BID-PRICE VARIABILITY
IN THE
SRI LANKAN CONSTRUCTION INDUSTRY

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Summary

The purpose of this study is to examine the bid-price variability in construction tenders and the project variables that would give rise to variability. This topic is interesting because the bid-price variability reflects market inefficiency and business strategies.

An efficient market results in small fluctuations around an equilibrium price. The equilibrium price is fair for both the client and contractor. Large price variability reflects a high level of inefficiency in the market. Thus, the intent of this study is to determine the key project variables that give rise to the bid-price variability in the Sri Lankan construction industry.

The research is designed as a regression model. An information survey was conducted among contractors and consultants in February – May 2004 to obtain the data on bids from 64 projects. Of these, data from 62 projects were usable in the regression model.

The study finds that bid prices follow a symmetrical bell-shaped distribution with few high-end outliers. This shows a higher randomness of bids than general perception. The average variability measured by the coefficient of variation is approximately 16%. These findings highlight the possible existence of large winner's curses in the Sri Lankan construction industry.

The current literature reveals six project variables that can affect the bid-price variability. The analysis shows that only three projects variables have significant impact on variability. These are quality of tender documents, level of prequalification requirements, and level of minimum grading requirement. The tendering method, the number of bidders for a project, and the bid duration have no influence on the bid-price variability.

The findings suggest that the quality of the tender documents and high levels of prequalification are major sources of bid-price variability. Steps should be taken to improve the information content of tender documents and less stringent but appropriate prequalification criteria should be used.

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Abbreviations and Variables

BOO	Build Own Operate – a procurement method
BOT	Build Operate Transfer – a procurement method
BQ	Bills of Quantities
CPI	Coordinated Project Information
CV	Coefficient of variation
CAWS	Common Arrangement of Work Sections
D	Bid duration
G	Minimum grading requirement
H	Level of prequalification requirements
ICTAD	Institute for Construction Training and Development (Sri Lanka)
LDC	Less-developed country
M	Tendering method
M1…M6	Contractor grading given by ICTAD
N	Number of competitors
P	Bid price
Q	Quality of tender documents
γ	Percentage winning-margin
λ	Winning-margin

CHAPTER 1: INTRODUCTION

The purpose of this study is to examine bid-price variability in construction tenders and the project variables that give rise to variability in the Sri Lankan construction industry. This topic is interesting because bid-price variability reflects market inefficiency. This is because bid prices are partly based on information available to bidders, and partly on business strategy. These two aspects are interrelated since business strategies are formulated on the basis of information.

1.1 Background

Tendering is the most common method of price discovery in construction project procurement. Most construction clients favour competitive bidding (Murdoch and Hughes, 1992; Dawood, 1994; Holt *et al.*, 1995). It is believed that competitive bidding gives the client value for money through free and fair competition (Trickey, 1982; Lingard and Hughes, 1998). Contracts are usually awarded to the lowest bidder (Merna and Smith, 1990). Awarding the contract to the lowest bidder is usually practised in the public sector particularly because of its greater accountability (Rankin *et al.*, 1996; Turner, 1979). Many private clients also award contracts to the lowest bidder for cost reasons. Therefore, the lowest bidder is typically the price setter.

The lowest bid may come from a firm that badly under-estimates the cost of the project (McCaffer and Pettitt, 1976). There is evidence that large winner's curses exist in construction (Dyer and Kagel, 1996). Hence, some contracts carry losses to contractors. This is detrimental for the industry for at least two reasons. First, some firms may become insolvent or they could abandon the contract (Holt *et al*., 1995). Second, firms may adopt illegitimate survival strategies. They may divert funds from other projects, make numerous claims to receive extra payments, or breach the contract.

A low price is not always favourable for the client, either. The lowest price is not the most competitive price when it is an underbid or an opportunistic bid. An adverse selection of a contractor generates high risk of losses to the client through eventual claims and disputes. In addition, it results in poor quality and time overruns that are again costs to the client (Ho and Liu, 2004; Lingard and Hughes, 1998; Kumaraswamy and Yogeswaran, 1998; Crowley and Hancher, 1995; Zack Jr., 1993). For example, an unwarranted delay in completion postpones the time of return of investment.

An efficient market results in small fluctuations around an equilibrium price (Varian, 1993; Quayle *et al*., 1994). The equilibrium price is considered to be "fair" for both the client and contractor. From this informational perspective, large price variability reflects a high level of inefficiency in the market, and both parties tend to incur high transaction costs to discover prices. Thus, it is worthwhile to investigate the causes of the price variability in construction projects. Although the construction industry is often labelled as "competitive" in the sense that there are a large number of buyers and sellers, it may not be efficient in the information sense. Imperfect information leads to departures from equilibrium as well as market failure. The two well-known problems are adverse selection and moral hazard. The former leads to risky contractors bidding for projects, and the latter can lead to contractors who may be less careful after contracts have been awarded, on the grounds that some form of insurance has been provided.

Historically, the factors that affect bid pricing are identified through empirical methods such as opinion surveys. These methods lack theoretical bases. As a result, a relatively large number of factors are put forward as variables that affect pricing decisions (Liu and Ling, 2005; Wanous *et al*., 2000; Fayek, 1998; Sash, 1993; Ahmad and Minkarah, 1988). For example, in two distinct studies, Wanous *et al.* (2000) found 38 factors, while Fayek (1998) reported 93 factors that affect tender pricing decisions in the construction industry. All these factors cannot be the basis for price decisions. Indeed, these factors may have been considered by bidders in differing combinations and weights, and in different contexts. For example, factors that are important during a recession may not as important when tenders are carried out during a boom. Further, small and large firms may have different considerations when bidding for construction work.

In the well-known "bidding theory" in Construction Economics, it is assumed that a bid is based on an estimated cost plus a mark-up, and success is determined by a fixed probability distribution of competitors' bids (Friedman, 1956; Gates, 1960; Park, 1979; Park and Chapin, 1992). The mark-up fluctuates in tenders with the business cycle and also depends on factors such as the size of the project and the structure of the industry. During the recession, construction contracts are limited and firms tend to reduce their mark-ups. Conversely, during a boom, contractors tend to raise their mark-ups. Mark-ups as a percentage tend to be lower for larger projects because of the bigger absolute dollar value.

The bid-price variability in the Singapore construction industry has previously been studied by Goh (1992), Betts and Brown (1992), and Li and Low (1986). There were many studies done in Europe, USA and Middle East (Gates, 1967; McCaffer and Pettitt, 1976; Beeston, 1983; Ahmad and Minkarah, 1988; Park and Chapin, 1992; Drew and Skitmore, 1997; Rawlinson and Raftery, 1997; Holt and Proverbs, 2001; and Skitmore and Lo, 2002). An extensive study in a less developed country (LDC) such as Sri Lanka is interesting because the construction market is likely to be less efficient than that of developed countries. Thus, bid-price variability is likely to be higher. In addition, since bid-price variability may reflect perceived project risk, large variations are detrimental to the development of the construction industry. By studying the project variables that affect such perceived risks, it is hoped that efforts may be made to reduce project risks and allow both owners and contractors to better manage their projects.

1.2 Research problem

The construction industry requires an efficient market where risk is well managed and resources are efficiently allocated for its growth. The sources of bid-price variability in Sri Lankan construction industry are not yet studied. An extensive study on bid-price variability is interesting because bid-price variability reflects market inefficiency.

Market inefficiency is largely a result of information and cost inefficiencies. Numerous factors with economic, political, social and technological roots contribute to these sources. Some project variables such as the quality of tender documents and bid duration may also contribute to market inefficiency. This study focuses on such project variables primarily because for industry stakeholders, these variables are far easier to control than socio-political factors.

1.3 Objectives

The objectives of this study are:

- To understand the general distribution of bid prices in the Sri Lankan construction industry as an indicator of market inefficiency as well as perceived risk, and
- To determine the key project variables that give rise to bid-price variability.

Understanding the general characteristics of the bid distribution is an essential first step in interpreting the relationships between bid-price variability and project variables. Therefore, it is a prerequisite and complementary to the second objective which is the main purpose of this study. Unlike descriptive studies, there is no attempt to develop a long shopping list of factors. Hence, only the key project variables are of concern in this study.

1.4 Scope of research

As aforementioned, the study focuses on discerning key project variables that cause bid-price variability. Economic, political, and social variables, while undoubtedly important, are excluded because of their complex relationships with bid-price variability and difficulties in measuring their impacts. Industry and firm level variables such as the number of firms in the industry and business strategies are also considered exogenous and are not explicitly analysed in this study. This is because it is not easy to quantify strategic behaviour or attribute project-level bid variability to industry level influences.

The study is based on the Sri Lankan construction industry and projects tendered in 2003 and the first quarter of 2004. All types of projects are considered, including residential, commercial, and infrastructural projects. No attempt is made to categorise projects by type on the assumption that information inefficiencies are fairly generic. To be sure, there are some differences in bidding behaviour across project types, but analyzing bid-price variability in each project type differently would result in very small samples.

1.5 Organisation of the report

Chapter 1 gives the introduction. Chapter 2 presents a three-part literature review. The first part reviews measures of bid-price variability. The second part explores the early descriptive studies in bid-price variability. In the last part, key project variables that can affect bid-price variability are reviewed. The chapter concludes with a research hypothesis.

Chapter 3 describes the research methodology. It starts with a brief background to the Sri Lankan construction industry to facilitate understanding of the research methodology. A regression model is selected to study the relationships between the dependent and independent variables. The chapter then delineates the adopted sampling method based on stratified sampling on a sample of 62 projects, the methods of data collection based on interviews and project document study, and data processing.

The data is analysed in Chapter 4. The general distribution of bid prices is first studied using descriptive statistics. This is followed by a regression analysis of the data and examination of the residuals for departures against normality and other ordinary least squares assumptions.

Finally, Chapter 5 summarizes the work and presents the contributions and practical implications. It concludes the study with key recommendations for practitioners and researchers.

CHAPTER 2: LITERATURE REVIEW

This chapter first reviews the measures of bid-price distribution and some of the descriptive studies in construction bid-price distribution. It then reviews the causes of bid-price variability and concludes with a research hypothesis.

2.1 Bid price distribution

2.1.1 Measures of bid distribution

Measures of bid price distribution include the bid price range, the inter-quartile range, the standard deviation of the price distribution, the variance of the price distribution, the coefficient of variation of the price distribution and the winning-margin (Beeston, 1983; Dahlby and West, 1986; Park and Chaplin, 1992). They differ by the level of emphasis given to the two key characteristics of the distribution: dispersion and central tendency.

2.1.1.1 Bid price range

Bid price range is defined as the difference between the lowest and the highest bid. For the purpose of mathematical representation, a project with n bids sorted in ascending order as $P_0, P_1, P_2, ..., P_{n-1}$ is assumed. Then, the bid price range is given by

(2.1) $$R = P_{n-1} - P_0$$

where R is the statistical range, P_{n-1} is the highest bid and P_0 is the lowest bid. The bid price range (R) is a useful measure to visualize the variability of bid prices for a proposed construction project. To compare the bid-price variability of projects of different sizes, the percentage bid range (r) is more appropriate. It is given by

(2.2) $$r = \left(\frac{P_{n-1} - P_0}{P_0}\right)(100\%).$$

It may be seen that the range is defined using only the lowest and highest values. It disregards the rest of the bids (and hence not a "sufficient statistic") and an extreme bid (either very high or very low) can distort the "real" distribution of bids (Beeston, 1983). Therefore, the bid price range is not used as a measure of price distribution in most studies. It is also not used in this study.

2.1.1.2 Inter-quartile range

The inter-quartile range (IQR) is the difference between the scores of the third quartile and the first quartile. A quartile is one of the four divisions of observations which have been grouped into four equal-sized sets based on their statistical rank. The quartile including the top statistically ranked members is called the first quartile and denoted as Q_1. The other quartiles are similarly denoted as Q_2, Q_3, and Q_4. The inter-quartile range is defined as

(2.3) $$IQR = Q_3 - Q_1.$$

IQR is not susceptible to the impact of extreme values. Therefore, it addresses the limitation found in using the bid price range. However, it uses only the rank and quartile scores rather than each individual score and therefore does not fully utilise the information in the sample. It is therefore not a sufficient statistic.

2.1.1.3 Standard deviation and variance

The sample variance (s^2) is the second central moment and is given by

(2.4) $$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(P_i - \overline{P}\right)^2$$

where n is the number of bids, P_i is the i^{th} bid and $\overline{P}$ is the mean bid. The sample in our context is the bids for the proposed project. Unlike the inter-quartile range, s^2 uses all the price information in the sample and is therefore a sufficient statistic. However, the measure is less appropriate in comparing the bid price distributions of projects that differ in size because it is an absolute value.

2.1.1.4 Coefficient of Variation

The coefficient of variation takes into account both the dispersion and the size of project. It is given by

(2.5) $$CV = \left(\frac{s}{\overline{P}}\right)(100\%)$$

where CV is the coefficient of variation, s is the standard deviation of the bid prices of the project and $\overline{P}$ is the average bid of the project. An undefined CV does not occur in Equation (2.5) as the mean bid is not equal to zero. Therefore, the coefficient of variation is an appropriate measure of the variability of bid prices that takes both dispersion and the project size into account.

2.1.1.5 Winning margin

The "winning-margin" (λ) is the difference between the lowest and second lowest bids. The "percentage winning-margin" (γ) is the ratio of λ to the lowest bid. These can be mathematically represented by

(2.6) $$\lambda = (P_0 - P_1) \text{, and}$$

(2.7) $$\gamma = \left(\frac{\lambda}{P_0}\right)(100\%)$$

where P_0 is the lowest bid and P_1 is the second lowest bid. The winning-margin is a popular measure of bid-price variability. Since contracts are typically awarded to the lowest bidder, the winning-margin is a useful measure of the level of competition in the local construction industry.

Some scholars define the winning-margin as the "spread" (Park and Chaplin, 1992), "bid-spread" or the "money left on the table" (Gates, 1960). Nonetheless, the term "spread" has been used in a different context by Rawlinson and Raftery (1997) to explain the difference between any two bids of concern (in contrast to only the lowest and the second lowest bids). The term "spread" has also been used to represent the difference between the lowest and highest bid, the lowest and mean bid, and the lowest and second lowest bids. In order to avoid confusion, this study uses the term winning-margin throughout.

2.1.1.6 Winner's curse

The winning-margin (λ) is often referred to as the "winner's curse" (Thaler, 1992). The winner's curse story begins with Capen, Clapp, and Campbell (1971). They claimed that oil companies had suffered unexpected low rates of return in the 1960's and 1970's on Outer Continental Shelf lease sales. They argue that these low rates of return resulted from the fact that winning bidders ignore the information on consequences of winning. That is, bidders naively based their bids on the unconditional expected value of the item (their own estimates of value) which, although correct on average, ignores the fact that you only win when your estimate happens to be the highest of those who are competing for the item. But winning against a number of rivals following similar bidding strategies implies that your estimate is an overestimate of the value of the lease conditional on the event of winning. Unless this effect is accounted for in formulating a bidding strategy, it will result in winning a contract that produces below normal or even negative profits. The systematic failure to account for this adverse effect is commonly referred to as winner's curse: you win, you lose money, and you curse (Kagel and Levin, 2002).

The reason why some researchers use the term "winner's curse" in the place of winning-margin is that it is obviously a "forgone profit" as the winner could have bid one dollar less than the second lowest bid and still won the contract. This is why sealed bids are typically used in construction projects so that bidders do not have access to how competitors will bid for the project. Such an arrangement benefits the client. For instance, if there are three bidders (A, B and C) and their reserved bids are $10.0m, $11.0m, and $12.0m respectively, then contractor A would bid $10.9m in an open bidding system (assuming bids are in decrements of $0.1m) compared to $10m in a sealed bid.

