each key risk, assuming the risk occurred.

Techniques for Assessing Risk Impact

- decision trees analysis;
- fault trees analysis;
- event trees analysis;
- probability analysis;
- sensitivity analysis;
- scenario analysis;
- simulation analysis; and
- ranking options.

The risks analysis techniques summarized above are not exhaustive, but reflect the key models that are commonly used on construction projects. For example, although techniques such as catastrophe theory, fussy set analysis, game theory and multi-criterion decision making models were known by most practitioners in the UK.

S.J. Simister (1994) reported that these techniques were either not used at all or used by only a handful of practitioners [16].

Research Design

According the findings of D. Simonton in 1996, and the analysis of S. Vick, in 2002, on the development of engineering expertise, it would appear that engineering experts reach the height of their expertise between the career ages of 10 and 33 which corresponds to chronological ages of 35 and 53 [17, 20].

Against this background, and in view of the specialist nature of construction contract risks and the relative infrequency of such risks, respondents were selected from construction experts based on a minimum of 10 years of industrial experience.

All the experts were sampled randomly from the United Kingdom (UK) using directories such as the 'Chartered Building Company' Directory, the 'Contractors' File' and the 'Consultants' File.'

Telephone and fax surveys were then used to identify qualifying and interested participants. Quantity surveyors, construction managers, contracts managers and project managers are the main construction professionals usually responsible for project risk management.

To achieve optimum efficiency in the study, the mail survey focused on such professionals from the civil engineering and building construction industrial sectors. These two sectors were chosen as the study was concerned with risks arising from contracts in these industries. 160 experts comprising 40 each from the four professions above were selected.

The research instrument comprised mainly of a set of questions each of which had a domain or a set of answers from which respondents were to choose. The option was also provided in each domain of answers for respondents to indicate their responses if their answer was not included in the list provided.

In addition to the benefit of being able to test the research constructs with real life responses, the questionnaire approach was considered beneficial because of its high efficiency in terms of research cost, time, and effort. The lower cost of using self-completing questionnaires was considered particularly important since the sample was widely spread geographically.

Also, the questions and response domains in the research used language that is part of the training and the regular professional practice of both the researcher and respondents. This would enhance the benefit of reduction in biasing errors that self-completion questionnaires provide [9]. One other advantage of the questionnaire approach is the reliability of measurements and its amenability to making statistical inferences and generalizations from data collected.

Restricted domain of responses ensures that consistent responses are obtained over all respondents. In addition, since responses have to lie in given domains, applying formal statistical techniques in the analysis is a relatively straightforward process. The potential adverse impact on the research by the constraints imposed on responders by the predetermination of the appropriate questions to ask and their response domains would also be minimized by the significant experience and knowledge of the field under investigation, as well as extensive literature review by the researcher. Consultations were also made with other researchers and construction experts to ascertain the appropriateness of the questions asked and the completeness of the response domain for each question.

Results and Analysis

Before proceeding to use the survey results to test the hypotheses, it is necessary to explain some basic computations applied to the data collected. An inspection of the questionnaire (Appendix 1) shows that apart from questions seeking factual information about respondents, the questions asked respondents to indicate how often (on a 5-point scale of: never, occasionally, frequently, very frequently, always) they use any of the key techniques and methods identified through the literature for identifying and analyzing contractual risks.

Answers to factual questions are in the form that can be readily applied in analysis of the respondents and thus the various professions within the construction industry. Frequency tables were also constructed and inferences based on the results. For the analysis of responses to the 5-point scale questions, first a carefully considered weight reflecting the degree usage of a particular technique being measured is assigned to each possible answer. Thus, responses were weighted according to the following scale:

Response	Scale Value
Always	4
Very Frequently	3
Frequently	2
Occasionally	1
Never	0

Using these scale values, the responses were then converted into rating values that are later plotted to provide a summary view of the risk identification and analysis practices within the industry. The total rating value (R) for a risk identification or analysis technique, T, was computed as:

$$U(x_i) = x_i \, a_i + b_i$$

equation 1

where n_i is the total number of respondents assigning scale value *i* to technique *T*. As an illustration, consider the response to the question on how often respondents used pondering in seeking to identify things that could go wrong on a project. Details of the responses and the corresponding rating scale values provided by the respondents are provided in table 1. From equation 1, the total rating value for pondering is computed as 86 with a mean rating value of 2.97:

$$U(x_{Ti}) = 0.0$$

equation 2

The approach and rating scale is similar to that used by J.F. Burchett and others in the analysis of the extent of risk identification within electrical supply projects, and by A.Y. Antwi for the analysis of urban land markets in Ghana [4, 7].

It should be pointed out that since the rating scale is applied in the same manner across all responses to the different techniques, direct comparisons of the resulting rating values can be made between different techniques and different sets of questions. Mean values calculated using this scale thus also represent the measures of central tendency of the usages of the different techniques [7].

