Risk Assessment in construction: The impact of experience and corporate learning in decision-making of contractors

DEEPAK BAJAJ

Project Management and Economics Program
Faculty of Design Architecture and Building
University of Technology Sydney
Deepak.Bajaj@uts.edu.au

Abstract

Proper management of risk by contractors is essential from the viewpoint of the long-term ability to survive in a highly competitive bidding environment. An understanding of the various elements of the risk assessment process is critical for contractors and their impact on the bid/no-bid and the mark-up decisions. The paper examines allocation of construction versus business risk and the quantification of risk involved at the bidding stage of projects.

The research found that contractors are aware of the impact of different types of procurement systems on their risk exposure. The fact that contractors carry an additional business risk under the design and construction procurement method is a further important finding of this research. This additional business risk can be as high as 50% of the total risk for design and construct projects. Specific individual characteristics of the contractors surveyed play a significant role affecting the size of the project risk contingency, which tends to fall as knowledge and experience of contractors improves.

It was also found that contractors have varying expectations of profit, depending on company characteristics. These expectations vary with economic condition and need to obtain the contractor's work.

Keywords: D&C procurement, risk, bidding decision, markup, risk pricing.

1. Introduction

Experience in the construction industry is always treated as an important consideration in the award of projects to contractors. The industry experience is also an important consideration by the client for the contractor to be preselected to bid for the project. The organisational learning associated with the experience in the construction industry for contractors and how it is captured and utilised largely affects the decision-making of the contractors. Contractors rely on subjective judgement to make decisions at the bidding stage for the projects. Experience plays an important role in making judgements at the bidding stage.

The paper describes the case study bidding simulation undertaken in Sydney to understand, quantify and detail the contractor decision-making process and also the shift in the risks with the changes to the procurement methods.

The paper firstly describes the case study project, analyses the data and quantifies the risks for the project from the three contractors involved in the bidding exercise, finally, summarises and discusses the results. The bidding simulation is the phase 3 of the PhD study undertaken by the author. Phase 1 was the pilot study (results of which are published in Bajaj, D. et al, (1997)) and Phase 2 was the main study involving 41 contractors and 52 construction projects in NSW Australia. Prior work from previous phases of the study is utilised in the development of Phase 3 questionnaire and list of risks.

2. Constructive case study

2.1 Experimental design of case study

A simulated study is one in which certain independent variables are manipulated, their effect on one or more dependent variables is determined and the levels of these independent variables are assigned at random to the units in the study.

However, ideally the independent variables should vary one at a time so that effect of one independent variable on the dependent variables is monitored and measured accurately in the experiment. In construction management and construction project based experiments, the usual approach is to devise a study in which the main independent variables, except the one of interest, are held approximately constant and consequences of the main dependent variable are measured.

In the present study, the project being studied the variables will be the construction companies and the factors that affect decisions at the bid stage.

The study focuses on the data collection from the representatives of the three respondent companies. These representatives are involved in the decision making process of the respective companies. The respondents involved are estimating and tendering manager along with a senior estimator of each respondent company. The case study approach in this study aims to simulate a bidding exercise in the offices of the construction companies. Certain variables have been made constant to focus on the other factors involved at the bidding stage. One such variable is the estimated basic cost for the project, which is made constant for the three bidding companies, so as to focus on the quantification of other variables as a proportion of the fixed basic project cost. The basic project cost is without the risks, contingencies, overheads, markup etc. that is an assumption and a limitation of this approach.

Based on the literature on risk classification there are various models of sources of risk, with Perry and Hayes (1985) model used for the depth of risks it covers. The risk assessment for the project uses the risk events that were ranked top 20 in a previous study involving the risk ranking based on survey of 41 contractors and 52 case study projects and then the risk events for design and construct (D&C) type procurement strategy were summarised.

For this study, the importance index based ranking of factors that affect the markup size for the project was used and all the factors have been considered and some have been fixed in order to quantify the individual variable factors as a proportion of the total basic project cost.

The tender documents for the simulated case study project were prepared to fix the variables so that the study could focus on the variables that are part of this study and then quantify one variable at a time.

Generally the contractor needs to assess three types of factors i.e. 'internal' to the company, 'external' to the company and 'project under review' based factors. This is based on the risk models developed by Uher (1994) and Raftery (1994).

The factors that affect bidding and the markup decisions of the contractor are listed below, some have been fixed and the ones that are variable for the purpose of this study are:

Risk assessment of the project - Degree of risk	**VARIABLE**
Contractual agreement	FIXED - D&C Type
Urgency of the company to win the job, work load	**VARIABLE**
Builder-client relationship	FIXED - SCENARIO DESCRIBED
Type of project	FIXED - RESIDENTIAL & COMMERCIAL
Size of project	FIXED - A$ 23 MILLION BASIC PROJECT COST
State of market, competition	**VARIABLE**
Amount of capital involved	FIXED
Duration of project	FIXED –12 to 13 MONTHS
Reliability of sub-contractor	FIXED - SCENARIO DESCRIBED
Project start time	FIXED - SCENARIO DESCRIBED
Location of project site	FIXED - REGIONAL CENTRE OF SYDNEY
Proportion of work to be sub-contracted	LEFT OPEN TO THE CONTRACTOR - BUT NOT SO IMPORTANT TO FIX
Type and no. of supervisory persons	LEFT OPEN TO THE CONTARCTOR - BUT NOT SO IMPORTANT TO FIX

As part of the simulation, the client has been described and the builder client relationship which is the most important factor in bid / no-bid decision has also been described as part of the tender documents.

The other factor that is important is the **company characteristics** and that will depend on the respondent company, type of work they do, size of the company, expertise available etc. The results show that the company characteristics have a major impact on the final outcome and have been presented in the summary of quantification of factor section later in the paper.

Therefore, the three important **independent variables** isolated for quantification in this study are as follows:

External factor of

- **State of the market - Industry/market environment**

Internal factor of

- **Need for work - work load or volume of work at hand**

Project based factor of

- **Project risk assessment of the project or degree of risk**

The **Basic Project cost** will be given to the respondents so that the estimating errors do not bias the results; hence this important factor is kept as a constant. Since the objective is not to measure the project cost but the additions to the project cost in order to arrive at the final tender price.