2.1.2 Studies of bids distribution

2.1.2.1 Early Studies

Early studies that model bid price distributions are based on learning experience. These bidding models are used as decision support tools by contractors to determine bid prices. The first model was introduced by Friedman (1956) and further developed by Gates (1967). They both asserted that the probability of winning a tender can be roughly estimated from previous bidding encounters. Such models are based primarily on mark-ups; the higher the level of mark-up, the lower is the probability of success. Firms learn about the elasticity of this empirical relationship through their bidding experience.

Since mark-ups depend on many factors and vary with the business cycle, it is difficult to develop a stable relationship between mark-ups and the probability of winning a contract. Thus, these early models are limited in their usefulness, and are no longer used.

2.1.2.2 Skewed distribution attributed to errors in bids

One of the earliest studies that focused on the distribution of construction bids is the work by McCaffer and Pettitt (1976). They tested the bid distribution from a sample of 535 public works (roads and buildings) contracts and concluded that they are normally distributed.

Skitmore *et al*. (2001) found that outliers were responsible for a positively skewed bid distribution. This is because bidders who want to win the tender estimate carefully and bid low. Their bids tend to be close to each other, resulting in a skewed distribution (Figure 2.1).

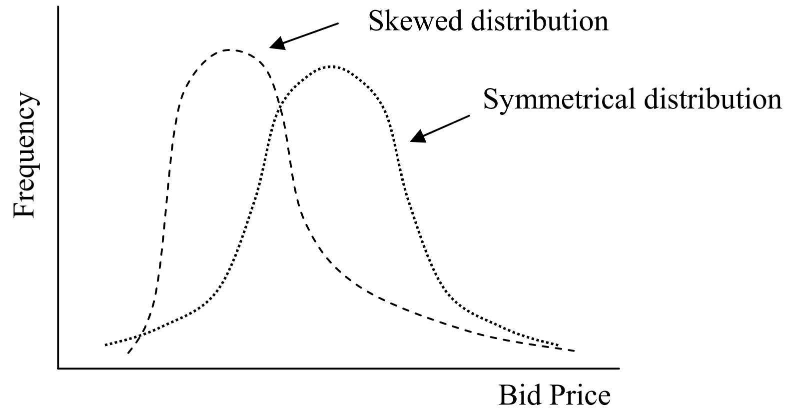

Figure 2.1 Normal and skewed distribution of bid prices

Beeston (1983) suggested that estimation errors are the major cause of bid-price deviations. A skewed distribution implies estimating errors are relatively low for most bidders since there are few outliers. Chapman *et al*. (2000) also emphasised the impact of uncertainty of cost estimates in bids. Kaka and Price (1993) also suggested that bidders would arrive at different prices for the same project due to estimation errors. Lange and Mills (1979) referred to "ever present" mistakes. However, van Der Muelen and Money (1984) likened tendering to a game of darts, suggesting random distribution of estimation errors, and Gates (1977) called it "the game of the greater fool" (see Runeson and Skitmore, 1999). Since the "greater fool" is the one who stands to lose most, this implies a winning bid is erroneous, a costly mistake that makes the winner a fool.

While these arguments may not be plausible rational propositions, they all emphasise how badly bidders suffer from errors in their estimates. There are three types of errors, namely

- random errors,
- systematic errors, and
- blunders.

The literature does not clearly pinpoint the types of errors found in construction bids. However, a combination of these three types in varying degrees can be expected to exist.

Random errors are statistical in nature and occur with certain probability. They occur due to chance variation in the process. Many studies in various disciplines such as engineering, business and economics assume that random errors are normally distributed. This assumption has empirical as well as statistical bases. It is well known that the sum of variables is likely to be normally distributed even if each variable is not a normal variate. It is also theoretically advantageous to assume that errors are normally distributed so that they can be modelled statistically.

Systematic errors are unusually unintended biases in basic prices and in the schedule of rates that lead to estimated values being consistently too high or too low. However, experienced construction firms tend to have smaller biases than newer firms as they learn from previous tenders. Unlike physical measurements, systematic biases in tender estimates cannot be calibrated with high precision because there is no such thing as the “true” bid. The winning bid is merely the bid that wins the contract. It is neither true nor false.

A blunder is typically attributable to faulty perception, misinterpretation of tender documents, arithmetic mistakes, carelessness, poor communication among estimators, and shortcuts (Thomas, 1991). Unlike random and systematic errors, blunders can be quite large such as having the incorrect decimal point in rates or quantities.

2.1.2.3 Pricing problems

Apart from errors, bid-price variability may also be caused by different mark-ups for the rate of profit. In theory, the percentage of mark-up varies with the business cycle, level of competition, and business strategy. During a downturn when tenders are scarce and competition is fierce, mark-ups tend to be lower. Conversely, during a boom, firms tend to raise their mark-ups. In some industries, the level of mark-up is used to penetrate new markets, limit the entry of new competitors (by using low mark-ups), establish price leadership in cartels or monopolies, and weed out weak competitors that do not have staying power (McAleese, 2001). However, predatory pricing can only be a short-term strategy; in the long run, a firm must pay attention to its rate of profit.

2.1.2.4 Empirical studies

Several studies report variability in tender bids in different markets (Table 2.1). In general, the price variability in Singapore seems to be larger than that of the UK and USA. The reasons for such variability are discussed below.

Table 2.1 Empirical studies on *CV* and percentage winning margin

Country	CV	Percentage winning margin	Type of work	Author
US, UK	5-9%	-	Most types	Beeson (1983)
UK	-	6%	Industrial refurbishment projects	Teo (1990)
Singapore	2-25%	4%	Public industrial projects	Goh (1992)
Singapore	-	12%	Public sector projects	Betts and Brown (1992)

2.2 Causes of bid-price variability

As aforementioned, the variability in bid prices has largely been attributed to **errors** and **pricing strategies** in the construction literature. Several other factors need to be considered, and these are discussed below.

2.2.1 Cost differences

If firms have different **cost** structures, bid prices will vary even with the same level of mark-up. Cost or productivity differences may arise from economies of scale and learning economies.

2.2.1.1 Economies of scale

Economies of scale occur when unit cost falls as output increases, that is, at *different* levels of output. This is the familiar U-shaped average cost curve depicted in standard neoclassical economics textbooks (Binger and Hoffman, 1998). The construction of mass public housing in many countries is an example of perceived economies of scale in housing construction. For small projects, economies of scale are less likely to occur. However, as the project size gets too large, diseconomies of scale sets in. These diseconomies are due primarily to increasing cost of inputs and greater complexity of organization and project management.

2.2.1.2 Learning economies

Learning economies arise when firms become more efficient at the *same* level of output and technology because of accumulated experience. A simple example is using word-processing software where a person becomes more proficient over time through learning. Learning by doing was first reported by Wright (1936) in his study of airframe production. Since then, such learning economies have been widely documented in many industries (Arrow, 1962; Yelle, 1979; Argote and Epple 1990; Bahk and Gort, 1993; Al-Mutawa, 1996).

However, Tan and Elias (2000) found that learning by doing was minimal in the Singapore construction industry. This is attributed to the temporary nature of construction projects and the team nature of production where each individual is a specialist, making learning difficult. There are also many institutional constraints to learning such as immigration laws that forbid foreign workers from working for more than a number of years. The cyclical nature of the building industry also impedes learning; during a recession, many construction workers leave the industry and never to return when the boom gets underway.

For this study, two project variables were used to capture cost differences. They are:

- minimum grading requirement (*G*); and
- level of prequalification requirement (*H*).

The minimum grading requirement (*G*) is a regulatory screen to ensure that contractors are able to carry out the work. It is a proxy for project size and, hence, scale economies.

The application of prequalification requirements *H* (in addition to the grading requirement) is to assess the experience of a potential contractor in projects of similar nature. Thus, it captures the learning economies of bidders.

2.2.2 Inefficient Information

As discussed in 2.1.2 (b), the bid-price variability can largely be attributed to errors in bids. If arithmetic errors are set aside, inefficiency of information becomes the key source of errors in bids. In a construction tender, a bidder requires two types of information, namely,

- information on proposed project, and
- information on market for the proposed project.

2.2.2.1 Information on proposed project

The major portion of the information on the proposed project is provided by the client through tender documents. A complete tender document includes

- Instruction for bidders,
- Form of contract,
- Bill of quantities,
- General and supplementary conditions,
- Drawings,

- Specifications, and
- Addenda (if any).

Any additional information required is obtained through site visits, pre-tender meetings, direct enquiries, and sometimes through informal networks.

The existence of imperfections and asymmetries in this information can cause variability in both estimates and mark-ups. For example, the information in Bills of Quantities, drawings, and specifications may contradict or are unclear. This provides avenues for misinterpretation and, consciously or unconsciously, variable pricing.

2.2.2.2 Information on market for the proposed project

The information on the market is basically the pricing information, and is generally not specific to the project. A bidder needs information on the business cycles, level of competition, and business strategies of other bidders to decide on his own mark-up. Firms have access to publicly available information on the general construction market. They also maintain their own set of private information about the market. This information is developed through in-house analysis or obtained from external sources.

In this study, the level of the information inefficiency is represented by two project variables. They are

- quality of tender documents (Q), and
- bid duration (D).

The variable Q captures to what extent the project information is imperfect, and the level of information asymmetry between client and bidders.

The bid duration (*D*) is the time given for bidders to work their bids out. Bid duration limits the time available for bidders to search for additional information and analyse the available information.

None of the two variables capture the effect of insider information being available to any bidder. Insider information is not publicly available, and they create information asymmetries among bidders. The leaking of insider information is difficult to trace, and this explains the paucity of work in this area.

2.2.3 Risk

Differences in mark-ups may also be attributed to differing risk perceptions on the part of bidders. It is well known that, when confronted with risks, individuals may not be rational (in the sense of making consistent choices) because of uncertainties surrounding the outcome (Tversky and Kahneman, 1987).

However, even if individuals are consistent, construction projects are saddled with many risks including (Cappen *et al.*, 1971; Dey *et al*., 1994; Charoenngam and Chien-Yuan, 1998):

- market risk;
- financial risk;
- technical risk;
- acts-of-God (accidents);
- payment risk;
- legal risks;

- labour disputes; and
- societal and political risks.

These risks are briefly discussed below.

2.2.3.1 Market risk

Market risk refers to changes or shifts in demand and supply that result in a project being scaled down or abandoned either because prices have fallen or demand has fallen.

2.2.3.2 Financial risk

Financial risks refer primarily to movements in interest rates and exchange rates. Changing interest rates affect the cost of capital as well as inflationary expectations that affect work effort because of money illusion, i.e., the perception of changes in real wages (Lucas, 1972). Non-price terms are just as important and they include items such as escrow accounts, terms of loans, origination fees, prepayment penalties, and price indexing of the principal. The inability to raise funds and cover debt service (from operating income) may also plague contractors, as are unreasonable retention.

2.2.3.3 Technical risk

Technical risks refer to construction related risks. A shift from an originally perceived scope of work affects the costs of inputs because of changes in methods and plan of work. Technical risks are partially predictable. For example, incomplete tender drawings warn about late drawings and instructions during the post-contract period.

Nevertheless, some risks such as unexpected subsoil conditions, shortage of quality material and design defects may not be unpredictable.

2.2.3.4 Acts-of-God risks

Acts-of-God risks refer to instances of uncontrollable natural forces such as floods, earthquakes, and disease. Accidents at sites may also be attributed to Acts-of-God and affect construction costs through disruption and physical damage.

2.2.3.5 Payment risk

Payment risks refer to both delay and decline of due payments. These occur due to change order negotiations, delay in dispute resolution, or default of client. Insolvency of either party to contract is also a risk in this category. A declined payment carries a direct loss to contractor, while a delay in payment affects cash flow. As contracting is largely a cash flow business, any disruption in cash flow can have serious cost implications.

2.2.3.6 Legal risks

In a construction project, the main legal risk arises from contractual problems such as defects, liability, payment, and dispute resolution. Apart from uncertainties pertaining to enforcement, legal risks also arise from uncertainties in existing legislation and unanticipated new legislation.

2.2.3.7 Labour disputes

Labour disputes, such as strikes and other union actions hinder the performance of work. The risks involved are disruption and sometimes physical damages, and they add to cost.

2.2.3.8 Societal and political risks

Pressure from society such as demands for environmental protection and other regulatory requirements can stall a project. Public disorders such as riots and armed struggles also have negative impacts on work efforts.

Political risks arise from the actions of the State and politicians. This may include arbitrary confiscation, corruption, and not honouring agreements entered into by the previous government.

Different perceptions of risks and responses cause variability in prices. A bidder who is risk-averse tends to bid a higher value than what is desirable so that he does not get the contract at a low offer. A risk-loving bidder is likely to bid lower to increase the chances of winning the contract. Finally, the risk-neutral bidder is indifferent about the outcome in a fair bet.

In this study, the quality of tender documents (Q) is used as a measure of project risk and contractual documents are tools for managing risk. In other words, only legal, financial, and technical risks are captured.

2.2.4 Competition

Differences in the mark-up may also be a result of differences in the nature of competition. In neoclassical economics, competition is studied in terms of market structure, that is, the number of firms in the industry. This is related to the number of bidders for a project (*N*) as well as the tendering method (*M*) which limits the number of bidders to a pre-selected list of contractors. *M* is a dummy variable which measures if tenders are "open" or "selective". Open tenders are open to any contractor who becomes eligible to bid for the project under the prevailing standards and regulations in the industry. Selective tenders are not open to public; only a selected list of contractors is invited for bidding. These contractors are usually pre-selected due to client's preference or their track records.

Baumol (1982) has argued that even if there are few firms in the industry, the threat of *potential* competition of new firms may be sufficient to keep existing firms from slacking. In other words, markets are "contested" and, for this reason, the number of competitors may not be an adequate measure of the level of competition or an explanation of variability on bid prices. This, of course, is an empirical question which this study hopes to unravel.

From a Marxian perspective (Marx, 1859), the level of competition is not limited to the number of firms as well. Firms compete in various forms such as in the materials input market, labour market, financial market, and internationally. The Porter's (1990) diamond is also a model of competitive analysis based on competitors, suppliers, customers, and other stakeholders.

2.3 Hypothesis

From the literature review, two statistical measures (*CV* and percentage winning-margin (γ) were identified to characterize the bid-price variability of construction tenders. Six project variables were selected as potential sources of bid-price variability (Figure 2.2). They are

G, the minimum grading required (ICTAD),

N, the number of bidders,

Q, the quality of tender documents,

D, the bid duration,

M, the tendering method (open/pre-qualify), and

H, the level of prequalification requirements.

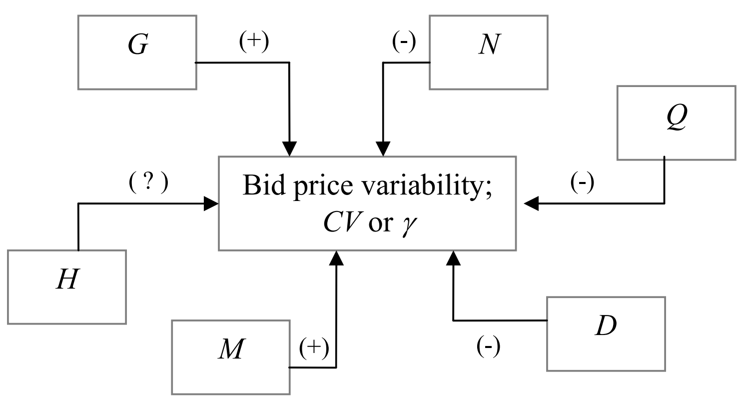

Figure 2.2 Hypothesis

Only a firm with a higher grading (recall that *G* = 1 is the highest grade) can tender for larger projects. Therefore, the bid-price variability should become relatively smaller for larger projects (i.e. for smaller values for *G*). Since larger *N* represents higher competition, a negative relationship between dependent variable and *N* is expected. As the quality of tender documents (*Q*) rises, the bid-price variability is likely to fall because the information available for bidders becomes efficient. Bid Duration (*D*) limits the time available for bidders to search for additional information and analyse the information available. Therefore, lower *D* would lead to higher bid-price variability. Tendering method (*M*) is a dummy variable to capture if the tenders are open or selective. If the bidders are pre-selected, the competition is low and bid-price variability tends to be high. Similarly, a higher level of *H* reduces the level of competition and would give rise to bid-price variability. On the other hand, a high *H* would qualify only the contractors with greater experience. Since, experience reduces the pricing errors; it would result in low variability in prices. Thus, it is stated that the theoretical direction of *H* is unknown.