Response	Scale Value (i)	Number assigning value (n_i)	Rating Value (in_i)
Always	4	13	52
Very Frequently	3	8	24
Frequently	2	3	6
Occasionally	1	4	4
Never	0	1	0
Total No. of Respondents $(\sum n_i)$		29	
Total Rating Value (R_T)			86
Mean Rating Value $(R_T / \sum n_i)$			2.97

Table 1 — Respondents' Ranking of Their Use of Pondering for Risk Identification

Characteristics of the Survey Respondents

The breakdown of the responses from the 160 questionnaires sent to the selected professionals is given in table 2. The "Other" category represents respondents who are now working in different professional capacities from the ones for which they were selected. They include a building manager, an estates director, two managing directors and a facilities manager. Seven other participants responded to indicate that they were unable to complete the questionnaire for a number of reasons (e.g. lack of relevant experience, busy personal schedule, etc). These were not included in the analysis.

As table 2 shows, the majority of respondents were either quantity surveyors or project managers. This may be reflective of the fact that as one of the primary repositories of construction cost and risk information, quantity surveyors are best placed to provide the required information.

Although the effective response rate of 18 percent appears small, it is consistent with survey responses within the construction industry generally and in the UK specifically [6, 7, 19].

The low response rate from construction managers was mainly attributed to either inexperience or lack of time. These were also the main reasons given for non-response by the other 131 survey subjects who were unable to participate in the study.

Two facts explain this reason. The first is that in view of the relative infrequency of contractual risks, experts would need to have been in the field that provides them with experience of the risks for significant number of years for them to be able to make informed judgements about the risks. Secondly, for most non-responses, the questionnaire was completed by a junior staff member in the original expert's company because of a lack of time on the part of the selected expert. The problem was that the average experience among such junior staff members (as revealed by the average years of experience of the non-respondents) was between 2-5 years.

Respondents also came from a variety of industrial sectors: 32.6 percent from quantity surveying consulting, 21.7 percent from building construction, 13.0 percent from project management consulting, 6.5 percent from civil engineering and 8.7 percent from each of legal and contracts consulting and property development.

With the exception of two respondents who were construction managers, all the respondents had more than 10 years of industrial experience (94 percent had more than 15 years of construction experience), and over 80 percent had more than 10 years of experience in their current profession within construction. This high percentage of highly experienced respondents is very significant in the light of the works of D. Simonton in 1996, and S. Vick in 2002, and lends further support to the credibility of the information obtained [20, 23].

The annual turnovers of almost 70 percent of the respondents were less than five million pounds (41.4 percent had turnovers less than £1 million, 27.6 percent between £1 million and £5 million, 13.8 percent between £16 million and £25 million, 6.9 percent between £26 million and £50 million, and 10.3 percent over £50 million). This contradicts the belief that formal risk management approaches could only be afforded by larger companies because of perceived extra cost of implementing such systems.

Extent of Use of Risk Assessment Approaches

Among the four professional categories studied, the task of risk assessment appears to be undertaken predominantly by one individual within the organization. This approach was used by about 76 percent of the respondents.

Profession	Number selected	Number Responding	Percentage Responding
Construction Managers	40	2	5.00%
Project Managers	40	4	10.00%
Quantity Surveyors	40	18	45.00%
Contracts Managers	40	1	2.50%
Others[1]	0	4	10.00%
Total Respondents	160	29	18.13%

[1] *Although the sampling strategy targeted only the four professions above based on the sources of the sample, the professions indicated by the actual respondents on the questionnaires included other professions that were not originally targeted. The 'Other' category therefore refers to professionals such as Directors of companies, Property Developers and Legal Consultants who felt that their current job functions did not fit accurately into any of the four main categories indicated on the questionnaire.*

Table 2 — Profile of Survey Sample

This is particularly so among quantity surveyors, about 83 percent of whom use this approach (see figure 1 (a)). As figure 1 (b) shows, this usage is consistent with levels of usage within the quantity surveying sector of the industry where over 93 percent of respondents use this approach compared to the 13 percent who use the in-house multidisciplinary group approach.

Whereas a case justifying this practice can be made in view of the high level of experience of those involved in the study, it has been generally argued that the complex and dynamic nature of construction projects requires more experience in identifying project risks than one expert can provide [5].

Modern construction spans several industries. Within the construction industry itself, technological advancements have created such myriad specializations in product and component technologies that no one professional can any longer claim to be a sole repository of construction risk knowledge.

The in-house Individual approach is the most susceptible to personal biases and perceptions and would be considered the least suitable among three main assessment approaches for contractual risk analysis, unless the projects being analyzed were very familiar, highly identical, or repetitive of previous projects for which rigorous risk analysis had previously been conducted. This hardly ever happens in construction.

About 24 percent of respondents used the in-house multidisciplinary group approach which also appears to be the standard practice within the civil engineering sector (100 percent of respondents as shown in figure 1 (b)). This must however, be interpreted against the background that the civil engineering sector makes up only 6.5 percent of the respondent population. Only about 14 percent of respondents used the in-house synectic team approach and 7 percent of respondents used other approaches

Extent of Use of Risk Identification Techniques

Figure 2 summarizes the results of the survey concerning the use of risk identification techniques in the UK construction industry.