In reality, in case a company makes a mistake in the project cost by using a lower than average estimate, it has to bear the consequences of either losing their contingency and markup to cover for the mistake or even lose money overall. At the same time, in case the estimate is higher than the average, the company renders itself un-competitive for bidding process.

The important thing in this study will be that most of the project factors will be constant as it will be the same project. Since being a hypothetical project for the respondent companies the issue of confidentiality of project information is not be a problem. Also, to further protect the company names, only their company characteristics have been described rather than the names and individuals involved.

2.2 List of Information for the Company Representative

As set of information provided to the company representatives has been enclosed in the appendix section of this dissertation.
For the case study based interviews following documents are provided to the representatives.

- Introduction
- *Project Information – Scenario, Drawings, project description and client information*
- *Trade wise breakup costs – Basic costing and assumptions*
- *Questionnaire*

2.2.1 Case Study Project Description

Empress Gardens
600 Railway Parade, Hurstville, NSW 2220

*** Developers: Sunrich Australia Pty Ltd**

"Empress Gardens" is a 19 storeyed proposed development located at Hurstville with streets on three sides of the site namely: Railway Parade (front), Woniora Road (side), and Empress Lane (rear). The site area is approximately 3270m2 and the overall building area is approximately 16000m2.

The project comprises, besides others, 165 units and three levels of underground car parks (levels 1, 2 and 3) with a capacity to accommodate 314 cars. Level 4 houses the reception lobby, heated swimming pool, spa, gymnasium, indoor golf practice area, sauna, shops and Woniora Gardens which is proposed to be a public park built on a suspended slab. Levels 5 to 18 comprise units in two separate towers with each tower per floor on the typical floors having 2 three-bedroom units, 2 two-bedroom units and 2 one-bedroom units. Level 19 comprises the mechanical plant.

At the rear, the site has a steep gradient approximately sloping from level 3 to level 1. At the front the gradient approximately slopes from level 4 to level 3. The access to the site during construction is to be from Empress Lane at the back until level 4 slab is poured and stripped.

The ground conditions on the project site are quite varying. Contaminated soil is found in most parts of the site beyond a certain depth. This will make it necessary to receive approval from EPA (Environmental Protection Authority) for tipping the contaminated excavation in

nominated tips. On the western side of the site the ground is reasonably firm with loose to medium shale. On the east side the ground is reasonably to extremely soft with a mixture of shale and clay with a volcanic dyke approximately 1.5m wide going diagonally through the site, where the ground is extremely soft.

The developers bought the land from Kogarah Council and as part of the agreement for sale, at the end of the project, the developers have to hand over to the Council, the carpark on level 3 and Woniora Gardens on level 4 fully furnished with landscape, lighting and street furniture. The developers also had to dedicate 3 metres of the site along the north and West Side (along Railway Parade and Woniora Road respectively) to the Council for future road widening. The security interfacing of the building has to be so designed to enable the one-bedroom units to be used as future serviced apartments if permitted and decided. Hence the building has various stratums within the strata with a proposed future body corporate responsible to undertake the maintenance of the project once it is completed and handed over.

2.2.2 Tender Process and Documents

The type tendering arrangement is competitive and selective, with your company being short-listed after pre-qualification document submission by your company. You can expect 4 bidders on this project including you, with most companies known to your organisation.

The type of contractual arrangement will be Lump sum and Design & Construction type with provision for design changes from the client as variations. Project is a D&C contract, as the conceptual design is complete with the council approval for DA, BA is to be obtained by you.

2.2.3 Tender Documents

- The brief for your company from the client is comprehensive and complete to define the client requirements at a sketch stage level. It also includes the schedule of finishes and specifications.
- The drawings provide the conceptual scheme.
- The client provides geo-technical report and contamination report and 10 boreholes on site.
- The form of contract will be AS2124 - 1992.
- The expected project duration is 12-13 months.

2.2.4 Basic Cost Estimate of the Project

The Trade wise cost break-up is as follows:

Table 1: Basic cost estimate is million $ 23.00

NO	TRADES	COST BREAKUP % OF BASIC COST
1	Preliminaries Total - Site Supervision & Mgmt -All others	17.0 7.0 10.0
2	Demolisher	2.50
3	Ground works	6.25
4	Formwork	9.25
5	Reinforcement	7.00
6	Concreter	7.25
7	Brickwork/ Blockwork	7.75
8	Waterproofing	1.25
9	Structural Steel & Metalwork	0.25
10	Hand Rails	1.25
11	Kitchens	1.75
12	Fire Doors	1.00
13	Door Hardware Supply	0.25
14	Cement Renderer	5.00
15	Plasterboard walls/ceilings	2.00
16	Ceramic Tiler	3.50
17	Carpet	1.75
18	Shopfront/ Aluminium Windows	2.50
19	Shower Screens	0.50
20	Painter	2.0
21	Kerb & Gutter	0.15
22	Landscaping	0.75
23	Fencing	0.10
24	Hydraulics	7.00
25	Electrical	5.00
26	Lifts	2.00
27	Mechanical ventilation	1.50
28	White goods	3.50
	TOTAL	**100%**

2.3 Results of the Analysis of the Study

The questionnaire is designed to model and quantify the risks for construction projects at the tendering stage for contractors. The project case study to be used in this analysis is a high-rise residential project in a suburb of Sydney. The case study site was chosen on the basis that it represent 80% of the projects undertaken in the Sydney region, rather than a unique mega

project, which will not have much value to the majority of contractors in the construction industry. Normally for mega projects the level of risk assessment undertaken at all levels of the project is significantly higher than the majority of projects undertaken in the construction industry.

The interview took place in the offices of the contractors. The approach taken is to record the interview to absorb the discussion of the interview. Since this is a qualitative area of research, the grounded theory will be used to analyse the results. The reason for the choice of grounded theory is that the area of risk quantification and finalisation of tender is considered an art rather than a science and the intension is to build theory from the responses and arrive at the conclusions.