CHAPTER 3: RESEARCH METHODOLOGY

This chapter presents the research methodology. Some background on the Sri Lankan construction industry is required to fully understand the research design. Consequently, the background is first presented, and this is followed by an outline of the research methodology used in this study.

3.1 Background

3.1.1 The Sri Lankan political, economic and social landscape

Sri Lanka is a republic. The legal system is based on a complex mixture of English common-law and Roman-Dutch, Kandyan (in central region), Thesawalamai (in north), Muslim, and customary law.

3.1.1.1 Political history

The island was ruled by a strong native dynasty from the 12th century, but was successively dominated by the Portuguese, Dutch, and British from the 16th century and finally annexed by the British in 1815. A Commonwealth State since 1948, the country became an independent republic in 1972.

Sri Lanka has a multiparty democracy. The United National Party (UNP) elected in 1977 governed the country for 17 years. In 1978, a major constitutional amendment was introduced by UNP to create an executive presidency. The executive president, elected for six-year term, is the Chief of State, Head of Government, and Commander-in-Chief for the armed forces. The legislative body is a unicameral 225-member Parliament. In 1985, R. Premadasa became the Prime Minister of the first executive President J. R. Jayewardene's cabinet. In 1989, R. Premadasa became the next president but fell a victim of a separatist suicide bomber in 1993. A coalition, the Peoples' Alliance (PA), led by the opposition Sri Lanka Freedom Party (SLFP), won the next presidential and parliament elections in 1994. In 2001, the United National Front (UNF, a UNP-led coalition) won the majority of parliamentary seats. Chandrika Kumaratunga remains as President. This result of having the Prime Minister and President from opposing parties led to political strains. This came to a head in 2004 when the President dissolved the UNP parliament. SLFP and Janatha Vimukthi Peramuna (JVP), also known as the People's Liberation Front (a Marxist group), formed the United People's Freedom Alliance (UPFA). UPFA was able to form a new government after the subsequent parliamentary election.

3.1.1.2 Ethnic conflict

Since independence, the Tamil minority has been uneasy with the country's unitary form of government. By the mid-1970s, Tamil politicians were moving from support for federalism to a demand for a separate Tamil State.

In 1983, the death of 13 Sinhalese soldiers at the hands of the Liberation Tigers of Tamil Eelam (LTTE, a separatists group) unleashed the largest outburst of communal violence in the country's history. The north and east became the scene of bloodshed as security forces attempted to suppress the LTTE and other militant groups. Terrorist incidents occurred in Colombo and other cities. Bombings directed against politicians and civilians were common. The conflict continued until 2001 amid a few unsuccessful attempts to negotiate for peace. In December 2001, the newly elected UNP government and the LTTE declared unilateral cease-fires and jointly agreed on a cease-fire accord in February 2002. Both parties continue to observe it at the time of writing.

3.1.1.3 Economy

The key natural resources in the island are limestone, graphite, mineral sands, gems, and phosphate. Textiles and garments, food and beverages, insurance and banking, and telecommunications are the largest sectors in the economy. The largest export market is United States, and was US$ 1.8 billion in 2003 (Central Bank of Sri Lanka, 2005). The leading suppliers to the country are India, Japan, Hong Kong, Singapore, Taiwan and South Korea.

Since achieving political autonomy, the development strategies of Sri Lanka have swayed between socialist and capitalist ideals. Prior to 1978, the State assumed the central role in allocating resources and steering the economic development of the country (Lakshman, 1997). Sri Lanka is highly dependent on foreign assistance; in 2003, a total of US$4.5 billion has been pledged for Sri Lanka in an aid conference in Tokyo.

Since 1978, the country has been steadily opening up to market forces. The State encourages private sector investment in developing commercial infrastructure facilities such as port services, electricity and telecommunication projects, highways, and industrial towns (ICTAD and Choy, 2004). Several economic reforms also took place and, as a result, Sri Lanka managed to achieve an average real GDP growth rate of about 5% over 1991-2003. During this period, inflation grew by about 9% per year (Figure 3.1). Overall, real economic growth managed to lower the unemployment rate to about 8% in the early 2000s.

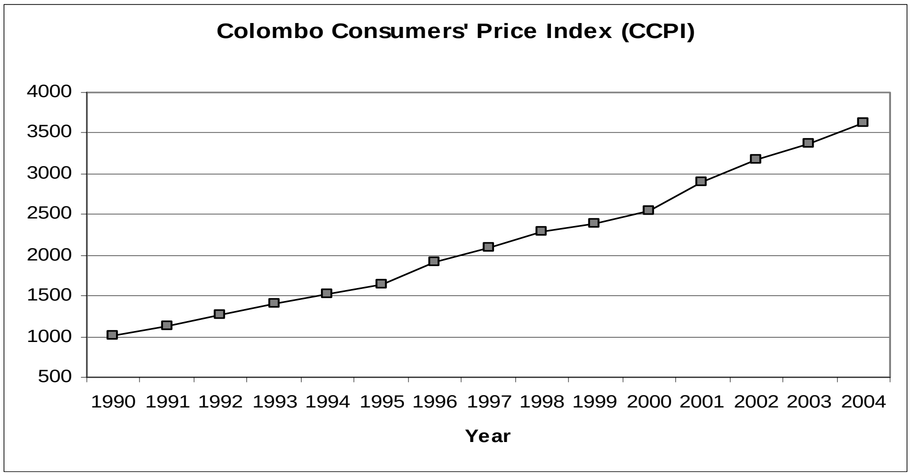

Figure 3.1 Colombo Consumers' Price Index
Source: Department of Census and Statistics (2005)

Table 3.1 provides data on external trade and finance. The current account balance has been negative and narrowing. Over the same period, the exchange rate has depreciated substantially against the US dollar.

Table 3.1 External Trade and Finance

Indicator	1990	1999	2000	2001	2002	2003
EXTERNAL TRADE (percentage change)						
Terms of trade	-12.5	-5.0	-6.1	-1.7	4.6	7.4
Export unit value index (1997 = 100)	9.1	-8.5	1.5	-5.2	-4.1	5.5
Import unit value index (1997 = 100)	24.7	-3.5	8.1	-3.6	-8.3	-1.8
EXTERNAL FINANCE (US$m)						
Current account balance	-377	-563	-1,066	-215	-237	-101
Current account balance (per cent of GDP)	-4.7	-3.6	-6.4	-1.4	-1.4	-0.6
EXCHANGE RATES						
Rs./US$ (Annual average)	40.06	70.39	75.78	89.36	95.66	96.52

Source: Central Bank of Sri Lanka (2005)

3.1.1.4 Social Landscape

The current population of Sri Lanka is about 19.4 million and it grows by about 1.3% per year. The population density is highest in the southwest where Colombo, the country's main port and industrial centre, is located. Sri Lanka is ethnically, linguistically, and religiously diverse.

Sinhalese make up 74% of the population and are concentrated in south, west, and central parts of the country. Ceylon Tamils, citizens whose South Indian ancestors have lived on the island for centuries, total about 12% and live predominantly in the north and east. Indian Tamils represent about 5% of the population. The British brought them to Sri Lanka in the 19th century as tea and rubber plantation workers, and they remain concentrated in and around the tea plantations in south-central Sri Lanka. Muslims (both Moors and Malays) make up about 7% of the population. Burghers who are descendants of European colonists (principally from the Netherlands and the United Kingdom) and aboriginal Veddahs constitute the remaining 1% (Department of Census and Statistics, 2005).

Most Sinhalese are Buddhists, and most Tamils are Hindus. The majority of Sri Lanka's Muslims practise Sunni Islam. Sizable minorities of both Sinhalese and Tamils are Christians, most of whom are Roman Catholic.

Sinhala, the native language of Sinhalese, and Tamil are official languages of the country. The use of English has decline since independence, but it continues to be spoken by the middle and upper classes, particularly in Colombo. Many private organizations such as banks use English as the working language. The government is seeking to promote the use of English, mainly for economic reasons.

Education is compulsory up to age of 14 years. A 96.5% of school attendance is recorded in this age group in year 2003 (Department of Census and Statistics, 2005). The country's literacy rate is 91% and is the highest compared to other LDCs in South Asia. The life expectancy is 71 years for males, and 76 years for females.

3.1.2 The construction industry of Sri Lanka

3.1.2.1 Construction output

The construction sector contributed about 7% to GDP and approximately 50 - 55% of gross domestic capital formation over the past decade. The sector has been continuously growing (see Figure 3.2) at an average rate of 5% per annum.

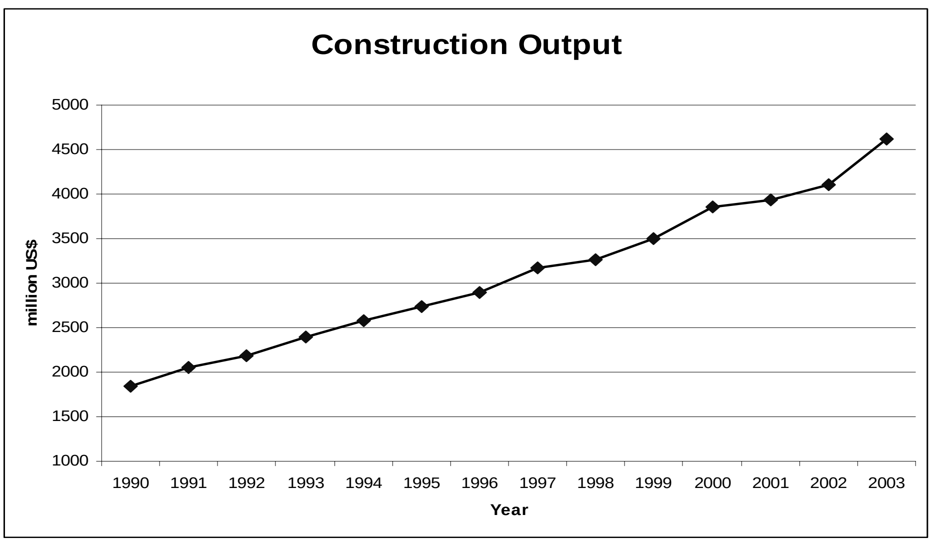

Figure 3.2 Construction output (US$m)
Source: Compiled from Department of Census and Statistics (2005), and Economist Intelligence Unit (2005).

In 2003, the construction output was approximately US$ 4.6 billion. The growth pattern closely follows that of the GDP growth (Figure 3.3).

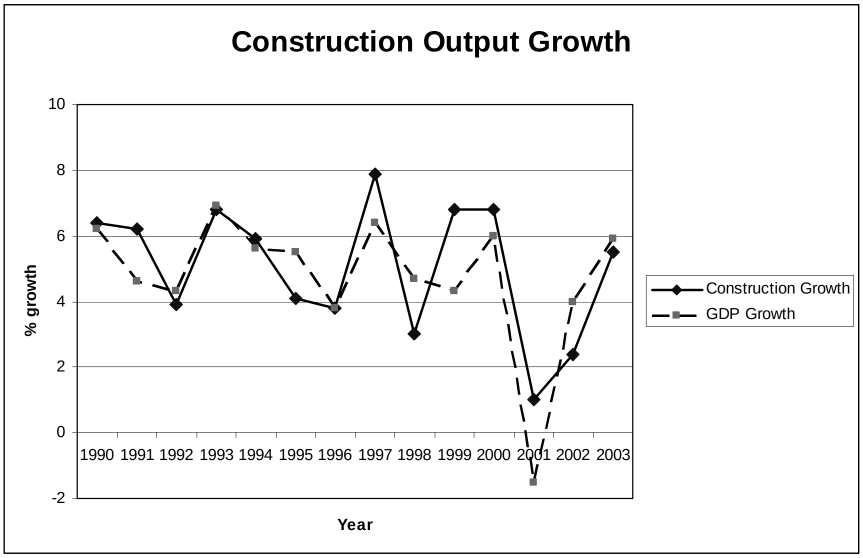

Figure 3.3 Construction output growth
Source: Compiled from Department of Census and Statistics (2005), and Economist Intelligence Unit (2005).

3.1.2.2 Work force

In 2003, the direct employment of construction workers was around 290,000 or 4.4% of the total employment of the country. About 97% are male workers. If the labour force in the building materials industry and building maintenance works are included, the construction industry employs approximately 10% of the total workforce of the country (Ganesan, 2000).

The education system is efficient in producing professional, technical, and skilled workforce to cater to industry needs. There are three universities producing about 900 engineering graduates per year (est. 2004). More than half of these graduates are qualified to work in construction and related fields (such as mechanical and electrical works). About 250 of them are specialized in Civil Engineering. In addition, the University of Moratuwa produces 50 Architecture and 50 Quantity Surveying graduates per year. The university also offers a National Diploma in

Technology, a three-year full time programme, adding about 100 skilled technical staff to the construction industry. Another equally skilled 120 is added to this by the Technicians Training Institute managed by the National Apprentice and Industrial Training Authority (NAITA). There are 37 technical colleges island-wide that enrol about 13,000 (est. 2002) students per year. There are many other public and private institutes producing qualified workers for the construction industry (Department of Census and Statistics, 2005; Central Bank of Sri Lanka, 2005).

Thus, Sri Lanka has a highly skilled construction labour force. However, their availability for the local construction industry is sometimes limited by the heightened overseas demand, particularly from the Middle East. Therefore, the industry faces a shortage of skilled labour, especially during booms.

As shown in Figure 3.4, nominal wages have risen by about two to three times during the late 1990s. However, real wages have remained largely constant over the same period.

Figure 3.4 Labour wages.
Source: ICTAD and Choy (2004).

3.1.2.3 Construction cost

Although construction costs have roughly doubled over the last decade (Figure 3.5), it has actually declined in real terms. As we have seen, real wages have remained largely constant while worker skills have improved. Consequently, productivity has been improving and this is partly responsible for declining construction costs.

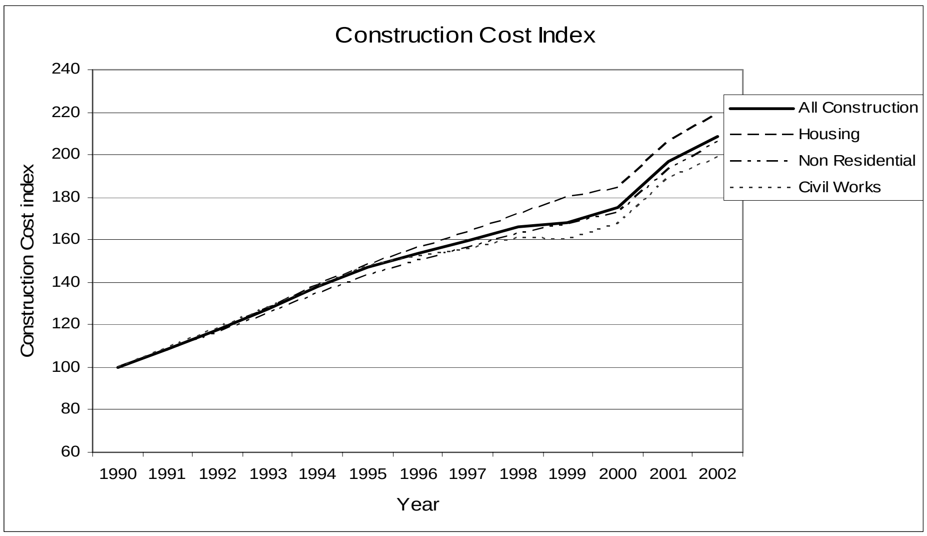

Figure 3.5 Construction cost index
Source: Department of Census and Statistics (2005).