Pondering appears to be the key risk identification technique employed in the industry. All the respondents use this technique to varying degrees (rating values: mode = 4.00; median = 3.00; mean = 2.97; inter-quartile range = 2.00 - 3.00) and about 85 percent of respondents use it at least frequently.

This is followed by the use of checklists. Like pondering, all but one of the respondents uses this method, about 72 percent of respondents using it at least frequently.

It is worth noting that the risk identification techniques listed in the survey instrument appear to be the only ones with which that the greater majority (97 percent) of the respondents were familiar.

Among the risk identification techniques, synectics and expert interviews are the least used among almost all the professions. These results are consistent with results from the analysis by industrial sector.

The higher usage of pondering and checklists (compared to synectics and expert interviews) can be attributed to the ease with which one person can use such techniques. In terms of corporate economics, they are cheaper techniques too!

While the practice of pondering and checklists are good approaches to risk identification, it is doubtful if they can adequately highlight all the risks in a

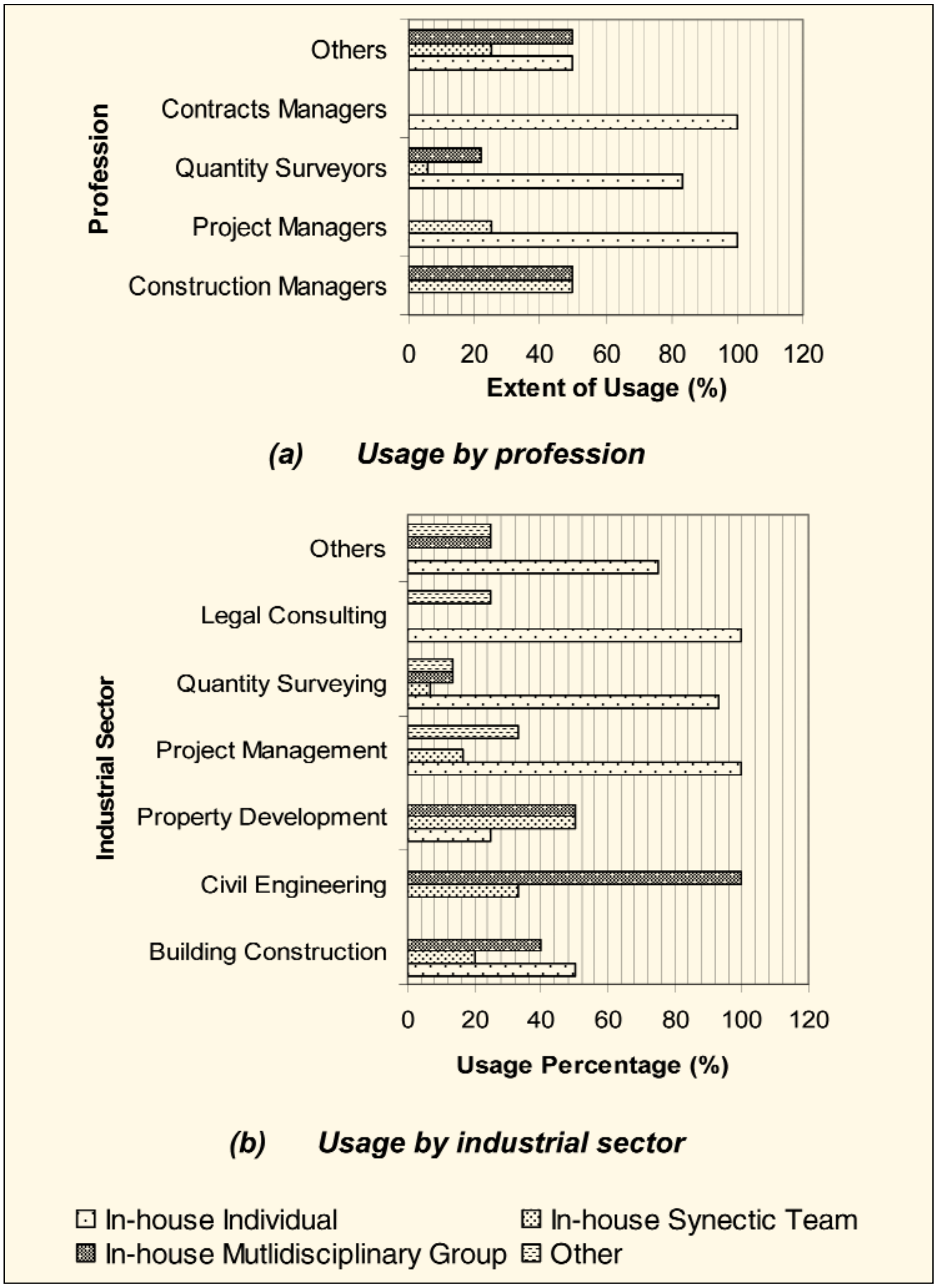

Figure 1 — Usage of Risk Assessment Approaches

complicated construction project, especially if these techniques are being used by just one individual on the project. As stated earlier, the multidisciplinary, cross-industrial and technologically specialized nature of modern construction makes it inappropriate for one professional to assume sole responsibility for the identification of construction project risks.