2.3.1 Introduction of Interviewed Companies

The introduction of the interviewed contractor is aimed at presenting the company characteristics, which have a major influence on the way contractors approach the bid process. To get a diversity of opinions in risk assessment and related decisions at the tendering stage three-construction contractors were interviewed for the project using detailed construction case study approach. The companies were different in terms of culture, size and history.

Pilot and Interview 1 Company

The first respondent contractor is a medium size construction company in Sydney. This company performs projects of similar type and size. The company on average has 2-3 projects running at any given time. The turnover of the company is around $30 million and has 2 years experience in the industry. The projects they execute are mainly building – residential and commercial type, high-rise construction is their expertise.

The purpose of the pilot run was to highlight any obvious mistakes in questions or their responses that need refining to get the message across the respondent. This pilot run helped substantially in the finalisation of the case study approach. This exercise took ½ day to perform.

It is a medium size construction company, performing construct only to construction management type contracts. The company is privately owned with the owner being active in securing projects and also in the management of projects. The company does not have large overheads and has a very lean staffing arrangement. The use of information technology is restricted to the site management and the head office tasks are carried out at the site where the owner is located.

The owner in consultation with the project manager(s) takes decisions to bid for projects. Project managers also act as the company estimator at the time of bidding. The owner is active in estimating and related decision making. The infrastructure in minimal and the company is competitive partly because of the low overheads.

Interview 2 Company

This construction company is a medium to large size contractor with more diverse project portfolio. The type of projects which the contractor undertakes span from building to

engineering. They also engage in consulting as project managers and have an in house design department. The company is staffed appropriately and tends to have high overheads. The management structure is more bureaucratic and committee based. The company is a subsidiary of a large international construction company and has a big presence in Sydney and Australia.

Decisions in this company are taken in consultation with the staff involved on the project. The company has various divisions and has a senior personnel in-charge of each division. The company has set procedures and all staff utilise information technology in their daily routines. The company infrastructure is good with regular updating and upgrading. The company has a turnover of $ 125 M and has 25 years experience in the industry. The company puts a lot of emphasis on procedures and records.

Interview 3 Company

This company is one of the large companies in Australia. They have international subsidiaries and are active in quite a diverse range of activities related to the construction industry. The company has a turnover of close to $ 1 Billion and has 52 years experience in the industry. The company is professionally run with various divisions and departments. The company staffs make good use of information technology in their daily routine tasks. The company has good investments in technology and regular upgrades and updates. The company has appropriate number of professional staff. Staff is regularly sent for professional development type programs aimed at the construction industry professionals.

The company has decision-making procedures in place and puts emphasis on innovation and continuous improvement. The company has different ways of arriving at project costs at the time of bidding for projects. The company is active in non-traditional procurement systems, such as, design and construct, development type and design construct and finance type of projects etc. The company has a separate estimating and cost-planning department.

2.3.2 Presentation of the case study results with different companies

Quantification of effect of 'need for work' factor in conjunction with 'economic environment' factor

The tables are based on 3 different states within the company in terms of need for more work. This is an internal company factor that is a corporate challenge for the decision-makers while planning tendering strategy and the risk assessment for the project. The tables present a summary of the response from companies. The factor cannot be considered independent of the external industry environment factor, as the responses will differ depending on the economic cycle.

Table 2: STATE 1: Desperate for work – work has fallen below the lower bound of workload

Respondent Economic Condition	Company 1	Company 2	Company 3
Boom	7	3	0
Downturn	5	0	-2
Bust	3	-1	-2
Upturn	4	3	0

Table 3: STATE 2: Enough work in hand – workload is between the Upper and the lower bound

Respondent Economic Condition	Company 1	Company 2	Company 3
Boom	8	6	+2
Downturn	6	3	0
Bust	4	2	-2
Upturn	5	5	0

Table 4: STATE 3: Enough work – workload is at or above the Upper bound

Respondent Economic Condition	Company 1	Company 2	Company 3
Boom	10	7	+2
Downturn	7	5	+2
Bust	5	4	0
Upturn	6	6	+2

The results from table 2,3, & 4 show that even though the companies have recognition of the changes in the market conditions and the changes in the workload of their companies, but the quantification of the factor is very different. **The difference in the value of the change in expectation is different for the three companies even though the change in the direction of the movement in expectation is similar.** In one case the change in profit expectation is negative, where as the other two have kept the expectation lower but not below the normal expectation. The results show that the contractors account for the changes in the conditions with a change in expectation to survive the ups and downs, but it is different for each contractor and their circumstances.

The summary of the risk assessment done by the three companies in terms of whether the individual risk is recoverable under the contract is presented in table 7.5 below.

Table 5: Risk Assessment of Project Case Study

	Sources of risk	Risk Factors/events	Recoverable under the contract Yes / No		
		INTERVIEWS ->	Company 1	Company 2	Company 3
1	Construction	Delay in possession of site	Y	Y	Y
2		Weather	Y	Y	N* only time
3		Quality, availability and productivity of labour	N	N	N
4		Suitability, availability and supply of materials	N	N	N
5		Quality, availability and productivity of sub-contractors	N	N	N
6		Ground conditions - unforeseen problems(latent conditions)	N	Y	N
7		Errors or omissions in Bills of quantities – prepared by you	N	N	N
8		Insufficient time to prepare bid tenders	N	N	N

	Sources of risk	Risk Factors/events	Recoverable under the contract Yes / No		
9		Delay in information from designers – your consultants	N	N	N
10		Unreasonableness of professional staff – client's representative	N	N	N
11		Extent of change – client driven	Y	Y	Y* only major
12		Ground conditions - inadequate information in documents – client provided reports	Y	Y	Y
13		Mistakes – done by you	N	N	N
14		Liaison with statutory and government authorities	N	Y	N*
15	Design	Discrepancy of information in client's brief	N	Y	N
16		Level of detail required and accuracy	N	N	N
17		Appropriateness of specification	N	N	N
18		Likelihood of change	Y	N	N
19		Interaction of design with method of construction	N	N	N
20		Incomplete design scope	N	Y	N
21		New technology	N	N	N
22	Financial	Cash flow problems for contractors due to slow payment by clients of completed works	Y	N	Y
23		Failure of lowest S/C to enter construction contract	N	N	N
24		Other: Industrial			N*
25		Other: Contract			N

* In some instances it may be possible to recover

The purpose of presenting the above information is to show if there is a dramatic variation in the interpretation of the contract with regards to the project based risks by the three respondent companies. It also shows that appropriately trained personnel have been involved in this case study. As can be seen there is just a minor difference in the assessment of the three companies, which will be discussed in the discussion section later in the chapter.