The cost of energy (Figure 3.6) has continued to rise faster than the Colombo CPI (compare with Figure 3.1) largely because Sri Lanka is a net energy importer, particularly oil. Apart from cost, hydroelectric power faces intermittent disruption and this creates some cost uncertainties for contractors.

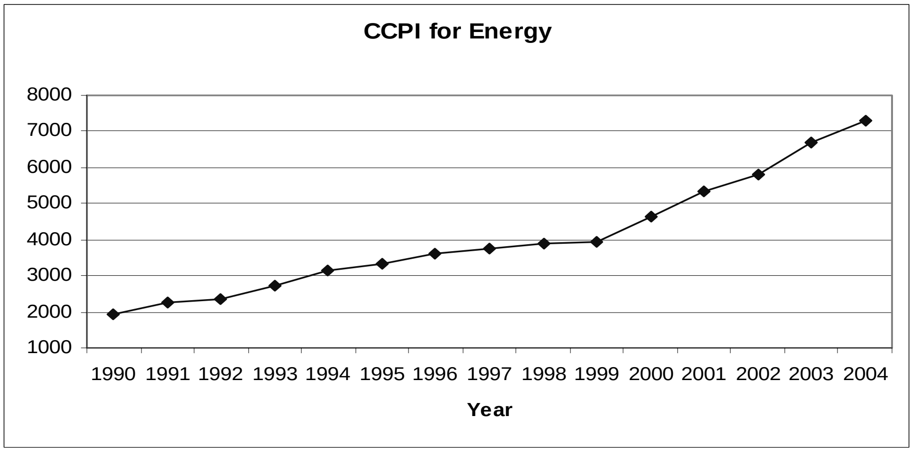

Figure 3.6 CCPI for Energy
Source: Department of Census and Statistics (2005)

3.1.2.4 Capital

The norm for mobilization advance payment equals to 30% of the contract sum. Under the standard conditions of contract, a contractor is entitled for the payment of 20% upon submission of performance bond and a work programme on how the advance payment is utilized. Another two payments of 5% each will follow in subsequent months. The repayment begins only after the contractor's monthly claim exceeds 30% of contract sum (ICTAD, 2002). The amounts are deducted from each monthly payment proportionately. This practice minimizes the contractors' capital requirement to start a new project. Since the repayment is also on monthly basis, the capital is not a major problem provided payments are made on time and in full. Progress payment delays are not uncommon.

Almost all medium and large contractors utilize bank overdraft facility when necessary. The maximum limit and interest rate vary with the reputation of contractor with the bank. Over the past five years, interest rates on overdrafts tend to vary between 6 to 36%. Small contractors usually obtain mortgage loans from banks for their capital requirements. Figure 3.7 shows that there has not been a significant change in interest charged on mortgage loans in recent years. As aforementioned, the capital required for a contractor in Sri Lanka is comparatively lower than other countries where the advance payment is low or zero.

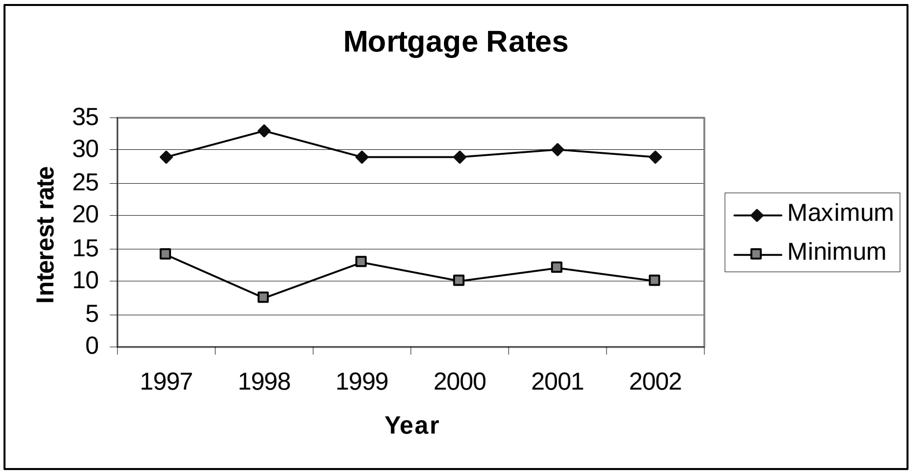

Figure 3.7 Commercial bank mortgage rates
Source: Central Bank of Sri Lanka (2005)

The State-owned Private Sector Infrastructure Development Company (PSIDC) provides long-term loans to clients for infrastructure projects. PSIDC supplements the usual commercial sources for financing large projects. PSIDC loans can fund up to 40 per cent of the total project cost and loan maturity is decided on a case-by-case basis for up to 22 years. Sri Lanka has a fully developed commercial banking system consisting of about 26 commercial banks. Two of the large commercial banks, which have an extensive network of branches in all parts of Sri Lanka, are public banks. In addition, there are four private local banks. All foreign commercial banks in Sri Lanka have operational services in Colombo.

3.1.2.5 Materials

Building materials account for 50% to 60% of the total cost of a building. Materials from smaller industries constitute an important share of this expenditure. With the growth of construction industry, the production of construction materials has increased significantly in recent times (Ganesan, 2000).

The building materials industry in Sri Lanka suffers from several problems including

- lack of adequate production,
- high cost of production and transport, and
- poor quality of materials.

In particular, the price of sand has increased sharply over the last few years (see Figure 3.8).

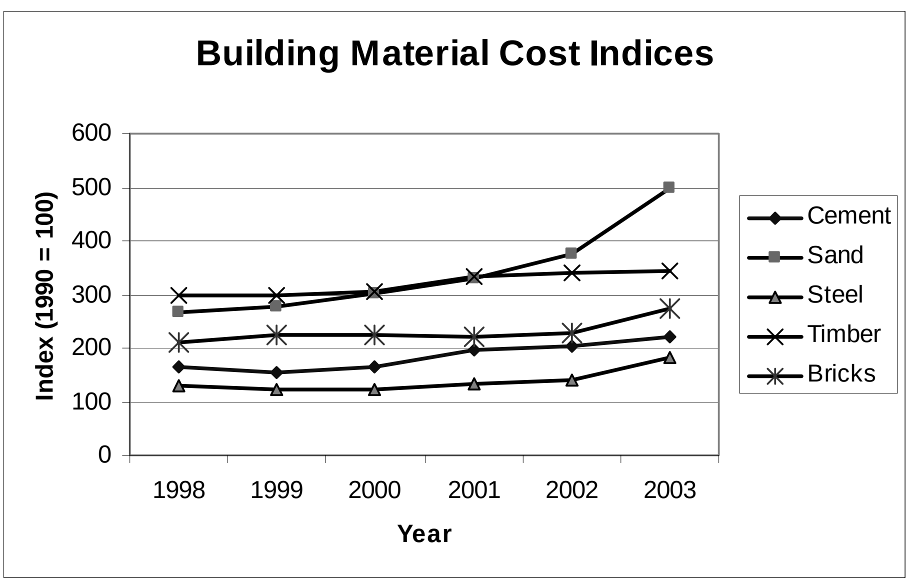

Figure 3.8 Building material cost indices
Source: ICTAD (2004)

3.1.2.6 Structure of the industry

The Sri Lankan construction industry is characterised by a large number of small firms and a small number of large firms. According to the revised national registration and grading system for contractors, the total number of registered main contractors by end of 2003 was 1620 (in all grades: M1 – M10).

Table 3.2 shows the number of registered contractors in each grade from M1 to M6 and the maximum value of single contract they may be awarded. Grades are given to contractors according to ability and fields of speciality to ensure that they do not undertake jobs beyond their capabilities.

Table 3.2 ICTAD Registered contractors

Category	Number of Contractors	Maximum Contract Sum Million Rupees	Maximum Contract Sum US$ '000
M1	20	300	3,045
M2	17	150	1,523
M3	33	50	508
M4	68	20	203
M5	123	10	102
M6	186	5	51

Source: ICTAD (2003)

3.1.2.7 Institutions

Institutions refer to the organisations, rules and practices that exist in the industry. The key institutions are outlined below.

Organizations

ICTAD

In 1981, the government established Construction Industry Training Project (CITP), which was subsequently renamed the Institute of Construction Training and Development (ICTAD) in 1986. ICTAD is the central authority on construction industry operations in Sri Lanka. Its emphasis has shifted from producer to facilitator and it is now involved in several facets such as industry development, registration of contractors and consultants, and development of conditions and other standards for the industry (Jayawardena and Gunawardena, 1998).

NCCASL

The National Construction Contractors Association of Sri Lanka (NCCASL) is the only association of contractors recognized by the State. Currently, it has over 2000 members. Some small contractors registered with NCCASL are not registered under ICTAD.

Other organisations

As mentioned earlier, PSIDC was established in 1995 to provide long-term loans to sponsors of infrastructure projects.

There are many other institutes setting standards, promoting construction sector development, and conducting research while acting as large clients to the construction industry. Examples include the Urban Development Authority (UDA), Road Development Authority (RDA), Buildings Department, and Ceylon Electricity Board (CEB).

Rules and practices

The Sri Lankan construction industry follows most of the British standards and guidelines. Although there are number of options available, only the conventional Standard Method of Measurement is used to prepare and price the Bills of Quantities (BQs). Even with contracts that do not demand the presence of a BQ (e.g. turn-key and design and build contracts), an internal BQ is prepared for management of work (Kodikara and McCaffer, 1993).

Most projects follow the traditional procurement method, while design-and-build (D&B) contracts have also gained popularity. With the State incentives for infrastructure development projects, non-traditional procurement methods such as Build-Operate-Transfer (BOT) and Build-Own-Operate (BOO) are also becoming popular.

Project managers are slowly replacing architects as the leader of the project team in Sri Lanka. Increasingly, modern techniques of management are applied to meet stringent deadlines within budget.

The contractor is entitled to claim for 80% of value of materials on site in addition to his work done in his monthly claim. Under the general conditions of contract, the maximum duration is 30 days to receive the payment after the submission of a duly prepared claim.

The claim procedure for variations is similar to other international standards such as the International Federation of Consulting Engineers (FIDIC) and the Institute of Civil Engineers (ICE). In the event of disagreement of valuation of such variations, the consultant shall fix a price as in his opinion, is reasonable and proper. This is stated in the contract.

Nominated sub-contractors are common for medium and large projects. Usually, sub-contractors for mechanical, air-conditioning, electrical, and glazing are nominated by clients.

3.2 Research design

The study is based on a regression model. This design is chosen because the objective of the study is to establish the relationship between bid-price variability and project variables. Figure 3.9 maps out the research methodology.

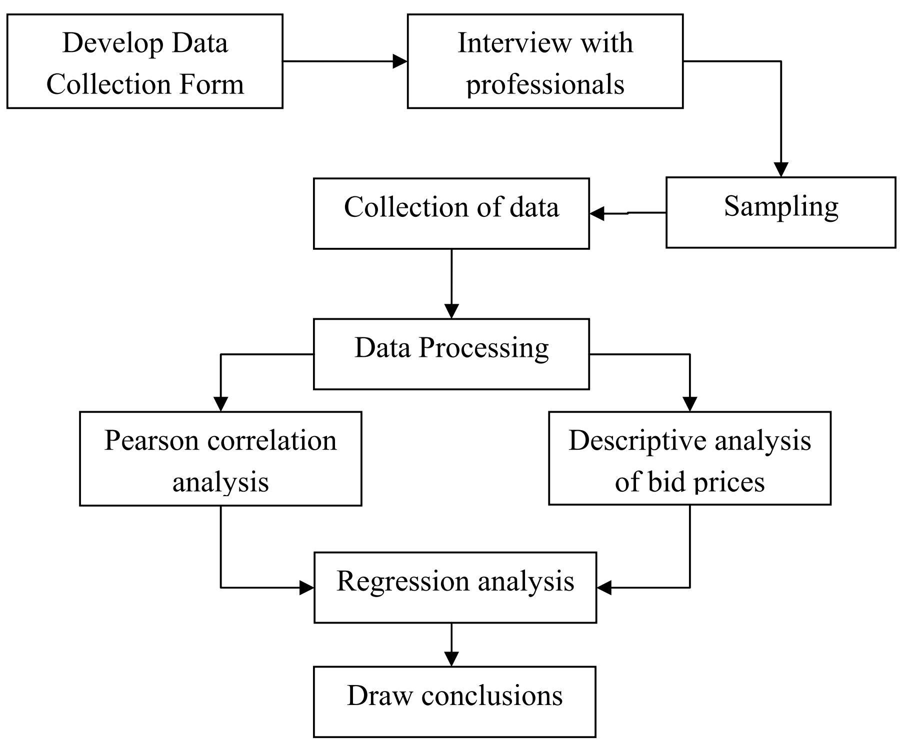

Figure 3.9 Research methodology

For convenience, the rest of the chapter does not necessarily follow the flow of this diagram. Instead, it flows through several sections which comprehensively discuss the research design and how it was put into practice.

3.3 Sampling

3.3.1 Population

The sampling population is all construction projects in Sri Lanka which were tendered between 2003 and 2004 Q1, and categorised M6 or above. The reasons for choosing the above periods are:

- There was no significant change in commercial bank lending rates during this period, and
- Interviewees felt that it would be difficult to provide satisfactory information on projects tendered more than one year ago.

Limiting the category to M6 and above sets the smallest project to be included in the sample to be larger than 5 million Sri Lankan Rupees (approximately SGD 0.08 million). Project categories below M6 are too small to provide reliable estimates of the relationships between bid-price variability and the independent variables. This is because sufficient information from such projects is difficult to obtain or is unavailable.

3.3.2 Sampling frame

A sampling frame is not used in this study because information on construction projects is difficult to obtain. Therefore, any project with accessible information is selected for the sample. However, bias is reduced by having a large number of projects from various firms.

3.3.3 Sampling method and responses

Projects are classified under three categories based on size. The minimum grading requirement is used as the base for this categorisation as illustrated in Table 3.3. The largest contract into which a contractor in each category shall enter was given in Table 3.2 earlier in this chapter. The contract limit and minimum grading requirement differ in definition and application. The highest contract sum is limited for the contractor by the registered grading while a minimum grading requirement for eligible bidders is specified by the client at the time of calling for bids.

Table 3.3 Project size category according to the minimum grading requirement

Project size category	Grading	Number of projects	Percentage
Large	M1 & M2	10	16
Medium	M3 & M4	31	50
Small	M5 & M6	21	34
		62	100

Since the minimum grading requirement is set based on the Engineer's Estimate (EE) or the client's budget, it is appropriate as a measure of the project size. A stratified sample based on Table 3.3 is used to minimize the probability of obtaining a sample biased towards one or two project size categories. It can be seen that there are relatively fewer large projects in the sample of 62 projects. A total of 73 projects were initially targeted but only 62 projects had sufficient information to allow estimation using regression analysis. For the descriptive analysis, data from 64 projects were usable because only the dependent variable needs to be analyzed.

3.3.4 Sample size

It can be seen from Table 3.3 that the sample size was 62, and this is deemed to be sufficient for a regression analysis with six independent variables.

3.4 Variables

From the literature review, six project variables are possible sources of price variability. From interviews with industry professionals, 14 additional variables were identified. The variables are discussed below.

3.4.1 Minimum ICTAD grading required (*G*)

The National Registration and Grading of Contractors in Sri Lanka is implemented by ICTAD. A grading is awarded to a contractor on the basis of the capacity to carry out construction work. The grading is expressed as M1, M2, M3, and so on from the largest to the smallest graded firm. The same grading is used by clients when calling for tenders. The minimum grading requirement (*G*) is determined by the client based on his own estimate for the proposed project, and is given in the tender notice or invitation to tender. The numerical figure is used in the regression analysis model. Therefore, smaller values for *G* represent larger projects.