Extent of Use of Risk Likelihood and Impact Assessment Techniques

Tables 3 and 4 summarize the results of this area. The predominant practices here (including practices among the professions and in different industrial sectors) involve the use of scaling methods and subjective probability assessments.

This is not surprising, as contractual risks by their nature do not lend themselves easily to the use of quantitative probability assessments. However, the fact that these techniques are not 'always' or 'very frequently' used would seem to confirm the work of R.W. Hayes and others in 1986 [11]. It reported that contractors hardly assess the separate risks that they are asked to carry, but resort to the addition of a single percentage cost contingency. This gives an overall impression of their perception of the total risks that they are asked to carry.

These findings are also consistent with the findings of S.J. Simister in 1994, in his survey of construction project risk analysis techniques used in the UK, and those of J.F. Burchett and others in the 1999 worldwide survey of risk management practices among electrical supply companies [7, 19].

The industry as a whole does not seem to have made significant progress in employing available analytical techniques since the 80s! Although scaling methods and subjective probability assessments are used in risk likelihood and impact assessments, they are on average not used "frequently." The assessments are generally conducted using the in-house individual approach.

This combination fails to maximize the potential benefits of the subjective probability approach. The assessments become heavily subject to effects of the personal perceptions and biases of the individual. After over a decade of technological, research, and management advances, the construction industry does not appear to have shifted very significantly from old practices.

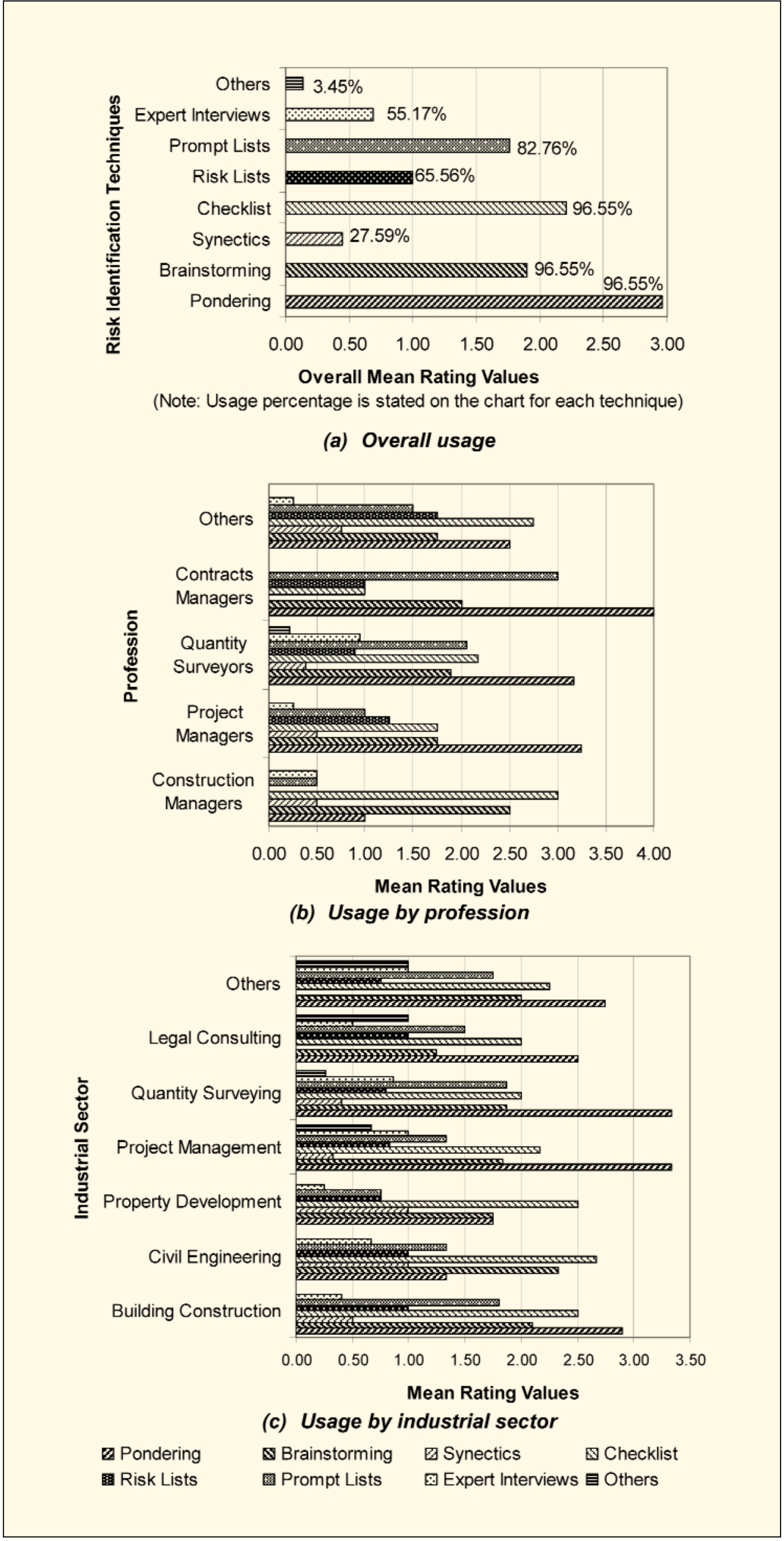

Figure 2 — Usage of Risk Identification Techniques

Risk Analysis Techniques

It is evident from table 5 that risk analysis in the form that is applied in economic risk analysis is very much an unexplored area when it comes to contract risk analysis.