2.3.3 Summary of Detailed Quantification of Risks

With the use of constructive case study where the scenario was based on D&C type of procurement system and the base cost was fixed to focus on the risk factors internal and external to the project. The three detailed interviews on the quantification of risks that have been presented in the previous section are summarised in this section.

Company One: Collection of Risk Factors Impacts

The company is a medium sized construction company with limited infrastructure, mainly performs the hard dollar tender projects in residential sector. It has expertise in high-rise projects.

The total most likely time delay for construction risks is 96 days.
The total most likely time delay for design risks is 171 days.
The total most likely time delay for financial risks is 5 days.

Hence, the total most likely time delay is 272 days on an expected contract period of 13 months. The percentage possible delay based on most likely time figures and with all the risks happening at the same time is as follows:

Time delay as a % of original expected contract period = 272 days lost / 365 working days = 74.5% increase in project time.

But it is highly unlikely that there would be such high chance of all risks happening. The interpretation of the results says that on average there is a 25% chance that all risks might happen. It is a gut-feeling estimate based on the experience of the contractor.

Taking the chance into account, the days lost would be 25% of 272 = 68 days or 18.5% extension of time. According to this estimate the contractor should make an allowance for contingency in the contract for negotiations to get an extra 68 days for the risks.

The 68 days delay also implies that the contractor would be involved on the project for an extra period of time and there is an opportunity cost associated with this extension or delay and site overheads have to be taken into consideration. Based on this company's estimate, every additional day involves a daily overhead of all preliminaries etc. approximately at $34,285 per week based on the scenario and overheads expected. The company expects to lose 68 working days / 6 working days per week x $34,285 = $ 388,563 which is 1.7% of the basic construction cost.

Hence, the project risk contingency for this project was decided at 1.7% of the project costs of $23m.

Due to the type of procurement strategy ie. design and construct, nearly two third of project risk contingency is for design related risks which the contractor has to absorb as part of the new procurement system. In the traditional system these risks would have been part of the clients risks. This is without taking the opportunity costs that can be much higher.

Of course, if all the risks happened at the same time then the total loss will be 272/6 x $34,285 per week = $1,554,253 for the project. In such a scenario the risk contingency required would be approximately 6.8% of the basic project cost. Although allowing for a contingency would render the company uncompetitive in bidding.

The company is allowing for a gross profit margin of 7% if desperate for work and the economy is booming ie. if things go wrong on this project that could wipe out all the return and the company would be struggling to break even on the project, even though that is unlikely but a possibility. The company will bid at a gross profit of 3% if the economy is in at

its bottom ie bust. This would certainly be very close and the contractor would be relying on luck to get them through. The situation improves with the contractor's need for work.

The summary of this contractor bid is consistent with other experience on majority of projects in stage 1 interviews. Where on majority of projects the contractor expectations of profit were met, mainly due to the strong performance of the economy and particularly construction industry. This company is a medium sized company and would be having 1-2 projects of this size at any point in time, hence the cash flow does get affected. The lack of experience in D&C projects stand out with the quantification of risk factors, suggesting that contractor will be uncompetitive for majority of projects. After pricing the factors, it will be very easy to allow a high contingency to cover risks.

Due to the change in the procurement system, the risks related to the business have increased, they are not direct construction risks and hence the traditional construction risks are proportionally reduced to only one third of the total risk contingency.

Company Two: Collection of Risk Factors Impacts

The company is a medium to large sized construction company with good infrastructure. The portfolio is spread between hard dollar tender projects and turnkey type projects. The company mainly performs in the commercial, industrial and some residential project.

The total most likely time delay for construction risks is 65 days.
The total most likely time delay for design risks is 85 days.
The total most likely time delay for financial risks is 14 days.

Hence, the total most likely time delay is 164 days on an expected contract period of 13 months. The percentage possible delay based on most likely time figures and with all the risks happening at the same time is as follows:

Time delay as a % of original expected contract period = 164 days lost / 365 working days = 44.93% increase in project time.

But it is highly unlikely that there would be such high chance of all risks happening. The interpretation of the results says that on average there is a 25% chance that all risks might happen. It is a gut-feeling estimate based on the contractor experience.

Taking the chance into account, the days lost would be 25% of 164 = 41 days or 11.23% extension of time. According to this estimate the contractor should allow for contingency in contract for negotiations to get an extra 41 days for the risks.

The 41 days delay also means that for that much extra time the contractor would be involved on the project and there is an opportunity cost associated with this extension or delay and site overheads have to be taken into account. This contractor could not quantify the daily or weekly costs of being on site more than expected. Hence based on company one's estimate every additional day involves a daily overhead of all preliminaries etc., which are at $34,285 per week based on the scenario and overheads expected. The company expects to lose 41 working days / 6 working days per week x $34,285 = $ 234,280 which is 1.02% of the basic construction cost of $23m.

Hence, the project risk contingency for this project was decided at 1.02% of the project costs.

Due to the type of procurement strategy ie. design and construct, just over 50% of project risk contingency is for design related risks which the contractor has to absorb as part of the new procurement system, whereas in the traditional system these risks would have been part of the clients risks. This is without taking the opportunity costs that can be much higher.

Of course, if all the risks happened at the same time then the total loss will be 164/6 x $34,285 per week = $937,123 for the project. In such a scenario the risk contingency required would be approximately 4.1% of the basic project cost. Although allowing for a contingency of that size might not be competitive for the company.