3.4.2 Number of bidders (*N*)

The number of bidders (*N*) is the total number of contractors competing for a project. Therefore, *N* is measured from number of tender documents issued. The number of bids submitted sometimes misrepresents the competition when some contractors do not submit their bids. It is assumed that contractors who obtain tender documents intend to bid and are therefore potential competitors based on our discussion on contestable markets. In the sample, there are only three cases where the number of tender packages issued does not tally with the number of bids received.

3.4.3 Quality of tender documents (*Q*)

The quality of tender documents (*Q*) refers to the completeness and clarity of the information provided in tender documents. A typical tender package consists of (Clough and Sears, 1994):

- Instruction to Bidders,
- Form of Contract,
- Bills of Quantities,
- General and Supplementary Conditions,
- Drawings,
- Specifications, and
- Addenda.

The instructions to bidders provide guidelines on the bidding procedure and interpretation of the tender documents. The form of contract is the specimen of the agreement to be signed if the contract is awarded. This has to be included in the tender documents so that the bidders can understand their possible post-contract commitments.

The bills of quantities (BQ) provide the detailed work to be carried out in the project. It includes all permanent work and a significant part of temporary work. The first section of BQ is the preliminaries, where most of the temporary works are given. It also includes other costs to the contractor such as insurance costs, costs of bonds and guarantees, and costs of obtaining clearance from various authorities. The units and methods of measurement follow accepted standards. Work items are described so that it is clearly understood. Preamble notes are given where necessary. The general conditions of a contract set forth the manner and procedures whereby the provisions of the contract are to be implemented according to the accepted practices in the construction industry.

The drawings relate to the architectural, structural, mechanical, electrical, and civil aspects of the project. They show the arrangements, dimensions, construction details, materials, and other information necessary for estimating and construction. A high quality set of tender drawings is complete, intelligible, accurate, and integrated. Specifications are written instructions concerning the project requirements. The specifications are statements concerning the technical requirements of the project such as materials, workmanship and operating characteristics.

A tender document complete with all above is regarded as of high quality. An example of a poor quality document is one with only an architectural sketch and a BQ with missing critical dimensions.

The quality of tender documents (Q) is measured on a scale from 0 to 5 where 5 represents high quality and 0 represents very poor quality. The rating is given by the author, and it is based on careful examination of the actual tender documents by the author together with contractors' quantity surveyors. The opinions of these quantity surveyors help to reduce the subjectivity of the ratings. Generally, there are few disagreements as the author is also a quantity surveyor and both parties adhere to a list of criteria for assessing the quality of tender documents in a systematic way. The entire tender package (that is, Instruction to Bidders, Form of Contract, Bills of Quantities, General and Supplementary Conditions, Drawings, Specifications, and Addenda) is assessed. It is relatively easy for an experienced quantity surveyor to determine the quality of tender documents. In many cases, documents of poor quality tend to have obvious discrepancies between drawings and BQs, and specifications tend to deviate from industry standard established by ICTAD.

3.4.4 Bid duration (*D*)

The duration given for bidders to prepare their bids is measured in weeks. This is calculated from the difference between the date of tender document issuance and bid closing date.

3.4.5 Tendering method (*M*)

There are two methods of tendering: open and selective. Any registered construction company can bid in open tenders. In the selective tendering process, firms are short-listed and only a limited number is invited to bid. This characteristic is measured as a dummy variable with $M = 0$ for open tenders, and $M = 1$ for selective tenders.

3.4.6 Level of prequalification requirements (*H*)

The level of prequalification requirements is based on track records, financial and capital resources, and expertise. H is measured in a three-point ordinal scale: low, medium, and high.

Each rating was made by a few senior professionals such as quantity surveyors and engineers who participated in the specific tender, and the rating was obtained through an interview. The rating was given relative to the size of the project. For an example, M3 project was rated relative to an average M3 contractor. Generally, a rating is based on track record and capital resources. A high rating was given if extensive track records were stipulated and, as a result, only a few contractors were short-listed in a selective tender. In open tenders, prequalification requirements set down on tender documents were considered for rating. If nothing was specified, a "low" rating was given.

Assigned codes rather than two dummy variables were used in the regression model so as not to reduce the degrees of freedom (Tan, 2004). Although the use of assigned codes implies equal increments, this disadvantage is not serious given that these ratings were based on professional opinions and contain some elements of subjectivity.

3.4.7 Other variables

In addition to the six project variables above that are likely to affect bid prices, 14 other variables were suggested by professionals during the interview (Table 3.4). These variables were first correlated with the dependent variable (*CV*) and, if the correlations are high, they will be included in the regression model. This step is necessary because the degrees of freedom will be low if these 14 variables are initially included in the regression model.

Of the 14 variables, only the first variable, the level of new technology required (*NT*), is based on the ordinal scale. It contains some level of subjectivity because what is "new technology" lacks common understanding. The measures for the other 13 variables are relatively straightforward.

The likely impact of each variable on *CV* is given in the last column of Table 3.4. A positive sign indicates that the variable is likely to lead to higher bid prices, and a negative sign indicates the reverse. A question mark indicates that the direction of impact is unclear.

Table 3.4 Additional independent variables

Independent variable	Description	Measure(s)	Impact on bid prices
NT	Level of new technology required	Ordinal: No, low, medium, and high. (0, 1, 2, 3)	+
CLT	Type of client	Public (= 1) or private client (= 0)	+
TDep	Tender deposit	Value of non-refundable deposit in Rs. ('000)	Minimal
BB	Bid bond	Value of bid bond Rs. (Million)	+
PB	Performance bond	Percentage of contract sum	+
MIns	Minimum 3rd party insurance	In Rs. (Million)	+
MMC	Minimum monthly claim	In Rs. (Million)	?
CnT	Type of contract	ICTAD standard; Yes = 1, No = 0	-
NSB	Nominated subcontractors' work	Percentage of contract sum	?
MP	Maintenance period	In months	+
LDD	Liquated damages per day	As a percentage of contract sum	+
LDL	Liquated damages limit	As a percentage of contract sum	+
PFl	Provision for price fluctuation	Allowed = 1 Not allowed = 0	-
CI	Building cost index	As publish by the ICTAD for the month of bid opening	+

3.5 Methods of data collection

All field data necessary for the study were collected in Sri Lanka. The survey took three months (February – April 2004) during which both the interviews and data collection were carried out.

3.5.1 Interviews

In-depth interviews with experienced professionals were conducted to help to identify the 14 additional variables discussed above, and to discern the practicality of measures selected for all 20 variables. Seven Sri Lankan professionals experienced in bidding were interviewed. The first interviewee was the chairman of a leading quantity surveying firm in Sri Lanka. Being involved in many academic and policy making activities as well, he had an excellent insight of the Sri Lankan construction industry. This was instrumental in having a second interview with him after interviewing six others. The second interviewee was a director of a consultant firm and the third was the manager (contracts) in a grade M1 construction firm. They both were keen on excelling themselves as experts in the field and hence seemed to follow academic literature and conducted some (mostly in-house) research. The fourth interviewee was a director in a consultant firm while having his own construction company. The fifth was a senior quantity surveyor in a M1 construction firm and the sixth interviewee was the chief quantity surveyor of a M2 construction firm. They both were responsible for the bidding process in respective firms. A lecturer in a leading university teaching project procurement was the seventh interviewee. As such, the interviewees were chosen to obtain a balanced input from a wider perspective.

The interviews were semi-structured and generally followed the following steps:

- Screening on the suitability and background of the interviewee;
- Brief self-introduction;
- A brief explanation of the aims and objectives of the study;
- A question on the key project variables that can cause variability in bid-prices;
- A discussion on variables that were not mentioned by the interviewee; and
- A question on practicality of measures proposed to measure each variable.

The questions did not strictly follow the aforementioned order, and variations inevitably occurred. (See Appendix A for sample questions.) Semi-structured interviews gave enough flexibility to make the interviewee express views clearly. There was a second round of informal interviews to gather additional data as required.

3.5.2 Project information

Project information was extracted primarily from project documents. The data were entered into a data collection form (see Appendix B) to ensure that they were complete. The form was structured under three main parts:

- General project information,
- Variables, and
- Bid prices.

General project information consisted of the name of the project, location of the project, date of bid opening, date of project start, names of client, contractor, and consultants, and so on. Variables were subdivided into project variables, contractor variables, client variables and tender variables. Bid prices from various contractors bidding for the project were also collected.

3.6 Data collection and processing

3.6.1 Data collection

Data were collected from February – April 2004 in the offices of the firms discussed earlier in the sampling section. Most of these firms were located in Colombo.

Apart from the data collection form, a tape recorder was kept on standby but was hardly used as the interviewees preferred that the interviews were not recorded.

3.6.2 Data processing

Bid prices of all projects were tabulated as given in Table 3.5. There were 62 projects (i.e. $n = 62$) and number of bidders for each project (m) varied from two to sixteen.

The computed means ($\overline{P}$), standard deviations (s), coefficients of variation (CV), winning-margins (λ) and percentage winning-margins (γ) were then transferred to Table 3.6. The table also contains data on the independent variables (X_k).

shows all the 20 independent variables. Variables selected for regression analysis are given in boldface font.

Table 3.5 Bid prices of different projects

Bid Number	$Project_1$	$Project_2$	…	$Project_i$	…	$Project_n$
1	$P_{1,1}$	$P_{2,1}$	…	$P_{i,1}$	…	$P_{n,1}$
2	$P_{1,2}$	$P_{2,2}$	…	$P_{i,2}$	…	$P_{n,2}$
3	$P_{1,3}$	$P_{2,3}$	…	$P_{i,3}$	…	$P_{n,3}$
…	…	…	…	…	…	…
j	$P_{1,j}$	$P_{2,j}$	…	$P_{i,j}$	…	$P_{n,j}$
…	…	…	…	…	…	…
m	$P_{1,m}$	$P_{2,m}$	…	$P_{i,m}$	…	$P_{n,m}$
Mean	$\overline{P}_1$	$\overline{P}_2$	…	$\overline{P}_i$	…	$\overline{P}_n$
Standard deviation	s_1	S_2	…	s_i	…	s_n
Coefficient of variation	CV_1	CV_2	…	CV_i	…	CV_n
Winning-margin	λ_1	λ_2	…	λ_i	…	λ_n
% Winning-margin	γ_1	γ_2	…	γ_i	…	γ_n

.

Table 3.6 Project variables

Project No.	$\overline{P}$	s	CV	λ	γ	X_1	X_2	X_3	…	X_k	…
1	$\overline{P}_1$	s_1	CV_1	λ_1	γ_1	$X_{1,1}$	$X_{2,1}$	$X_{3,1}$	…	$X_{k,1}$	…
2	$\overline{P}_2$	s_2	CV_2	λ_2	γ_2	$X_{1,2}$	$X_{2,2}$	$X_{3,2}$	…	$X_{k,2}$	…
…	…	…	…	…	…	…	…	…	…	…	…
i	$\overline{P}_i$	s_i	CV_i	λ_i	γ_i	$X_{1,i}$	$X_{2,i}$	$X_{3,i}$	…	$X_{k,i}$	…
…	…	…	…	…	…	…	…	…	…	…	…
n	$\overline{P}_n$	s_n	CV_n	λ_n	γ_n	$X_{1,n}$	$X_{2,n}$	$X_{3,n}$	…	$X_{k,n}$	…

Table 3.7 Independent Variables (X_k)

variable	Description
G	**Minimum ICTAD Grading requirement**
M	**Tendering method**
N	**Number of competitors**
Q	**Quality of tender documents**
D	**Tender duration**
H	**Level of prequalification requirements**
NT	Level of new technology required
CLT	Type of client
TDep	Tender deposit
BB	Bid bond
PB	Performance bond
MIns	Minimum third-party insurance
MMC	Minimum monthly claim
CnT	Type of contract
NSB	Nominated subcontractors' work
MP	Maintenance period
LDD	Liquated damages per day
LDL	Liquated damages limit
PFl	Provision for price fluctuation
CI	Building cost index

CHAPTER 4: DATA ANALYSIS

4.1 Descriptive data analysis

4.1.1 Standard deviation and mean of bid prices

It is of interest to know how bid prices vary with project size proxied by mean bids. All projects were analysed to identify the best fit curve under the following plausible models:

Linear model: $s = \beta_0 + \beta_1(\overline{P})$

Quadratic model: $s = \beta_0 + \beta_1\overline{P} + \beta_2\left(\overline{P}\right)^2$

Cubic model: $s = \beta_0 + \beta_1\overline{P} + \beta_2\left(\overline{P}\right)^2 + \beta_3\left(\overline{P}\right)^3$

Power model: $s = \beta_0\overline{P}^{\beta_1}$

Table 4.1 Curve-fit results

Model	R^2	F	Sigf	β_0	β_1	β_2	β_3
Linear	0.54	73.08	0.000	2.120	0.087		
Quadric	0.62	50.45	0.000	-1.111	0.174	-0.000	
Cubic	0.63	34.22	0.000	0.182	0.118	0.000	-0.000
Power	0.68	129.29	0.000	0.180	0.865		

The power model gives the highest R^2, and it is given by

(4.1) $$\hat{s} = 0.18\left(\overline{P}\right)^{0.865}$$

This model was derived from

(4.2) $$\ln(\hat{s}) = -1.712 + \underset{(\pm 0.076)}{0.865}\ln(\overline{P}).$$

However, β_1 was found to be not significantly different from 1. Under H_0: $\beta_1 = 1$, the test statistic was

$$t = (0.865 - 1)/0.076 = -1.7763\,.$$

The critical t value at 5% level of significance for 62 degrees of freedom is 1.960 and therefore H_0 was not rejected. From (4.1), this implies

(4.3) $$\hat{s} = k\overline{P}$$

where k is a constant. Thus, the standard deviation is proportional to the mean bid or project size.

The result is not unexpected since variability is likely to increase with project size. As a project becomes more complex, information becomes increasingly imperfect, business strategy also becomes more variable, and there are fewer competitors.

4.1.2 General distribution of bids

The major obstacle in modelling the general distribution of bids was that there were not enough bids in any given project to produce a sensible probability distribution. The number of bids per project varied from two to sixteen. Figure 4.1 provides a simple illustration of this limitation. It shows the histograms for two projects having 15 and 12 bids respectively. The distributions appear erratic, and frequencies for certain bid prices were missing.

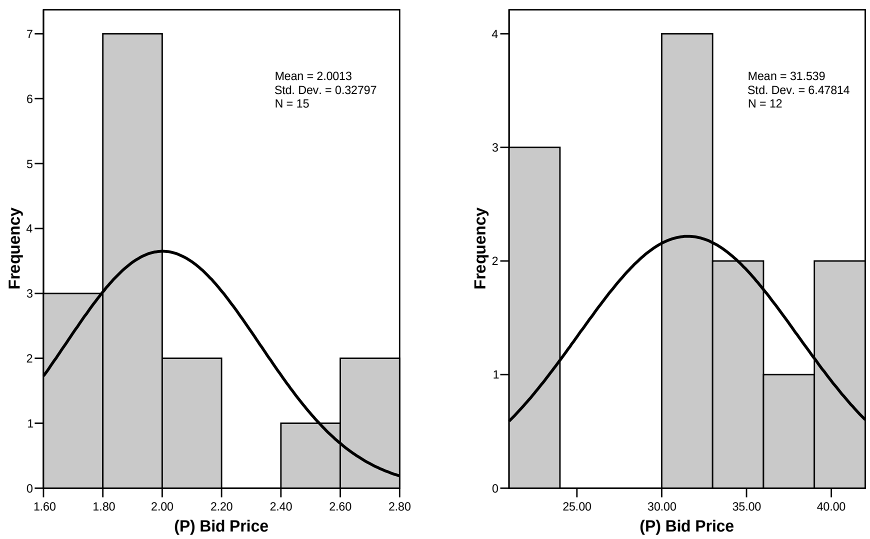

Figure 4.1 Histograms of bid prices

As a result, it is necessary to merge the raw data for all projects. Since raw prices varied substantially across projects, normalization was required.