Generally, none of the techniques surveyed by the study is used to any significant degree. On average, probability analysis, sensitivity analysis, scenario analysis, and ranking options are generally either never used or used only occasionally.

It is also significant to note that most of the experts who use the probabilistic techniques were from comparatively smaller companies with annual turnovers of less than £5 million, and that no other methods of risk analysis are used by any of the respondents.

At first sight, the results appear to contradict the findings of S.J. Simister in 1994, in whose study about 72 percent and 60 percent of respondents indicated that they currently used Monte Carlo simulation and sensitivity analysis respectively [19]. However, Simister's 1994 study merely reported how many of the surveyed participants currently use the techniques but did not investigate how frequently they use them [19].

The majority of the 72 percent that used Monte Carlo simulation according to S.J. Simister's 1994 study could well be occasional users of the probabilistic approach [19].

The present study does not only measure the numbers of participants who use the various approaches, but also how frequently they actually use the different approaches.

Even though scaling methods and subjective probability assessments are the techniques used most frequently for evaluation risk likelihood and impact, they are only used occasionally when making final analytical decisions about the risks.

This suggests that the estimates that are derived for risk likelihood and impact are often single point estimates and not of the type that can be used in a rigorous probabilistic analysis such as Monte Carlo simulation. Although management systems are becoming more reliable and efficient and construction project environments more complex, it appears that not much effort is being made by the industry to incorporate available and adaptable systems into its risk management practices.

Testing the Hypotheses

Hypothesis (i) is considered as supported if the majority of the participants use it "less-than-frequently." Thus, on the rating scale of 0 to 4 explained earlier, a mean rating value of less than "2" (which represents "frequent" use) would indicate a support for the hypothesis.

The various risk identification and analytical techniques and their capacity to deal with the effect of perception on the subjective estimates used in risk analysis were discussed earlier.

Hypothesis (ii) is considered as supported if the majority of the participants frequently use those techniques that do not adequately deal with the effect of perception on the subjective estimates, or if they use techniques that adequately deal with the effect of perception on the subjective estimates "less-than-frequently."

Thus, on the rating scale of 0 to 4, a mean rating value of more than "2" (which represents "frequent" use) for the first set of techniques, less than "2" for the techniques that deal with perception would indicate a support for the hypothesis (ii). Table 6 presents a listing of all the risk management techniques evaluated in this study ranked in the order of their overall mean rating values.

Testing of Hypothesis (i)

For risk Identification, the only techniques with mean ranking values of more than "2" are pondering and checklists. Synectics and expert interviews that have the highest potential for

	Rating Values for usage of risk likelihood assessment techniques			
	Relative Frequency	Subjective Probability	Scaled Assessments	Others
Usage by profession				
Construction Managers	0.00	0.50	0.50	0.00
Project Managers	0.25	1.00	0.75	0.00
Quantity Surveyors	1.06	2.22	2.28	0.00
Contracts Managers	1.00	2.00	2.00	0.00
Others	1.00	1.25	1.00	0.00
Usage by industrial sector				
Building Construction	0.60	1.50	1.30	0.00
Civil Engineering	1.00	1.33	1.00	0.00
Property Development	0.50	1.50	1.00	0.00
Project Management	0.67	2.00	2.33	0.00
Quantity Surveying	0.93	2.20	2.27	0.00
Legal Consulting	1.00	0.75	1.75	0.00
Others	0.75	1.00	2.25	0.00
Overall rating value	0.86	1.79	1.76	0.00
Overall percentage usage	51.72%	86.21%	86.21%	0.00%

Table 3 — Usage of Risk Likelihood Assessment Techniques

	Rating Values for usage of risk impact assessment techniques			
	Relative Frequency	Subjective Probability	Scaled Assessments	Others
Usage by profession				
Construction Managers	0.50	0.50	1.00	0.00
Project Managers	0.25	1.00	0.75	0.00
Quantity Surveyors	1.28	1.61	1.89	0.00
Contracts Managers	1.00	2.00	2.00	0.00
Others	1.00	1.25	2.00	0.00
Usage by industrial sector				
Building Construction	0.80	1.40	1.80	0.00
Civil Engineering	1.33	1.00	1.33	0.00
Property Development	0.75	1.25	1.25	0.00
Project Management	1.17	0.83	2.00	0.00
Quantity Surveying	1.20	1.47	1.80	0.00
Legal Consulting	1.00	1.00	1.25	0.00
Others	1.50	1.00	1.00	0.00
Overall rating value	1.03	1.41	1.69	0.00
Overall percentage usage	62.07%	75.86%	86.21%	0.00%