The company is allowing for a gross profit margin of 3% if desperate for work and the economy is booming ie. if things go wrong on this project that could wipe out all the return and the company would be returning a loss of approximately 1.1% on the project, even though that is unlikely but a possibility. The company will bid at a gross profit of -1% if the economy is in at its bottom ie bust. The contractor would definitely make a loss from day one even without the risks materialising. The situation improves with contractor need for work. This company did not have much experience of new procurement systems and the value adding and how to convert value addition into profit.

Company Three: Collection of Risk Factors Impacts

Company three has had plenty of experience on D&C type of procurement systems. It is one of the large construction companies of Australia and has executed some of the largest projects in all types of industries. The company representatives found it very difficult to quantify the risks in terms of time delay or costs associated. They were only able to quantify 3 risks, weather and industrial in construction, ground conditions – inadequate information provided by the client in design. Also, an important risk according to the representatives is availability, quality and productivity of subcontractors and labour is not in terms of time delay but they would allow for 10% premium on the subcontractor pricing. This is different to the other two contractors who were more comfortable estimating time delay rather than costs associated. This contractor used a combination of the time and cost delay.

The risks according to them had a high probability and should be assumed to be sure to happen. On this basis,

The total most likely time delay for construction risks is 20 days.
The total most likely time delay for design risks is 14 days.
The total most likely time delay for financial risks is 4 days.

Hence, the total most likely time delay is 38 days on an expected contract period of 13 months. The percentage possible delay based all the risks happening at the same time is as follows:

Time delay as a % of original expected contract period = 38 days lost / 365 working days = 10.4% increase in project time.

Taking the chance of the risks happening for sure as described by the company representatives, the days lost would be 38 days or 10.4% extension of time. According to this

estimate the contractor should allow for contingency in contract for negotiations to get an extra 38 days for the risks.

The 38 days delay also means that for that much extra time the contractor would be involved on the project and there is an opportunity cost associated with this extension or delay and site overheads have to be taken into account. Based on the company one's estimate every additional day involves a daily overhead of all preliminaries etc., which are at $34,285 per week based on the scenario and overheads expected. The company expects to lose 38 working days / 6 working days per week x $34,285 = $217,138 which is 0.95% of the basic construction cost.

Hence, the project risk contingency for this project was decided at 0.95% of the construction costs plus 10% premium on subcontract prices of some trades.

Due to the type of procurement strategy ie. D&C, close to 37% of project risk contingency is for design related risks but only time delay which the contractor has to absorb as part of the new procurement system, in the traditional system these risks would have been part of the clients risks. This is without taking the opportunity costs that can be much higher.

Of course, if all the risks happened at the same time then the total loss will be 38/6 x $34,285 per week = $217,138 for the project plus the 10% premium for subcontract price for some trades. In such a scenario the risk contingency required would be approximately 1% of the basic project cost.

The company did not disclose what the expected profit margin was on average project of this size and type, but they discussed in terms of % the adjustment required for the need for work factor and economic situation factor. If desperate for work and the economy is booming there would be no change to expectation that is 0% adjustment to the expected profit. The company decided on the adjustment to gross profit of -2% if the economy is in at its bottom ie bust. This would certainly be very close and the contractor would be struggling to make profit, but that's quite normal in that situation. This is the scenario when many companies go into liquidation due to lack of work and cash flow to maintain the overheads and payments. The situation improves with contractor need for work.

The summary of this contractor bid is consistent with other experience on majority of projects in the previous stage interviews, where on majority of projects the contractor expectations of profit were met, mainly due to the strong performance of the economy and particularly construction industry.

Summary

The summary of the individual responses of three companies clearly shows that all have different method, procedure and style of allowing for contingency allowance and more importantly very different method of quantifying risk factors. Of the three companies, only the first one was comfortable quantifying risks in terms of time delays expected and costs involved. The responses go deeper into the organisational culture, infrastructure available, and education and training in the process of risk assessment of the personnel involved. Unless these issues are addressed different contractors will deal with the risks differently and the person making the mistake in assessment will most likely win the project. In the case of design and construction type procurement system, the awareness is even less deep and quite

likely that two of the three companies interviewed were relating to the traditional form of procurement instead of D&C type, where the scenario changes dramatically.

3. Quantification of Risks

3.1 Risk Factor: Insufficient time to prepare bid tender

This risk factor was one of the important factor to be ranked among the top 25 risks and also has been quantified by construction companies in the light of its importance in D&C type projects. The difference in the three company responses is remarkable and can be explained. The summary of the three company responses is as follow:

Company 1: No D&C experience
Maximum time delay - 120 days
Minimum time delay - 0 days
Most likely time delay - 30 days
The responses from this company represent a triangular distribution for this risk factor.

Company 2 - Some D&C experience
Maximum time delay - 7 days
Minimum time delay - 7 days
Most likely time delay - 7 days
The responses from this company represent a uniform distribution for this risk factor.

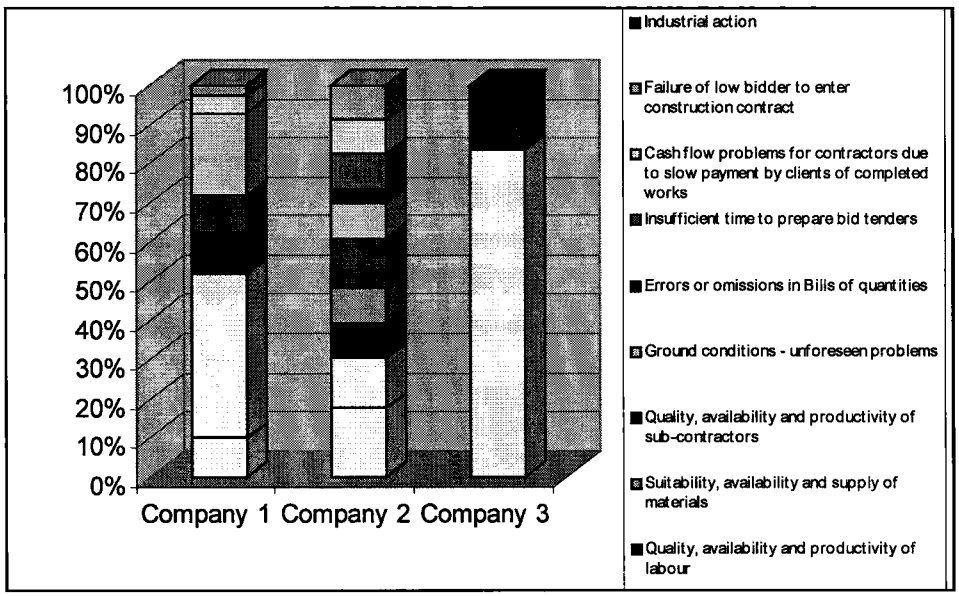
Company 3 - Good D&C experience
Maximum time delay - 0 days
Minimum time delay - 0 days
Most likely time delay - 0 days
According to this company, it just means that more resources have to be allocated to make things happen, rather than allow a time delay to take place on the project.