If standard scores were used, the required transformation for the j^{th} bid in i^{th} project is given by

(4.4) $$Z_{ij} = \frac{P_{ij} - \overline{P}_i}{s_i}$$

where P_{ij} is the original bid price, $\overline{P}_i$ is the mean bid-price and s_i is the standard deviation of bids. The Z score is distributed with zero mean and unit standard deviation. This is undesirable because the standard deviation is fixed at unity.

A better option is to normalize using the following transformation (Beeston, 1983):

(4.5) $$P'_{i,j} = (P_{i,j} / \overline{P}_i)(100\%)\,.$$

If $g(.)$ and $f(.)$ represent densities, then

(4.6) $$g\left(P'_{i,j}\right) = f\left(P_{i,j} / \overline{P}\right) J$$

where J is the Jacobian of the transformation. From (4.5), J = 1/100 so that the transformation scales the density $f\left(P / \overline{P}\right)$ by a factor of 1/100. The important point is that the skewness is not affected. In general, if y is a function of x, then

(4.7) $$g(y) = f(x)J$$

where J = abs(dx/dy) and abs(.) refers to absolute value. A density function cannot assume negative values.

All normalized prices ($P'_{i,j}$) were pooled together to obtain a single sample with sample size n = 389. The descriptive statistics are shown in Table 4.2 and the distribution is plotted in Figure 4.2. The distribution is only slightly skewed but has a high peak (kurtosis).

Table 4.2 Standardised bid prices: Descriptive Statistics

	Statistic	Standard Error
N – sample size	389	
Mean	100	0.8180
95% Confidence Interval for Mean		
Lower Bound	98.3544	
Upper Bound	101.5710	
5% Trimmed Mean	99.4325	
Median	99.3925	
Variance	260.3010	
Std. Deviation	16.1338	
Minimum	52.4437	
Maximum	206.4810	
Range	154.0373	
Interquartile Range	14.7761	
Skewness	1.1790	0.124
Kurtosis	6.5540	0.247

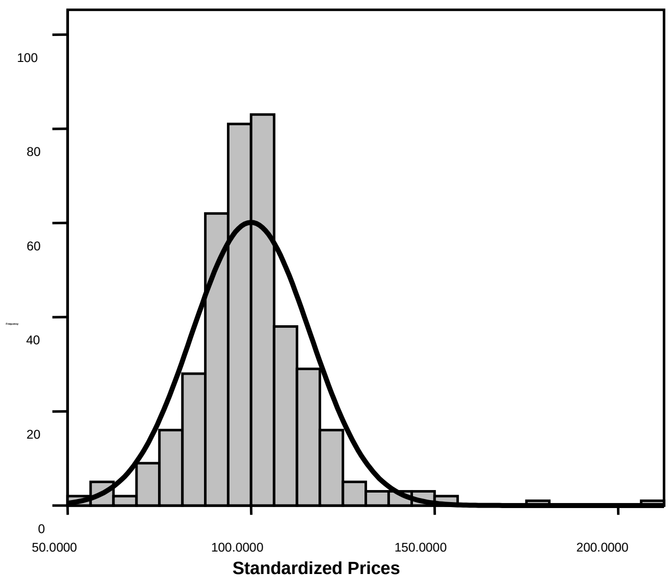

Figure 4.2 Standardized Prices Histogram

Various tests (Table 4.3) were conducted to test for normality. The significant levels were lower than 0.05. From the normal Q-Q plot (Figure 4.3), it can also be concluded that the distribution of bid-prices is not normal.

Table 4.3 Standardised Prices: Tests for Normality

Kolmogorov-Smirnov			Shapiro-Wilk		
Statistic	df	Sig.	Statistic	df	Sig.
0.102	389	0.000	0.920	389	0.000

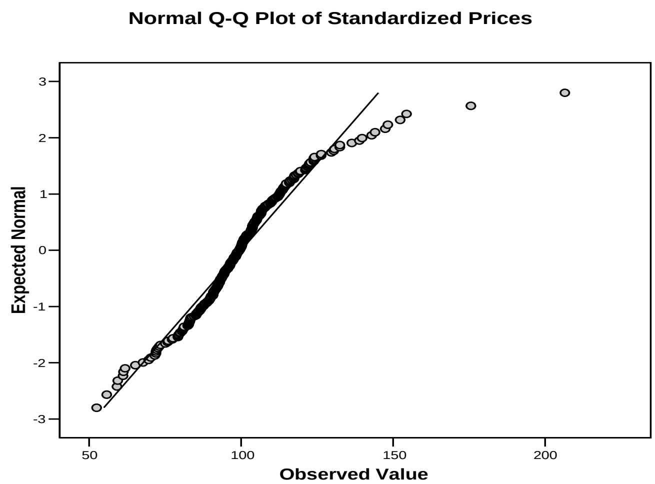

Figure 4.3 Normal Q-Q Plot of Standardized Prices

The coefficient of variation is given by

$$CV = \left(\frac{s}{\overline{P}}\right)(100\%).$$

Since $\overline{P} = 100$,

$$CV = s$$

Therefore, the coefficient of variation for all construction bids in the sample is 16.134. This value is generally higher than that found in previous studies conducted in the US, UK and Singapore (see Section 2.1.2). This is not unexpected given that Sri Lanka is a developing country and markets are less efficient.

For an in-depth analysis on the coefficient of variation, the sample was segregated by project size (Table 4.4, Figures 4.4, 4.5, and 4.6). It can be seen that the *CV* is high for small projects but relatively constant for medium and large projects. For small projects, the standard deviation tends to be large relative to the mean, resulting in relatively higher values of *CV*.

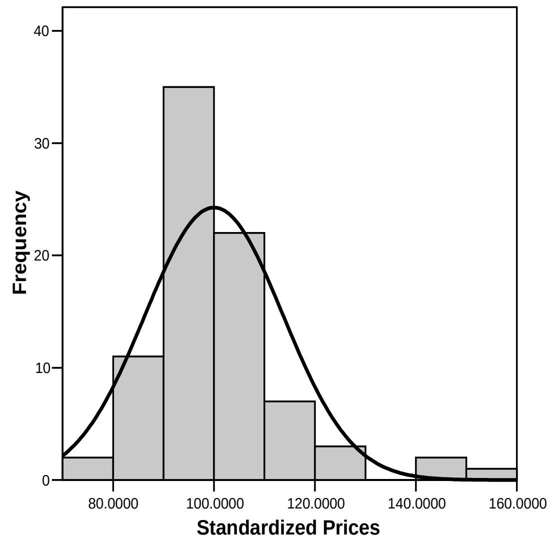

Figure 4.4 Price histogram for large projects

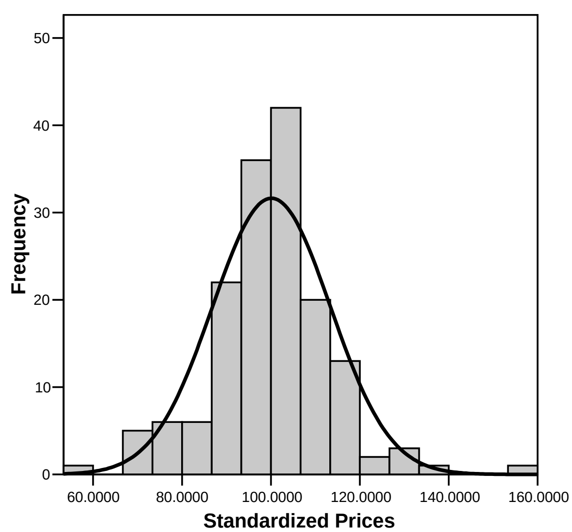

Figure 4.5 Price histogram for medium size projects

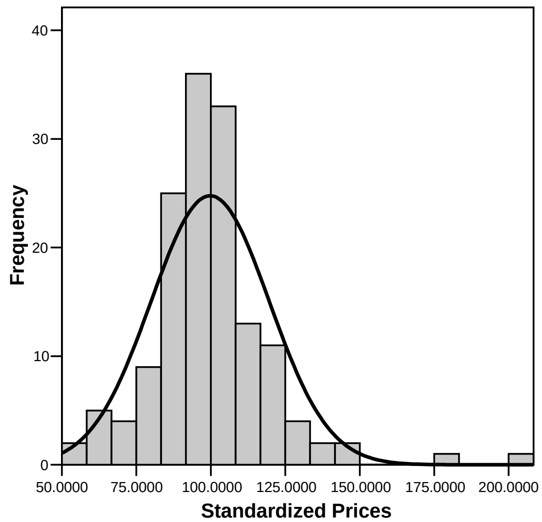

Figure 4.6 Price histogram for small projects

Table 4.4 Bid price distribution in different project sizes

Project Size	N	$S = CV$	Skewness	Kurtosis
Large	83	13.6465	1.548	4.169
Medium	158	13.2804	0.266	2.130
Small	148	19.8682	1.334	6.273
All	389	16.1338	1.179	6.554

4.2 Analysis of correlation

In this study, correlation analysis is used for two main purposes:

- to identify the relationships between variables; and
- to identify possible multicollinearity.

Table 4.5 shows the correlation matrix. A ***bold-italic*** coefficient indicates that the correlation is significant at the 0.01 level and a **bold**-only coefficient indicates the correlation is significant at the 0.05 level.

Table 4.5 Pearson correlation analysis

	(*CV*) Coefficient of Variation	(*γ*) Percentage winning margin	(*G*) Minimum ICTAD grading	(*M*) Tendering Method	(*N*) Number of competitors	(*Q*) Quality of tender documents	(*D*) Tender duration (weeks)	(*H*) Prequalification requirements	(*NT*) New Technology	(*CLT*) Type of Client	(*TDep*) Tender Deposit (Rs. '000)	(*BB*) Bid Bond (Rs. Million)
(*CV*) Coefficient of Variation	***1***	***.317***	.310	-.119	**.213**	***-.536***	-.199	**.292**	-.018	-.107	-.200	***-.244***
(*γ*) Percentage winning-margin	***.317***	***1***	-.029	**.211**	**-.264**	-.122	.041	.156	.065	.120	.007	-.041
(*G*) Minimum ICTAD grading	***.310***	-.029	***1***	-.028	.037	**-.259**	***-.407***	-.164	.066	**-.248**	***-.534***	***-.570***
(*M*) Tendering Method	-.119	**.211**	-.028	***1***	***-.406***	.193	-.180	-.142	.176	***.631***	-.096	-.118
(*N*) Number of competitors	**.213**	**-.264**	.037	***-.406***	***1***	-.201	-.039	.008	-.052	-.166	.086	.006
(*Q*) Quality of documents	***-.536***	-.122	**-.259**	.193	-.201	***1***	**.254**	-.017	.176	.154	.119	.133
(*D*) Tender duration (weeks)	-.199	.041	***-.407***	-.180	-.039	**.254**	***1***	.121	-.115	-.197	**.242**	***.386***
(*H*) Prequalification requirements	**.292**	.156	-.164	-.142	.008	-.017	.121	***1***	**.269**	-.067	.064	.064
(*NT*) New technology	-.018	.065	.066	.176	-.052	.176	-.115	**.269**	***1***	.070	-.048	-.051
(*CLT*) Type of Client	-.107	.120	**-.248**	***.631***	-.166	.154	-.197	-.067	.070	***1***	.170	.133
(*TDep*) Tender deposit (Rs. '000)	-.200	.007	***-.534***	-.096	.086	.119	**.242**	.064	-.048	.170	***1***	***.591***
(*BB*) Bid Bond (Rs. Million)	**-.244**	-.041	***-.570***	-.118	.006	.133	***.386***	.064	-.051	.133	***.591***	***1***
(*PB*) Performance Bond %	-.076	-.071	***-.310***	**.227**	-.055	.172	-.026	***.326***	-.027	***.392***	.038	.137
(*MIns*) Minimum 3rd Party Insurance	**-.267**	-.082	***-.368***	***.340***	-.179	.493	-.056	-.205	.115	***.370***	**.282**	.193
(*MMC*) Mini. Monthly claim (Million)	***-.349***	-.179	***-.505***	.118	-.153	***.444***	.075	-.123	.082	**.249**	***.309***	***.434***
(*CnT*) Type of contract	.150	.172	-.008	.126	**-.261**	-.031	.078	.190	.148	-.047	-.112	-.102
(*T*) Type of procurement	.167	.262	**-.213**	-.116	.036	-.120	.058	.054	-.026	-.180	-.033	-.093
(*NSB*) Nominated Sub-contractors' work %	-.013	.196	-.014	***.425***	-.144	-.020	-.140	.100	***.438***	***.384***	**.212**	.182
(*MP*) Maintenance Period (Months)	-.073	-.072	**-.232**	-.080	.118	.186	.107	-.065	.110	.079	.200	.191
(*LDD*) LD per day %	.181	-.037	.005	-.170	-.029	.119	.085	***.336***	-.128	-.006	-.025	-.010
(*LDL*) LD Limit %	-.035	-.005	**.251**	-.043	.057	**.231**	-.004	-.011	-.002	-.036	.038	.032
(*PFI*) Provision for Price Fluctuation	-.034	-.106	***-.309***	**-.277**	.118	.006	***.375***	.056	.112	-.151	**.229**	***.374***
(*CI*) Building Cost Index	-.213	.095	-.135	-.085	-.026	-.040	.113	**-.304**	***-.397***	.026	**.248**	**.257**

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	(*PB*) Performance Bond %	(*MIns*) Minimum 3rd Party Insurance	(*MMC*) Minimum Monthly claim (Million)	(*CnT*) Type of contract	(*PrT*) Type of procurement	(*NSB*) Nominated Subcontractors' work %	(*MP*) Maintenance Period (Months)	(*LDD*) LD per day %	(*LDL*) LD Limit %	(*PFI*) Provision for Price Fluctuation	(*CI*) Building Cost Index
(*CV*) Coefficient of Variation	-.076	**-.267**	**-.349**	.150	.167	-.013	-.073	.181	-.035	-.034	-.213
(*γ*) Percentage winning-margin	-.071	-.082	-.179	.172	.262	.196	-.072	-.037	-.005	-.106	.095
(*G*) Minimum ICTAD grading	**-.310**	**-.368**	**-.505**	-.008	**-.213**	-.014	**-.232**	.005	**.251**	**-.309**	-.135
(*M*) Tendering Method	**.227**	**.340**	.118	.126	-.116	**.425**	-.080	-.170	-.043	**-.277**	-.085
(*N*) Number of competitors	-.055	-.179	-.153	**-.261**	.036	-.144	.118	-.029	.057	.118	-.026
(*Q*) Quality of documents	.172	**.493**	**.444**	-.031	-.120	-.020	.186	.119	**.231**	.006	-.040
(*D*) Tender duration (weeks)	-.026	-.056	.075	.078	.058	-.140	.107	.085	-.004	**.375**	.113
(*H*) Prequalification requirements	**.326**	-.205	-.123	.190	.054	.100	-.065	**.336**	-.011	.056	**-.304**
(*NT*) New Technology	-.027	.115	.082	.148	-.026	**.438**	.110	-.128	-.002	.112	**-.397**
(*CLT*) Type of Client	**.392**	**.370**	**.249**	-.047	-.180	**.384**	.079	-.006	-.036	-.151	.026
(*TDep*) Tender Deposit (Rs. '000)	.038	**.282**	**.309**	-.112	-.033	**.212**	.200	-.025	.038	**.229**	**.248**
(*BB*) Bid Bond (Rs. Million)	.137	.193	**.434**	-.102	-.093	.182	.191	-.010	.032	**.374**	**.257**
(*PB*) Performance Bond %	**1**	**.297**	**.317**	**.383**	-.145	.179	.065	**.395**	.022	-.034	-.038
(*MIns*) Minimum 3rd Party Insurance	**.297**	**1**	**.753**	-.037	-.033	.200	.092	-.099	.040	-.084	-.022
(*MMC*) Mini. Monthly claim (Million)	**.317**	**.753**	**1**	.058	-.088	.093	.009	-.003	.148	.057	.169
(*CnT*) Type of contract	**.383**	-.037	.058	**1**	.044	-.008	.135	.199	-.025	-.067	-.099
(*T*) Type of procurement	-.145	-.033	-.088	.044	**1**	-.028	-.029	-.109	**-.416**	-.033	.067
(*NSB*) Nominated Sub-contractors' work %	.179	.200	.093	-.008	-.028	**1**	.074	-.025	.121	-.049	-.163
(*MP*) Maintenance Period (Months)	.065	.092	.009	.135	-.029	.074	**1**	.086	-.103	.204	-.174
(*LDD*) LD per day %	**.395**	-.099	-.003	.199	-.109	-.025	.086	**1**	.197	-.092	-.079
(*LDL*) LD Limit %	.022	.040	.148	-.025	**-.416**	.121	-.103	.197	**1**	.080	-.067
(*PFI*) Provision for Price Fluctuation	-.034	-.084	.057	-.067	-.033	-.049	.204	-.092	.080	**1**	-.113
(*CI*) Building Cost Index	-.038	-.022	.169	-.099	.067	-.163	-.174	-.079	-.067	-.113	**1**

Of the additional 14 variables identified through the interviews, bid bond (*BB*), minimum third party insurance (*MIns*), and minimum monthly claim (*MMC*) showed significant correlations with *CV*. However, these three variables vary directly with project size. Therefore, they are proxied by the minimum grading requirement (*G*).