Table 4 — Usage of Risk Impact Assessment Techniques

	Rating Values for usage of risk analysis techniques								
	Decision Tree Analysis	Fault Tree Analysis	Event Tree Analysis	Probability Analysis	Sensitivity Analysis	Scenario Analysis	Simulation Analysis	Ranking Options	Others
Usage by profession									
Construction Managers	0.00	0.00	0.00	0.50	0.50	0.50	0.00	0.00	0.00
Project Managers	0.00	0.00	0.00	0.75	0.50	1.75	0.25	0.00	0.00
Quantity Surveyors	0.28	0.28	0.33	1.28	0.50	0.78	0.44	0.00	0.00
Contracts Managers	0.00	0.00	0.00	1.00	2.00	2.00	0.00	0.00	0.00
Others	0.25	0.25	0.50	1.00	0.75	1.00	1.00	0.00	0.00
Usage by industrial sector									
Building Construction	0.10	0.10	0.20	0.70	0.70	0.60	0.40	0.90	0.90
Civil Engineering	0.00	0.00	0.00	0.20	0.10	0.20	0.20	0.30	1.00
Property Development	0.00	0.00	0.00	1.00	0.75	0.75	0.50	0.00	0.00
Project Management	0.17	0.17	0.17	0.83	0.67	0.83	0.67	0.00	0.00
Quantity Surveying	0.20	0.20	0.27	1.33	0.47	1.07	0.40	0.00	0.00
Legal Consulting	0.50	0.50	0.75	1.00	0.25	1.00	0.25	0.00	0.00
Others	0.50	0.50	0.75	1.00	0.50	0.75	0.25	0.00	0.00
Overall Rating Value	0.21	0.21	0.28	1.10	0.59	0.97	0.45	0.79	0.00
Overall percentage usage	17.24%	17.24%	24.14%	65.52%	44.83%	51.72%	27.59%	48.28%	0.00%

Table 5 — Usage of Risk Analysis Techniques

generating the broadest listing of risks have mean rating values of less than one, indicating that at best, they are only used occasionally. The mean rating values for risk likelihood, risk impact and risk analysis techniques are all less than "2." It is worth also noting that these techniques (including the risk identification techniques) are generally used within an in-house individual assessment setting. The survey results support hypothesis (i).

Testing of Hypothesis (ii)

The only contractual risk management techniques that can adequately deal with individual perceptions and biases are subjective probability estimates derived within a group setting (synectics or in-house multidisciplinary group) and probability analysis including simulation analysis. The mean rating values for these techniques are all less than 2. Furthermore, they are also generally used within an in-house individual assessment setting. These results support the hypothesis (ii).

It is evident from these results that there is a significant gap between the techniques available to the construction industry and what are actually used in the management of contractual risks. Contractual risks by their nature make it highly unlikely that one individual will

Risk Management Technique	Mean Rating Value
Risk Identification	
Synectics	0.45
Expert interviews	0.69
Risk records	1.00
Prompt lists	1.76
Brainstorming	1.90
Checklists	2.21
Pondering	2.97
Risk Likelihood	
Relative Frequency	0.86
Scaled Assessments	1.76
Subjective Probability	1.79
Risk Impact	
Relative Frequency	1.03
Subjective Probability	1.41
Scaled Assessments	1.69
Risk Analysis	
Decision Trees Analysis	0.21
Fault Trees Analysis	0.21
Event Trees Analysis	0.28
Simulation Analysis	0.45
Sensitivity Analysis	0.59
Ranking Options	0.79
Scenario Analysis	0.97
Probability Analysis	1.10

Table 6 — Ranking of Mean Rating Values of Risk Management Techniques

have sufficient first hand experience of each risk to enable him/her to conduct accurate identification and analysis. That is without making the whole risk management exercise heavily subject to the errors caused by personal biases and perceptions.

This is supported by the fact that although 160 professionals were selected to participate in the study, based on at least 10 years of industrial experience, only 29 believed they had sufficient experience to enable them respond to the survey questions. Yet the predominant practices in the industry seems to center on one individual dealing with risk management. These practices do not adequately take account of the nature of contractual risks nor help to make risks explicit.

The economic practicality of bringing together a team of experts for risk analysis on small projects is undoubtedly questionable, but it is possible to employ available computing and information technology or consultative approaches (e.g. expert interviews) in overcoming the disadvantages of the individual expert assessment approach.

This appears not to be the case in the industry generally. Very few professionals use risk analysis techniques such as probability analysis, sensitivity analysis, and scenario analysis. Those who use them appear to do so only occasionally. There is a use of scaled and subjective judgmental probability assessments techniques to various degrees, but very little application is made of these assessments. Such assessments would include input variables for a formal, systematic probabilistic analysis and quantification of the risks.