It is evident from the responses of three companies that due to the variation in the experiences of the three companies, there are different approaches in quantifying risk factor. The company with the most D&C type project execution had allowed for no extra time and instead opted for just extra resources. This kind of response reflects that time delays can be avoided once the company develops the knowledge in the area of design and can integrate the two functions of D&C projects. The other extreme was the company with no D&C experience and the response basically reflects a complete overwhelming of the company management with the tender submission and lack of objectivity in the response and the company is not prepared for shift towards non-traditional procurement system. The second company's response was quite reasonable with an expected most likely delay of 7 days due to lack of sufficient time to prepare bid tender. This response shows that the company's learning curve has been very sharp with the limited experience they have had in D&C type project. They are not projecting over confidence and are still taking a cautious approach to the time involved in being able to completely understand the project at the time of bid. The first 2 companies predict that the chance of this risk factor happening is high and the impact of risk event happening in dollar terms is directly proportional to the omissions and liquidated damages. Company three that has a good amount of experience on D&C projects and has been executing D&C projects as a part of their overall portfolio of different types of projects regularly. The company predicts that the chance of the risk factor of insufficient time to

prepare bid tenders is low in their particular case; they can program the process with enough confidence and accuracy. The company projects that most risks of design and construction type project will not delay the project and the best way of managing the risks is to have good communications with the client and set up processes and procedures to handle the project. Hence they have not included time delay among most risks. The company is ready for all types of projects and sufficient knowledge and experience has been gained and incorporated in the organisational culture.

3.2 Comparison of breakdown of construction risks

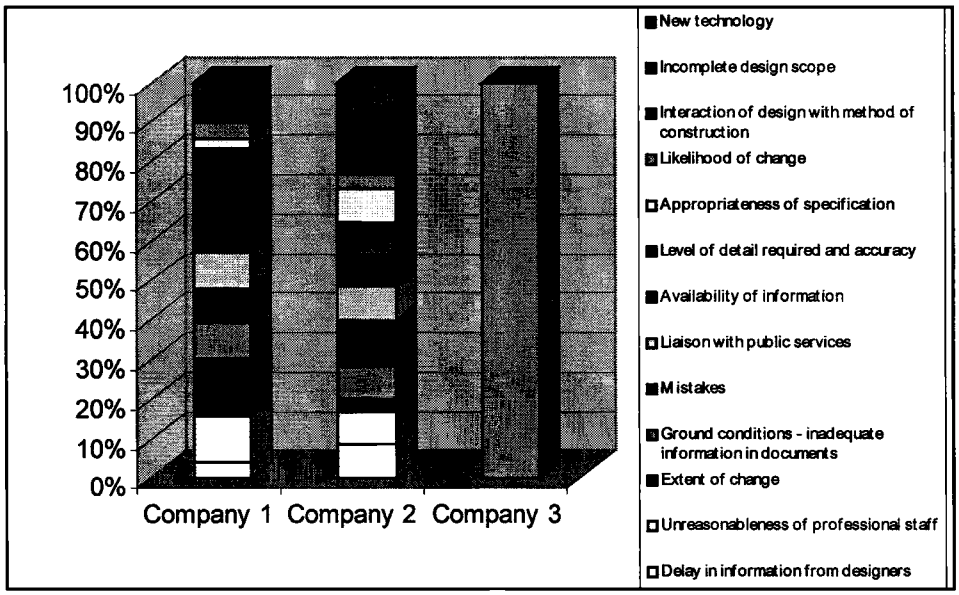
Figure 1: Construction risks Breakdown



The above figure compares the responses of three companies in the quantification of construction risk factors. The response of company three is worth mentioning, mainly because they are able to control all the factors and manage them except the one factor that is weather and hence allowed 20 days as the most likely delay in time for the project. This value is in between the projections of the other two companies. Company one projected most likely delay of 75 days and company two projected a most likely delay of 10 days. Weather is the only risk factor in the construction phase that the company three has allowed for amongst all the construction risks. The other risk factor in construction phase that company three has mentioned is 4 days delay due to industrial action for which the other two companies did not mention or allow for as a likely delay risk factor.