None of the 11 other variables showed significant correlations with *CV* or *γ*. This justifies the decision to drop the 14 variables from the regression model.

Table 4.6 shows the correlations for the two dependent variables and six independent variables. It is a subset of Table 4.5 and it is reproduced here for convenience. Of the six independent variables, only tender duration (*D*) does not have a significant correlation to either of the dependent variables.

Table 4.6 Pearson correlation analysis for regression variables

	(*CV*) Coefficient of Variation	(*γ*) Percentage winning-margin	(*G*) Minimum ICTAD Grading	(*M*) Tendering Method	(*N*) Number of competitors	(*Q*) Quality of documents	(*D*) Tender duration (weeks)	(*H*) Prequalification requirements
(*CV*) Coefficient of Variation	***1***	***0.317***	***0.310***	-0.119	**0.213**	***-0.536***	-0.199	**0.292**
(*γ*) Percentage winning-margin	***0.317***	***1***	-0.029	**0.211**	**-0.264**	-0.122	0.041	0.156
(*G*) Minimum ICTAD Grading	***0.310***	-0.029	***1***	-0.028	0.037	**-0.259**	***-0.407***	-0.164
(*M*) Tendering Method	-0.119	**0.211**	-0.028	***1***	***-0.406***	0.193	-0.180	-0.142
(*N*) Number of competitors	**0.213**	**-0.264**	0.037	***-0.406***	***1***	-0.201	-0.039	0.008
(*Q*) Quality of documents	***-0.536***	-0.122	**-0.259**	0.193	-0.201	***1***	**0.254**	-0.017
(*D*) Tender duration (weeks)	-0.199	0.041	***-0.407***	-0.180	-0.039	**0.254**	***1***	0.121
(*H*) Prequalification requirements	**0.292**	0.156	-0.164	-0.142	0.008	-0.017	0.121	***1***

The correlations among the independent variables are not sufficiently high to suggest that multicollinearity is a major problem. The highest correlation coefficient is only -0.407. This is not unexpected because the independent variables capture different types of information and are not highly correlated with each other. For instance, the quality of tender documents is not correlated with the number of competitors.

4.3 Regression

Table 4.7 shows some basic descriptive statistics of the sample of 62 projects. For the dependent variables, we have seen that the distributions are not strictly normal but are sufficiently "normal" (see Figure 4.2) so that ordinary least squares (OLS) may be used and the Box-Cox (1964) transformation is not required. OLS is robust with respect to slight departures from normality.

Table 4.7 Descriptive statistics of regression variables (sample size = 62)

Variable	Mean	Standard deviation	Minimum	Maximum	Skewness	Kurtosis
Dependent						
CV	13.842	9.068	0.59	45.09	1.397	2.437
γ	9.101	9.019	0.12	35.18	1.353	1.048
Independent						
G	3.89	1.427	1	6	-0.074	-0.819
N	6.37	3.234	2	16	0.862	0.464
Q	3.35	0.722	2	5	0.419	0.132
D	3.67	2.840	1	17	3.196	12.398
H	1.98	0.833	1	3	0.030	-1.561
M	0.40	0.493	0	1	0.432	-1.874

It may be seen from Figure 4.2 that there are two outliers. These outliers were not removed from the model because they were valid bids, and the purpose of this study is to examine bid variation. These two outliers were from small projects (see Figure 4.6).

Several linear and nonlinear regression models were experimented and the linear model has the best fit. The estimated models are

$$CV = 20.709 + \underset{(\pm 0.648)}{1.768}\, G - \underset{(\pm 1.249)}{5.934}\, Q + \underset{(\pm 1.068)}{3.219}\, H, \qquad \overline{R}^2 = 0.420. \tag{4.8}$$

$$\gamma = 14.499 - \underset{(\pm 0.347)}{0.818}\, N, \qquad \overline{R}^2 = 0.069. \tag{4.9}$$

The *t*-statistics are all greater than 1.96, indicating that the parameters are significant at the 0.05 level of significance (refer Appendix C). It can be seen that model (4.9) predicts relatively poorly compared to model (4.8). This is understandable because γ is the percentage winning-margin based on the lowest two bids. As such, it does not adequately capture bid-price variability. Based on the above results, the discussion that follows is based on model (4.8).

It can be seen from model (4.8) that *CV* is related to only three variables, namely, minimum grading requirement (*G*), quality of tender documents (*Q*), and level of prequalification requirements (*H*). Since a firm with a lower grading (i.e. larger *G*) can tender only for smaller projects, the positive regression coefficient is of correct sign, that is, *CV* falls with project size. The negative sign for *Q* is also expected since *Q* is measured from 0 to 5 (highest quality). As the quality of tender documents rises, bid-price variability is likely to fall. Finally, *H* is measured as Low, Medium or High prequalification requirement and is coded as 1, 2 and 3 respectively. The theoretical direction of causality is unknown because it is an empirical question how *CV* will vary with *H*. A higher level of *H* reduces the level of competition but pre-qualified firms may bid in a variety of ways. Model (4.8) shows that *H* is positively related to *CV*. Therefore, higher levels of prequalification requirements lead to larger bid-price variability.

The adjusted R-square is 0.420. The relatively low R-square is not unexpected given that project information is relatively inefficient in Sri Lanka. Of the 62 projects used, the quality of tender documents from 39 projects was graded at or below 3 out of a scale of 5 (highest quality). Another reason for the relatively lower R-square value is that bids are also based on business strategies that are not captured by any of the independent variables. This is because business strategies, by their nature, are qualitative and cannot be adequately measured.

The next step in the regression analysis analyzes the residuals for departures from normality. A randomly scattered distribution is found in the residual plot (Figure 4.7), and Kolmogorov-Smirnov test (Table 4.8) reveals that the significant level is greater than 0.05. Therefore, the residuals are normally distributed. This substantiates the appropriateness of using ordinary least squares for this study and no transformation of functional form or observations to obtain randomly distributed residuals is required.

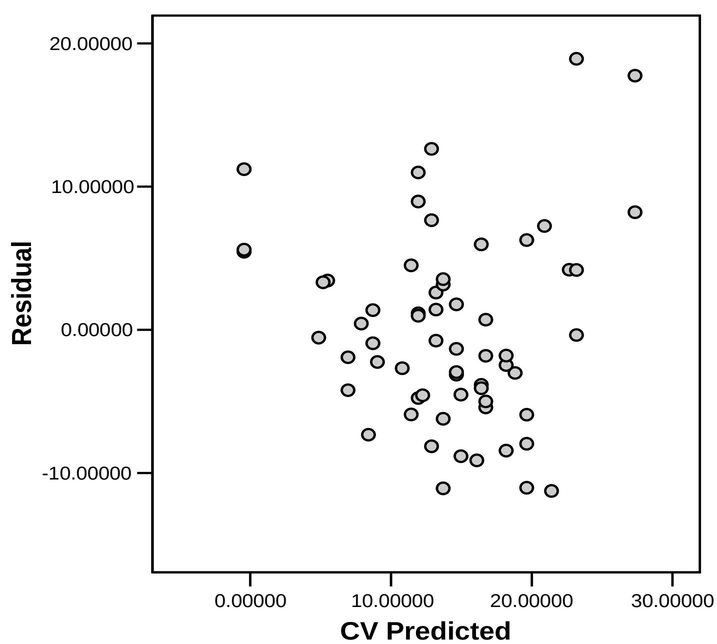

Figure 4.7 Residual Plot

Table 4.8 Test for normality of residuals

	Kolmogorov-Smirnov		
	Statistic	df	Sig.
Residuals	0.074	62	0.200

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The purpose of the study is to examine the project variables that cause bid-price variability in construction tenders. This study is interesting because bid-price variability represents the market inefficiency. This is because bid prices are partly based on information available to bidders, and partly on business strategy. These two aspects are interrelated since business strategies are formulated on the basis of information.

The objectives of the study are: (1) to understand the general distribution of bid prices in the Sri Lankan construction industry as an indicator of market inefficiency, and (2) to determine the key project variables that give rise to bid-price variability.

The hypothesis is that the bid-price variability, measured by the coefficient of variation (CV) and winning-margin (γ), is affected by the minimum grading required (G), number of competitors (N), quality of tender documents (Q), bid duration (D), tendering method (M), and level of prequalification requirements (H). A further 14 variables were also identified through interviews with professionals and practitioners as possible factors that affect bid-price variability.

The research was designed as a regression model. It was preceded by an exploration study (a descriptive analysis) to explain the general distribution of bid prices from a sample of 64 projects. Interviews were carried out with seven Sri Lankan professionals with extensive experience in bidding. They comprised consultants, contractors and academics. Project information for the regression analysis was extracted primarily from project documents from 62 projects. Any additional information was acquired through informal interviews.

The analysis of bid-prices showed that the standard deviation was proportional to the project size. The bid prices approximate a symmetrical bell shaped distribution. The distribution is only slightly skewed but has a high peak. The average coefficient of variation of all bids in the sample was about 16, and the variation was higher in small projects than in large and medium size projects.

Of the additional 14 variables, only 3 showed a significant correlation to *CV*. But they were not selected for the regression model because these variables, namely, bid bond (*BB*), minimum third party insurance (*MIns*), and minimum monthly claim (*MMC*), were proxied by minimum grading requirement (*G*) in the regression model.

The correlations among the independent variables were not significantly high to suggest that multicollinearity was a major problem. The regression model for percentage winning-margin (γ) was relatively poor in goodness of fit, and is related only to the number of competitors (*N*). The regression analysis using *CV* as the dependent variable concluded that the linear model has the best fit. Only three independent variables, namely, minimum grading requirement (*G*), quality of tender documents (*Q*), and level of pre-qualification requirements (*H*), were significantly related to *CV*. The R-square was 0.448, which is relatively low because of imperfect information and the inability of the model to "measure" the business strategies that also influence bids.

5.2 Contributions and implications

5.2.1 Distribution of Bid Prices

The first contribution of the study is the exploration of the general distribution of bids of Sri Lankan construction industry. It was found that standard deviation of bids was proportionate to the project size. This is not unexpected as the variability of bid prices is likely to increase with the complexity of a project, because information becomes more imperfect with increasing complexity. Other basic features of the bid distribution in the sample are summarized in Table 5.1.

Table 5.1 General distribution of bid prices

Measure	Value	Comment
Coefficient of Variation	16.1338	High variability
Skewness	1.1790	Slightly positive
Kurtosis	6.5540	High peak

The distribution is slightly positively skewed. This is due to the existence of few unrealistically high bids (outliers) (see Skitmore *et al*. (2001) for similar bid distribution in UK). A high kurtosis implies most bids are scattered closely around the average bid. The high dispersion reflects relatively high information inefficiency and possible existence of large winner's curses in the Sri Lankan construction industry.

Among different project sizes, small projects showed the highest variation in *CV* of about 20% while medium and large projects showed about 13% variability. This shows that the market for small contracts is more inefficient than that for medium and large contracts. The high variability and skewness also suggest the existence of large errors in bids as indicated by Beeston (1983), Chapman *et al*. (2000), and Runeson and Skitmore (1999).

The distribution of the bids in this sample is not normal. This differs from expected normal distribution as previously found by McCaffer and Pettit (1976). However, this is an acceptable deviation as the sample distribution is approximately normal.

5.2.2 Impact of project variables on bid-price variability

The second contribution is the establishment of relationship between bid-price variability and project variables. The estimated model is

$$CV = 20.709 + \underset{(\pm 0.648)}{1.768}\ G - \underset{(\pm 1.249)}{5.934}\ Q + \underset{(\pm 1.068)}{3.219}\ H, \qquad \overline{R}^2 = 0.420.$$

The bid-price variability (measured by *CV*) is related to only three variables, namely, minimum grading requirement (*G*), quality of tender documents (*Q*), and level of prequalification requirements (*H*). It does not have any relationship with bid duration (*D*), tendering method (*M*), or number of competitors (*N*).

G is rated from 1 to 6, where 1 refers to largest projects. Hence, the study shows that bid-price variability falls with project size. This means that market for larger projects is relatively efficient in the informational perspective. Cost differences are low among large firms and they also have the advantage of scale economies. But, among small firms, cost differences are high because some are less experienced. Further, there is a high tendency for them to use predatory or risky pricing. The study shows that the tendering method (*M*) or number of bidders (competitors, *N*) does not affect *CV*. Therefore, the neoclassical view of competition based on market structure, is found to be ineffective in altering bid-price variability.

High levels of prequalification requirements (*H*) yield relatively high variability in bid prices. Prequalification requirements had been identified in previous work on pricing and mark-up decisions (Liu and Ling, 2005; Fayek, 1998; Ahmad and Minkarah, 1988), but a study on how it would affect bid-price variability was not found. Bidders with good qualifications would bid high as they are more confident while less confident bidders would try to compete through price alone.

Inefficient information is the third key factor to increase bid-price variability. Some previous studies also have identified this affect towards contractors' pricing decisions (Liu and Ling, 2005; Fayek, 1998; Ahmad and Minkarah, 1988). The negative sign of *Q* emphasizes the role of quality of tender documents in reducing the pricing errors and mistakes. Further, incomplete (i.e. low quality) tender documents carry high risk for bidders. Their mark-ups vary according to their risk attitudes. This also leads to high variability of prices.

5.3 Limitations of the study

The limitations of the study are as follows. First, bid prices from a sample of 62 projects were pooled in the estimating procedure. This is because there are only a few bids in each project. This pooling necessitates a transformation of the raw bid prices that scales the dispersion but normalizes the mean bid to 100. This process is justified in terms of the objective of the study to study bid price variability; clearly, a transformation that scales the dispersion loses or distorts some of the original information.

Second, the lack of sufficient previous theoretical work inhibited the clear identification of variables that affect bid-price variability. In this sense, this study contributes to current knowledge by identifying three project variables that affect bid price variability.

Third, it is difficult to measure business strategies because of their qualitative nature and this partly accounts for the relatively lower R-square.

Fourth, several dummy variables or codes were used as measures for the independent variables. To the extent that dummy variables capture only dichotomies rather than a range of values as possible outcomes, they impose a limitation on the study.