Further interviews with some of the experts suggest the perception that such a formalized process is perhaps only within the resource capabilities of the very large construction firms. This perception is not supported by the findings of the research. On the contrary, the majority (about 68 percent) of companies using all the various kinds of risk management techniques have a turnover of less than £5 million. In fact, companies with turnover of under £1 million, who use the various techniques, account for over 40 percent of the respondents.

The author's view is that the use of formalized processes for risk management is not, and need not, be only within the resource capabilities of very large construction firms. This is based upon advances in modern technology and evidence from this research and from other industries.

Most of the techniques surveyed are used on a regular basis by other industries that are prone to similar risk as those faced by the construction industry, and are considered generally beneficial to the risk management effort.

It is evident from the study that the extent of application of systematic and rigorous probabilistic methods to contract risks in construction is very scant. Also, the analytical methods currently used to manage such risks do not adequately deal with the effect of perception on the subjective estimates used in these analytical techniques.

The reliability of these findings is reinforced by the results obtained through the analysis of the mean rating values (MRV) of the various techniques. The only risk management techniques used that had a MRV of more than "2" ("2" signifying that the technique is used frequently) are pondering and checklists.

Assessments are also largely done by single individual in an organization. Construction contract risks are rare by nature and largely undocumented. It is therefore highly unlikely that one individual will have sufficient first hand experience of each risk to enable him/her conduct accurate and thorough identification and analysis of such risks in any major construction project.

This fact was evident in the survey by the fact that although 160 professionals were selected in the UK, based on at least 10 years of industrial experience, to participate in the study, only 29 believed they had sufficient experience to enable them respond to the survey questions.

The study highlights the fact that there is a significant gap between the techniques available to the construction industry and what are actually used in the management of contract risks. Further research is needed in investigating the use of available techniques that fully address the subjective nature of construction contract risks. Such techniques should also be able to obtain subjective risk estimates for analysis in a manner that minimizes the impact of individual perceptions and biases on the estimates used for the analysis. ◆

REFERENCES

1. Adams, F.K. *The Management of Risks in International Infrastructural Projects*. PhD Thesis. The University of Edinburgh. United Kingdom, 2004.
2. Al-Bahar J.F., and K.C. Crandall. *Systematic Risk Management Approach for Construction Projects*, **Journal of Construction Engineering and Management**; 116, 3 (1990):533-546.
3. Ansell J. *Reliability: Industrial Risk Assessment*. J. Ansell and F. Wharton, editors. **Risk: Analysis, Assessment and Management**. UK: Wiley, 1992
4. Antwi A.Y. *Urban Land Markets in Sub-Saharan Africa: A Quantitative Study of Accra Ghana*. Ph.D. Thesis, Napier University. United Kingdom, 2000.
5. Ashley DB, S.L. Stokes, and Y.H. Perng. *Combining Multiple Expert Assessments for Construction Risk Identification*. **Proceedings of the 7th International Conference on Offshore Mechanics and Arctic Engineering**, Houston, Texas, 1988. p. 183-192
6. Baker S, D. Ponniah D, and S. Smith. *Risk Response Techniques Currently Employed for Major Projects*. **Construction Management and Economics**, 17 (1999): 205-213.
7. Burchett, J.F., V.M. Rao Tummala and H.M. Leung. *A Worldwide Survey of Current Practices in the Management of Risks Within Electrical Supply Projects*. **Construction Management and Economics** 17 (1999): 77-90.
8. Chapman C, and S. Ward. **Project Risk Management: Processes, Techniques and Insights**. UK: Wiley, 1997.
9. Cicourel A.V. **Methods and Measurement in Sociology**. New York: Free Press, 1964.
10. Diekmann J.E., E.E. Sewester and K. Taher. **Risk Management in Capital Projects**. Texas: CII, University of Texas at Austin, 1988.
11. Hayes R.W., J.G. Perry,P.A. Thompson and G. Willmer. **Risk Management in Engineering Construction**. London: Telford, 1986.
12. Kadane J.B., and L.J. Wolfson. *Experiences in Elicitation*. **The Statistician**. 46, 4 1997): 1-17.
13. O'Hagan, A. *Eliciting Expert Beliefs in Substantial Practical Applications*; **The Statistician**. 46, 4 (1997).

SECTION 1: PERSONAL DETAILS

Name: ……………………………………………………….. Title (Mr/Miss/Mrs/Dr, etc): ……………………....

Company:…………………………………………………………………………………………………..........................

Address:…………………………………………………………………………………………………..........................