3.3 Comparison of breakdown of design risks

Figure 2: Design Risks Breakdown



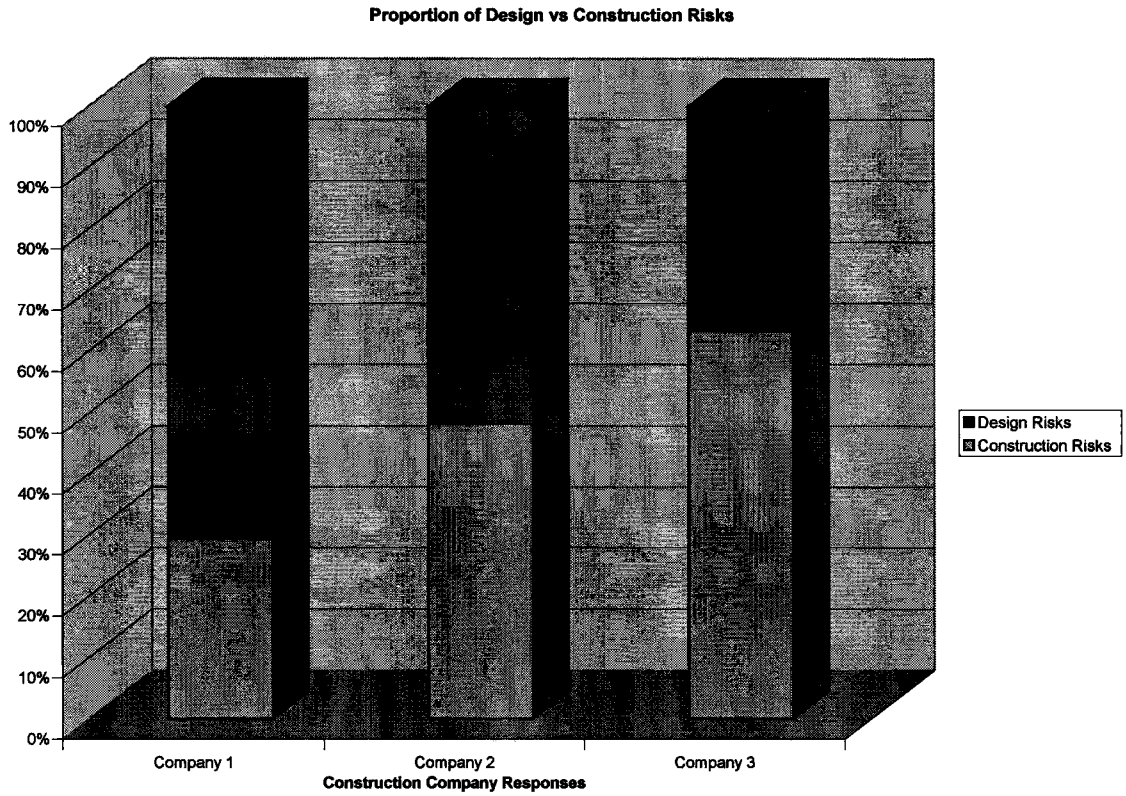
The figures 1 & 2 present the breakdown in terms of proportions for construction risks and design risks by the three companies. The company three's response to design risks is remarkably different to that of one and two. The only design risk that the company three feels may delay the project would clients provide inadequate information in documents i.e. the reports. That is the only risk factor out of the design risk factors that this contractor was not able to manage and hence projects a delay of 14 days in the most likely scenario. The company controls all the other risks and no allowance has been made for delay due to particular situations.

Thus, the responses of the three companies show either there is lack of knowledge on the part of first and second companies in the quantification of risk factors, or there is over confidence on the part of company three in ignoring all the risks apart from the inadequate information provided by the client and weather conditions that are obviously beyond their control.

3.4 Design Risks

The three bars in figure 3 (that are based on three responding companies) for design related risks as a percentage of total risks associated are 67%, 52% and 37% that are additional business risks due to the new procurement system. These bars represent the calculations of company 1,2, and 3 of medium sized, medium to large sized and large sized contractors respectively. The company 3 has the best infrastructure, technology, and training and has a strong risk management culture and above all has the highest D&C project experience amongst the three companies. This company has the highest chance of generating value from this project. The value adding will lead to better profits than the traditional form of procurement.

Figure 3: Proportion of design vs construction risks based on company experience



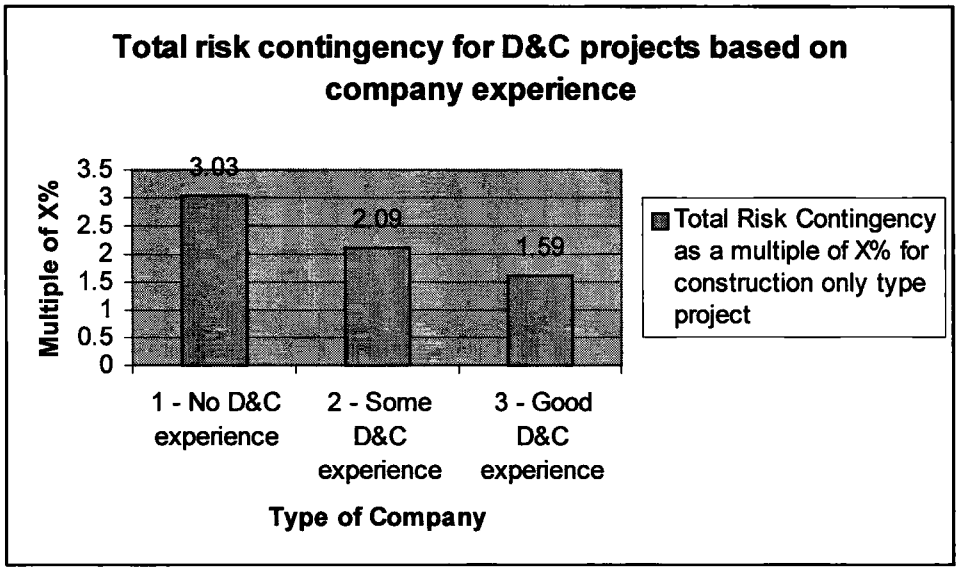
The figure 3 showing the breakdown of design and construction risks in terms of possibility of total time delay shows that company 1 with no design experience has worked out 67% of the total risks being design risks and remaining 33% being construction risks. Since the project still has to be constructed as part of the contract, the risks that are relevant to the fixed price lump sum tender are still relevant. **Assuming that normally in that fixed price lump sum construction only contract the risk contingency would have been X% and just due to the lack of knowledge and experience in the design field and included in the project the company has such high proportion** ie. twice the size of the normal construction risks. It will thus make the company risk contingency **3.03X%** or close to it in case of a D&C project and as such will render the bid uncompetitive in most cases. This clearly represents the risks and the multiplication factor of three for the risk contingency with the change in procurement systems.

The response of company two with some experience on design and construction type projects comes with 52% of the total risks being for design risk. This means in case the same project was construction only type project, and the risk contingency X% was allowed by the contractor, with the design function in view of the additional risks the above calculation make the risk contingency for the D&C project equal to **2.08X%**.