Finally, the sample of 62 projects, while sufficient for the regression analysis, may not be representative of construction bids in Sri Lanka.

Despite these limitations, the descriptive statistics and regression analysis do provide some insight into the bidding behaviour of Sri Lankan contractors. Specifically, bids were approximately normally distributed and three project variables, namely minimum grading requirement, quality of tender documents, and level of prequalification requirements, affect bid-price variability.

5.4 Recommendations

Three recommendations may be made as a result of this study.

(a) Quality of tender documents

First, the quality of tender documents needs to be raised to improve the efficiency of the market. If tender documents are of poor quality, there is a higher probability of unrealistically low bids. Since standard forms are widely used, the main areas of improvement lie in production information such as drawings, specifications, schedules of work and quantities.

Standardization and effective communication are the means of improving the quality of production information. Numerous initiatives to standardize such information are evident from the past. These vary from introducing common phraseology for BQs (Fletcher and Moore, 1979) to standard method of measurement (Association of Cost Engineers, 1972), and to specification writing guidelines (Marsh, 1967). With the development of the construction industry, improved and efficient standards and codes became available (RICS, 1979; Willis and Willis, 1997; Seely, 2001; Emmitt and Yeomans, 2001; Hackett and Robinson, 2003; Keily and McNamara, 2003; CIDB, 2004).

In 1980s, quality assurance of production information received a wide interest. In the UK, the Coordinated Production Information (CPI) scheme was initiated by the Construction Project Information Committee (CPIC). CPIC was formed from representatives of the major industry institutions: Royal Institute of British Architects, Institution of Civil Engineers, Chartered Institution of Building Services Engineers, Royal Institution of Chartered Surveyors, and the Construction Confederation. In 1987, CPIC published its first CPI documents comprising the following:

- Code of Procedure for Production Drawings;
- Code of Procedure for Project Specification; and
- Common Arrangement of Work Sections (CAWS).

Production drawings are drawn (graphic) information and prepared by the design team to be used by the construction team. The main purpose is to define the size, shape, location and construction of the building and its components. The spatial coordination and technical coordination are the most important aspects of production drawings.

Specifications are the written information prepared by the design team to be used by the construction team. The main purpose is to define the products to be used, the quality of work, any performance requirements, and the conditions under which the work is to be executed. These should be consistent with the drawings and work items in Bills of Quantities.

CAWS is the coded classification of work. In 1998, CAWS was revised. The new code, covering both drawings and specification, replaced the separate 1987 codes on production drawings and project specification. At the same time, a revised edition of the Standard Method of Measurement (SMM7), co-ordinated with the new CPI conventions, was also published (RICS, 1998).

CAWS defines an efficient and generally acceptable arrangement for specifications, drawings, and bills of quantities for building projects. It consists of a set of detailed work section definitions within a classification framework of groups and sub-groups. The same work sections are followed in specifications, drawings and SMM7. Thus, CAWS is a scheme for coordinating the design information that independent consultants produce so that it fits together as a coherent description of the anticipated final product (the building). This helps to ensure that design information produced by each consultant is consistent with that produced by all others.

Recent developments in Information Technology (IT) and Computer Aided Draughting (CAD) have made it possible to build a virtual prototype of projects (i.e. 3D models). This also enables errors, omissions and coordination problems in the production drawings to be identified and rectified before tendering. However, virtual models are still expensive and time-consuming to construct, and is unlikely to be widely used in the Sri Lankan construction industry in the near future.

(b) Level of prequalification

Second, a higher level of prequalification requirements increases the variability of bids because it reduces competition. Therefore, setting up unnecessarily high levels of prequalification is unwise. In the sample, more than a third of total projects required high levels of prequalification.

The purpose of setting prequalification requirements is to screen out the incapable contractors from bidding. In a less developed country, contractors may not have diverse experience because the number of projects of a specific nature is limited. For example, in a large hotel project tender, setting a requirement of experience in three similar projects would disqualify most of large contractors who are actually capable of handling the project but lack the experience because there are not many such projects. Therefore, an experience-based prequalification method is not necessarily desirable for the Sri Lankan construction industry.

Several prequalification models have been developed to solve this problem. Table 5.2 summarises the prequalification models that have been previously studied in construction tendering.

Table 5.2 Prequalification Models

Model	Author(s)
Multi-attribute utility model	Diekmann (1981)
Fuzzy sets model	Nguyen (1985)
Statistical model	Jaselskis (1988)
Prequalification formula	Russell and Skibniewski (1990a)
Knowledge-intensive model	Russell and Skibniewski (1990b)
Dimensional weighting	Jaselskis and Russell (1991)
Dimensional-wide modelling	Jaselskis and Russell (1991)
Two-step modelling	Jaselskis and Russell (1991)
Financial model	Russell (1992)
Linear model	Russell (1992)
Hybrid model	Russell (1992)
Analytical hierarchy process (AHP)	Fong and Choi (2000)
Balanced scorecard (BSC)	Johnson and Jayasena (2003)

Historically, the prequalification assessment criteria has widened with time. This is because experience and financial capacities are not adequate indicators of capability. This suggests that the prequalification of bidders based on wider performance criteria is a better solution to the problem identified in this study. Since there are several methods available (Table 5.2), an appropriate method should be introduced to the Sri Lankan construction industry.

These methods can be adapted from Performance Based Procurement Systems (PBPS). The frequently used criteria for performance evaluation of contractors are (Australian Procurement and Construction Council, 1998):

- technical capability,
- financial capacity,
- quality management,
- occupational health safety and rehabilitation,
- compliance with code of practice,
- human resource management (including skill formation),
- commitment to client satisfaction,
- co-operative contracting and partnering,
- management of environmental issues,
- management for continuous improvement, and
- compliance with legislative requirements.

The traditional method of prequalification also focused on few of the criteria above. The difference in innovative PBPS is that the evaluation is not based on experience in project of similar nature. It assesses the contractors from a wider performance spectrum.

The latest models such as Analytical Hierarchy Process (AHP) (Saaty, 1980) and Balance Scorecard (BSC) (Kaplan and Norton, 1992) have been adapted in contractor selection (Fong and Choi, 2000). A conceptual BSC framework that had been developed for the Australian construction industry (Johnson and Jayasena, 2003) has subsequently been shown to be applicable to the Sri Lankan construction industry

(Johnson, 2003, Johnson *et al.*, 2005).

(c) Winner's curse

Third, the possible existence of large winner's curses in the Sri Lankan construction industry should be considered in awarding the contracts. The common practice of awarding the contract to the lowest bidder would be an adverse selection if the lowest bid is an underbid. Because of this reason, some scholars support non-lowest bid contractor selection (Jaselskis and Russell, 1991; Kashiwagi, 1997; Kumaraswamy and Walker, 1999). The considerations are that the (a) lowest price may not yield the value; (b) low price may not be cost-saving; and (c) price is significantly linked to the quality and performance. The main problem with using bid price alone is that it is one-dimensional and is unable to deal with the multi-dimensional aspects of a construction product that include not only cost but also time and quality. Thus, a contract that has been awarded based on price alone will leave the quality dimension imperfectly determined (through specifications, supervision, performance bonds, and so on). Vickrey (1961) has long suggested that, in one-sided sealed bid auctions, the contract should be awarded to the second lowest bidder to remove the winner's curse. Contractors then have the incentive to "reveal" their true bids because the contract will not be awarded based on their bids but on the second lowest bid. Recall that the winner's curse is the difference between the two lowest bids.

The PBPS framework introduced above is a possible solution to this problem. However, the implementation of PBPSs is still problematic. One example is the National Museum of Australia project which procured under PBPS. It has been reported that even some leading contractors found it difficult to prove their performance due to lack of evidence (Walker *et al.*, 2001). Therefore, the change has to be pragmatic so that it does not burden the industry.

Johnson (2003) found that the Sri Lankan construction industry has the capacity to adapt the BSC framework. However, this is only a performance measure. A tender evaluation method has to be devised by coupling BSC with bid-price evaluation methods.

5.5 Further Research

A limitation of this study is that bid-price variability reflects both information inefficiencies and business strategies. The latter include perceptions of risk which leads to differences in mark-ups. This explains why the R-square is 0.448, which is not high. There is clearly scope for further research on how business strategies affect bids to complete the picture.

An inefficient construction market leads to post-contract conflicts. Therefore, another interesting area would be to couple this study with studies in claims management and project success (Ho and Liu, 2004; Lingard and Hughes, 1998; Kumaraswamy and Yogeswaran, 1998; Crowley and Hancher, 1995; Zack Jr., 1993).

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APPENDIX A: INTERVIEW GUIDE

The interview generally followed the following steps.

1. Self introduction.
2. Summary explanation of the study: key point was the intention to study which project variables could affect bid-price variability. Few examples were also given.
3. Questioned; "What sort of project variables would affect bid-price variability in your opinion?"
4. All his/her points were noted and compared with the current list of variables. If all variables in the current list were mentioned in direct or indirect terms, step 5 was skipped.
5. Questioned; "Other than what you've mentioned, some professionals I met pointed that X & X also affect bid-price variability, would you agree and why?"
6. Questioned; "For my analysis I measure factor X in a scale from 0 to 5, where 0 represents lowest quality and 5 represents the highest. This will be rated by a senior professional who involved in bidding for the construction project in concern. Do you feel this scale is practical and I will receive objective response?"
7. Questioned; "You involved in bidding for project A. How would you rate factor X for that project?"

APPENDIX B: DATA COLLECTION FORM

Name of the Project					
Location of the project					
Client					
Contractor					
Architect					
Engineers					
Quantity Surveyors					
Date of Bids Opening					
Date of Project Start					
Engineers Estimate					
Mark-up used in EE (%)	O/H		Profit		O/H + Profit	

Project variables						
Project Size (Contract sum)						
Project Duration (Months)						
Project Type (Housing, Commercial, Civil)						
Use of new/innovative technology	none	minor	average	high		
Contractor variables						
Minimum ICTAD grading required						
Client variables						
Type of client (public/pte)						
Source of funding (esp when public client)						
Tender variables						
Tender Deposit (value)						
Bid bond (value)						
Performance bond (value)						
Level of Advance Payment (% of total contract sum)						
Amount of retention (% of monthly claim)						
Minimum third party insurance (value)						
Minimum monthly claim (in Rs)						
Tendering method	0 = open	1 = selective				
Number of competitors (Number of bids)						
Tendering duration (weeks)						
Prequalification requirements	low	medium	high			
Type of contract	0 = ICTAD standard	1 = custom				
Type of procurement (traditional, D&B, Mgt, etc)						
Completeness of documents (On scale)	0	1	2	3	4	5
Use of nominated subcontractors (% of total work)						
Maintenance period (months)						
Value of liquidated damages (% of total work)		Per day				
Provision for material price fluctuation	0 = Not Allowed	1 = Allowed				

Builder Code	Name of Builder	Bid Price

APPENDIX C: REGRESSION ANALYSIS

Regression

Notes

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Variables Entered/Removed(b)

Model	Variables Entered	Variables Removed	Method
1	(H) Pre Q requirements, (N) No. of competitors, (D) Tender duration (weeks), (Q) Quality of documents, (G) Minimum ICTAD Grading, (M) Tendering Method(a)	.	Enter

a All requested variables entered.
b Dependent Variable: (CV) Coefficient of Variation

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.680(a)	.462	.403	6.93728

a Predictors: (Constant), (H) Pre Q requirements, (N) No. of competitors, (D) Tender duration (weeks), (Q) Quality of documents, (G) Minimum ICTAD Grading, (M) Tendering Method

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2272.661	6	378.777	7.871	.000(a)
	Residual	2646.926	55	48.126		
	Total	4919.587	61			

a Predictors: (Constant), (H) Pre Q requirements, (N) No. of competitors, (D) Tender duration (weeks), (Q) Quality of documents, (G) Minimum ICTAD Grading, (M) Tendering Method
b Dependent Variable: (CV) Coefficient of Variation

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	17.480	7.098		2.463	.017
	(G) Minimum ICTAD Grading	1.784	.707	.281	2.524	.015
	(M) Tendering Method	1.907	2.075	.104	.919	.362
	(N) No. of competitors	.308	.306	.110	1.006	.319
	(Q) Quality of documents	-5.907	1.333	-.478	-4.432	.000
	(D) Tender duration (weeks)	.012	.358	.004	.034	.973
	(H) Pre Q requirements	3.377	1.095	.312	3.085	.003

a Dependent Variable: (CV) Coefficient of Variation

Regression

Notes

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	Cases Used	Statistics are based on cases with no missing values for any variable used.
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Variables Entered/Removed(b)

Model	Variables Entered	Variables Removed	Method
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a All requested variables entered.
b Dependent Variable: (CV) Coefficient of Variation

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.670(a)	.448	.420	6.84076

a Predictors: (Constant), (H) Pre Q requirements, (Q) Quality of documents, (G) Minimum ICTAD Grading

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2205.423	3	735.141	15.710	.000(a)
	Residual	2714.164	58	46.796		
	Total	4919.587	61			

a Predictors: (Constant), (H) Pre Q requirements, (Q) Quality of documents, (G) Minimum ICTAD Grading
b Dependent Variable: (CV) Coefficient of Variation

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	20.709	6.110		3.390	.001
	(G) Minimum ICTAD Grading	1.768	.648	.278	2.727	.008
	(Q) Quality of documents	-5.934	1.249	-.480	-4.752	.000
	(H) Pre Q requirements	3.219	1.068	.297	3.014	.004

a Dependent Variable: (CV) Coefficient of Variation

Regression

Notes

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	Cases Used	Statistics are based on cases with no missing values for any variable used.
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Variables Entered/Removed(b)

Model	Variables Entered	Variables Removed	Method
1	(H) Pre Q requirements, (N) No. of competitors, (D) Tender duration (weeks), (Q) Quality of documents, (G) Minimum ICTAD Grading, (M) Tendering Method(a)	.	Enter

a All requested variables entered.
b Dependent Variable: (Y) % Winning margin

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.427(a)	.182	.093	8.59869

a Predictors: (Constant), (H) Pre Q requirements, (N) No. of competitors, (D) Tender duration (weeks), (Q) Quality of documents, (G) Minimum ICTAD Grading, (M) Tendering Method

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	907.187	6	151.198	2.045	.075(a)
	Residual	4066.560	55	73.937		
	Total	4973.746	61			

a Predictors: (Constant), (H) Pre Q requirements, (N) No. of competitors, (D) Tender duration (weeks), (Q) Quality of documents, (G) Minimum ICTAD Grading, (M) Tendering Method
b Dependent Variable: (Y) % Winning margin

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	17.184	8.798		1.953	.056
	(G) Minimum ICTAD Grading	.185	.876	.029	.212	.833
	(M) Tendering Method	4.179	2.572	.227	1.625	.110
	(N) No. of competitors	-.700	.379	-.249	-1.973	.070
	(Q) Quality of documents	-3.086	1.652	-.248	-1.868	.067
	(D) Tender duration (weeks)	.365	.444	.115	.821	.415
	(H) Pre Q requirements	1.615	1.357	.148	1.190	.239

a Dependent Variable: (Y) % Winning margin

Regression

Notes

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	Cases Used	Statistics are based on cases with no missing values for any variable used.
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Variables Entered/Removed(b)

Model	Variables Entered	Variables Removed	Method
1	(N) No. of competitors(a)	.	Enter

a All requested variables entered.
b Dependent Variable: (Y) % Winning margin

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.291(a)	.085	.069	8.71076

a Predictors: (Constant), (N) No. of competitors

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	421.105	1	421.105	5.550	.022(a)
	Residual	4552.642	60	75.877		
	Total	4973.746	61			

a Predictors: (Constant), (N) No. of competitors
b Dependent Variable: (Y) % Winning margin

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	14.499	2.494		5.814	.000
	(N) No. of competitors	-.818	.347	-.291	-2.356	.022

a Dependent Variable: (Y) % Winning margin