Town/City: ………………………………………………. Post code: …………………………………………

Tel: ……………………………………………………… Fax: ……………………………………………

SECTION 2: AREA(S) OF EXPERTISE

1.0 Profession/Job Title/Job Function (please tick (✓) only the most applicable one)

- ❑ Construction Manager
- ❑ Project Manager
- ❑ Quantity Surveyor
- ❑ Contracts Manager
- ❑ Other *(please specify)*: ………………………………………………………………………………

2.0 Approximate Number of Years of Experience

(a) In the Construction Industry: ………………………………………………………………………

(b) In your current profession: …………………………………………………………………………

3.0 Nature of Business (please tick (✓) as applicable)

- ❑ Building Contracting
- ❑ Civil Engineering Contracting
- ❑ Property Development
- ❑ Project Management Consulting
- ❑ Quantity Surveying/Cost Consulting
- ❑ Legal/Contracts Consulting
- ❑ Other *(please specify)*: ………………………………………………………………………………

4.0 Type(s) of Work Normally Undertaken (please tick (✓) your top 2)

- ❑ Commercial/Industrial Buildings
- ❑ Public/Community Buildings
- ❑ Road/Civil Engineering Construction
- ❑ Other *(please specify)*: ………………………

5.0 Average Annual Turnover (please tick (✓) as applicable)

❑ Under £1m ❑ £1m - £5m ❑ £6m - £25m ❑ £26 - £50m ❑ Over £50m

SECTION 3: TECHNIQUES FOR ASSESSING THINGS THAT CAN GO WRONG

1.0 By what means are assessments of contract risks normally made in your current company (please tick (✓) as many as apply):

- ❑ In-house Individual
- ❑ In-house Synectic Team
- ❑ In-house Multi-disciplinary Group
- ❑ Other *(please specify)*: ………………………

2.0 In seeking to identify things that can go wrong (risks) on a project, how often do you use the following techniques (please tick (✓) for those that apply):

	Always	Very Frequently	Frequently	Occasionally	Never
Pondering					
Brainstorming					
Synectics					
Checklists					
Risk Records					
Prompt Lists					
Expert Interviews					
Other *(please specify)*:					

Appendix 1— Survey Questionnaire

3.0 In assessing how likely any identified risks are to actually occur on a project, how often do you use the following techniques (please tick (✓) those that apply):

	Always	Very Frequently	Frequently	Occasionally	Never
Quantitative Probability Assessments based on Historical Data					
Subjective Probability Assessments based on Expert judgement					
Scaled Assessments (e.g. High ÷ Low) based on experience					
Other *(please specify):*					

4.0 In assessing the severity or consequences of risks, how often do you use the following techniques (please tick (✓) for those that apply):

	Always	Very Frequently	Frequently	Occasionally	Never
Quantitative Probability Assessments based on Historical Data					
Fresh Estimation of Actual severity should risk occur					
Scaled Assessments (e.g. High ÷ Low) based on experience					
Other *(please specify):*					

5.0 In seeking to quantify or assess the impact of risk on a project, how often do you use the following techniques (please tick (✓) those that apply):

	Always	Very Frequently	Frequently	Occasionally	Never
Decision Tree Analysis					
Fault Tree Analysis					
Event Tree Analysis					
Probability Analysis					
Sensitivity Analysis					
Scenario Analysis					
Simulation Analysis					
Ranking Options					
Other *(please specify):*					

6.0 Please list in descending order the three contract risks whose effective management you consider most important to the performance of a project

1	
2	
3	

Appendix 1— Survey Questionnaire Continued

14. O'Hagan A, and R.G. Haylock. Bayesian Uncertainty Analysis and Radiological Protection. V. Barnett and K.F. Turkman, editors. *Statistics for the Environment* 3, **Pollution Assessment and Control**, Chichester, UK, 1997. p. 109-128
15. Raftery J. **Risk Analysis in Project Management.** London: E & FN Spon, 1994.
16. Simister S.J. *Usage and Benefits of Project Risk Analysis and Management*. **International Journal of Project Management**, 12, 1 (1994):5-8
17. Simonton D. *Creative Expertise: A Lifespan Developmental Perspective*. K. Ericsson, editor. *The Road to Excellence: The Acquisition of Expert Performance in the Arts and Sciences*, **Sports and Games**, Erlbaum, Mahwah, N.J. p. 227-253.
18. Spiegelhalter D.J., N.L. Harris, K. Bull and R.C.G. FranklinG. *Empirical Evaluation of Prior Beliefs About Frequencies: Methodology and a Case Study in Congenital Heart Disease*. **Journal of the American Statistical Association**, 79, 387 (1994):489-500
19. Tversky A. *Assessing Uncertainty*. **Journal of the Royal Statistical Society**, Series B, 36, 2 (1974):148-159.
20. Vick S. **Degrees of Belief - Subjective Probability and Engineering Judgement**. Virginia: ASCE Press, 2002.

RECOMMENDED READING

1. Dey P.K. **Quantitative Risk Management Aids Refinery Construction. Hydrocarbon Processing** (International Edition) 81, 3 (2002).
2. Flanagan R, and G. Norman. **Risk Management and Construction**. Oxford: Blackwell Scientific Publications, 1993.
3. Godfrey P.S. **Control of Risk: A Guide to the Systematic Management of Risk from Construction**. London: CIRIA, 1996.

ABOUT THE AUTHOR

Dr. Francis K. Adams is an assistant professor of construction management with Goodwin College of Professional Studies in Philadelphia, PA. He can be contacted by sending e-mail to franciskadams@drexel.edu.