The response for company three with reasonable design and construction experience on more than one project. The design risks proportion representing 37% of the total risks involved with the project. This represents that the construction risks represent 63% of the risk. In case the project was lump sum type contract, the construction risk would have been the total risks assuming that the contractor normally uses an X% for total risk contingency. The responses suggest that the contractor has quantified that the additional role in D&C type adds

approximately half the construction risks and therefore the contractor will charge **1.59X%** for the risk contingency.

Figure 4: Risk contingency for D&C projects based on company experience



The results clearly indicate that the experience of a company enables it to develop a culture of D&C type procurement and generally in non-traditional procurement systems within the company. The organisational culture to learn and to improve boosts up the company with the technology, communication systems and infrastructure to manage design and construction. With experience and improvisations the company sets up procedures and processes to manage D&C type projects. The investment in technology and processes will lead to the D&C projects becoming manageable and enables it to adopt a balanced and competitive approach towards D&C projects. All these factors lead to reduction in risk contingency factor to be added to the basic costs. It is evident from the above figure that experience and knowledge in the area, makes the company so confident that the risk factor descends from 3.03 to 2.09, which is no doubt dramatic in view of its limited experience. Again, with further improvements in the fields of the knowledge and processes within the company, the risk factor further declines from 2.09 to 1.59. It can however be asserted that the risk factor will never go below to 1 that implies that the risks are same as the traditional construction only project. It may sound practical in view of the additional risks involved in the process.

The research shows that the company 3 with good knowledge of D&C has an edge in increasing their expectation of profit by 0.5X% (ie. the difference between the company 3 and company 2 risk contingency = 2.09 - 1.59 = 0.5) and still be competitive price wise. The point may be remembered that the company is so much better prepared to handle such a project that the company could go even higher and still come out of the presentation and submission as a winning bid. The client will be confident that this company could deliver the goods and hence go for this company in terms of value for money and other subjective factors i.e. organisational culture, preparedness towards risk events, communication systems, experience and infrastructure in handling the project technically and technologically. The client will most definitely be getting a better product as a result of this company being awarded the project.

Based on the bid price the company has a competitive advantage and could easily beat the competition based on the price because they have superior risk handling systems and strategies in place within the company. This is based on the assumption that all the companies have same basic cost on the project and have similar profit expectations. This is however, not true in real life as the companies will arrive at different design and hence the costs will not be the same. The purpose of this research was to bring out the difference in risk handling processes and its link to the experience of the company in executing non-traditional procurement systems.

It can thus, be asserted that the research suggests that the company have to develop a culture, procedure, and technology to support D&C type projects within the company. The profile of staff within the company will also require a rethink as not all construction managers may have expertise in design management. Organisational learning has a role to play in the reduction of the risks and hence reduction in the overall risks perception, which for a risk-averse business strategy is a critical component.

3.4 Discussion of research results

Risk management is a process that construction companies are aware of and choose not to move into more sophisticated methodology as the industry does not appreciate and take notice of the methodology. The bottom line is still important to clients and effort in risk management of the project is not rewarded. Subjective factors like documentation and the availability of information is still lacking on the part of the clients as described by the contractors.

The project based risk management study in isolation does not mean much as the risk management plan is only complete with an all-important aspect of corporate risk assessment study. The corporate risk assessment is a combination of objective and subjective factors. Issues like workload is fairly objective, but working relation with the client is very subjective. Yet all these factors combined contribute to the final tender price, which includes the base price and a reasonable assessment of the conditions, workload, project risk to come up with a final price.

The results for the use of information technology in risk assessment and estimating practice generally point to the fact that the contractors have embraced the technology. There has been a marked improvement in the use of databases etc. by contractors between 1995 pilot survey and the 1998 stage 1 survey (Bajaj & Lenard, 1999).

The results of the experience of the contractors on construction project in the previous stage survey indicate that most of them are making profit with or without the project being documented appropriately and accurately by the client or their representatives. The results are significant in terms of the innovation, as the contractors do not have to be ahead in technology and still make money. This shows that the results on projects are more dependent on the economic conditions that have been fairly good for sometime now in Sydney as compared to any other factor. Obviously mistakes on the part of the contractor should be taken into account.

Thus it becomes obvious that the use of subjective judgement in risk quantification is much more important than any other method. This goes on to show that any methodology without the use of subjective assessment will not be successful.

Based on the results in the paper where the case study project is described and analysed and reported, the three-company comparison is presented in table 6 below.

Table 6: Comparison of analysis

Company Code	Years in Operation	Turnover of the company	Ranking based on risk contingency allowance
Company 1	2 years	$30 m	3.03X% (Highest risk allowance)
Company 2	25 years	$125 m	2.59X% (Middle risk allowance)
Company 3	52 years	$1 bn	1.59X% (Lowest risk allowance)

4. Conclusion

The research found that contractors are aware of the impact of different types of procurement systems on their risk exposure. The fact that contractors carry an additional business risk under the design and construction procurement method is a further important finding of this research. This additional business risk can be as high as 50% of the total risk for design and construct projects. Specific individual characteristics of the contractors surveyed play a significant role affecting the size of the project risk contingency, which tends to fall as knowledge and experience of contractors improves. The contingency factor was measured to be 3.03 times the contingency factor for contractors engaged on traditionally procured projects, declining to 2.59 times where contractors had some experience with the design and construct procurement method, and further dropping to 1.59 times of the normal contingency for contractors with strong design and construct experience. The resulting curve between the experience of the contractor and the contingency amount for the project suggests an exponential relationship between the two variables, but there are not enough points on the curve to statistically prove that from this research. It could be a hypothesis for the further research in the area.

It was also found that contractors have varying expectations of profit, depending on company characteristics. These expectations vary with economic condition and need to obtain the contractor's work. The direction of the adjustment was found to be in line with the bidding theory, even though the extent of change was different for each contractor. Based on the research, it is recommended that contractors need to develop a culture conducive to the application of systematic risk management, as well as adopting procedures and technologies capable of supporting design and construction type projects.

The findings of this research provide a useful contribution in defining a model which can be used for implementing risk management in the bidding stage of projects, which is necessary not only for the survival of contractors in the construction industry, but for their growth and increased profitability. It also advances knowledge in contractor decision-making and identifies opportunities for future research.

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