# DETERMINATION OF CONTINGENCY FOR INTERNATIONAL CONSTRUCTION PROJECTS DURING BIDDING STAGE

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# ABSTRACT


## DETERMINATION OF CONTINGENCY FOR INTERNATIONAL CONSTRUCTION PROJECTS DURING BIDDING STAGE



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Determination of contingency for international projects plays an important role for inclusion of risks taken by the contractor on the bid amount. Although determination of contingency is an important stage of bid preparation for international projects, the methods that are being used by Turkish contractors for quantification of contingency are very limited. In this thesis the factors affecting the contingency decisions of Turkish contractors for international projects will be investigated. The significance of these factors will be determined and a model determining the contingency will be developed.



Keywords: Contingency, Correlation, Regression, Neural Networks

# ÖZ

## ULUSLARARASI İNŞAAT PROJELERİ İÇİN TEKLİF HAZIRLANMASI AŞAMASINDA RİSK PRİMİNİN BELİRLENMESİ

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Uluslararası projelerde risk priminin belirlenmesi müteahhit firma tarafından alınan risklerinin teklif fiyatına yansıtılması aşamasında büyük önem taşımaktadır. Risk priminin belirlenmesi, uluslararası projelerde teklif hazırlanmasının önemli bir aşaması olmasına rağmen Türk müteahhitlik firmalarının risk priminin belirlenmesinde kullandığı yöntemler son derece kısıtlıdır. Bu araştırmada Türk müteahhitlerinin uluslararası projelerde risk primi kararlarını etkileyen faktörler incelenecektir. Bu faktörlerin önemi belirlenecek ve risk primi belirlenmesi için bir model geliştirilecektir.

Anahtar Kelimeler: Risk Primi, Korelasyon, Regrasyon, Yapay Sinir Ağları

TO MY FAMILY

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| **$** | United States Dollar |
| **AACE** | American Association of Cost Engineers |
| **APE** | Average Percentage Error |
| **CAR** | Contractors' All Risks |
| **EIB** | European Investment Bank |
| **ICRG** | International Country Risk Guide |
| **JV** | Joint Venture |
| **JBIC** | Japan Bank for International Cooperation |
| **M $** | Million Dollar |
| **NN** | Neural Network |
| **PRS** | Political Risk Services Group Company |
| **RM** | Regression Model |
| **SPSS** | Statistical Package for the Social Sciences (Computer Program) |
| **US** | United States |

# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction

Turkish contractors entered the international construction market in late 1970's and got a work load of about 1,8 billion $ (USD Dollars) in Kuwait, Iraq, Kingdom of Saudi Arabia and Libya that time. Today the statistics show that completed works in international market by the Turkish contractors have reached to 2,850 projects in 62 different countries with a total budget of 60 billion $ (USD Dollars) in late 2004's (TCIR 2004).

The changes in the Turkish construction market and the world economy have leaded Turkish contractors to search new business opportunities in the international construction markets. Therefore majority of Turkish contractors focused on international markets.

When a contractor has desire to work abroad and plans to attend a tender/bid in the new market he should get some knowledge about some parameters at the country, market and project levels (Dikmen & Birgonul 2004). After getting all these information, if the contractor decides to bid for a project in that country, a proper contingency should be used to account for the level of risk taken. Due to the nature of construction projects there are several unknowns during the bidding and also during construction process. The purpose of using a contingency in the budget is to account for the uncertainties and risks for the project bidded.

## 1.2 The Purpose of the Study

The purpose of this study is to develop a model for determining the amount of contingency during tender stage of international projects. Although determination of contingency is an important stage of bid preparation for international projects the methods that are being used by Turkish contractors for quantification of project contingency are very limited. Moreover it is almost impossible to make an estimate with proper contingency amount since it requires so much time and data. Therefore what is needed for the contractors is a model that calculates the contingency by analyzing the possible inputs in an efficient way. In this study the reasoning of the Turkish contractors for determination of contingency will be investigated. Factors that affect the contingency and the significance of these factors will be determined and a model for determining the contingency will be proposed.

This study consists of totally five chapters.

1. *Chapter 1 – Introduction:* The introduction chapter contains the general frameworks and the purpose of the study. The need and the objective of this study is clearly mentioned in this part.

2. *Chapter 2 – Contingency and the Construction Industry:* In this chapter general definitions about the contingency and the literature review forming the general structure of the contingency knowledge and the contingency calculation methods are given.

3. *Chapter 3 – The Research Methodology and the Structure of the Questionnaire:* In this chapter the research methodology, and the steps followed in forming the questionnaire and the basic framework of a questionnaire are explained in detail.

4. *Chapter 4 – The Results of the Questionnaire and the Models:* In this chapter, after the overview of the study is given, initial results obtained from the questionnaire, and the statistical methods used in the study are explained and finally the results of the models are given with their prediction performances.

5. *Chapter 5 – Conclusion:* In this chapter, a review of the results obtained is given. Additionally suggestions for the contractors and the future studies are included.

# CHAPTER 2

## CONTINGENCY AND THE CONSTRUCTION INDUSTRY

### 2.1 What's Contingency?

Contingency, which is one of the important cost elements evaluated in the cost and bid analysis, and is an integral part of the total estimated cost of a project (Ostwalt 2001). Estimation of the total project cost during the bidding stage in the international market by the contractors is an important concern for the company's competitiveness and potential profitability as it involves not only risk but also several uncertainties. Most of the time because limited information is included in the tender documents and there is limited time available to prepare the bid, most of the companies can not analyze the project and the project country conditions properly. That's one of the main reasons why construction projects are notorious for running over budget [Hester et al 1991, Zeitoun and Oberlander 1993]. And after these overruns in some projects are observed, construction companies like the other organizations from different industries recognized the importance of contingency and contingency management.

It is a well known fact that people working in the construction industry as contractors have a great potential to face with a composition of problems including lots of unknowns, undesirable, unexpected and sometimes unpredictable factors (Fong 1987). Like risk in the construction industry, there is not a single and complete definition of contingency covering all applications and that‘s why contingency is almost the most misunderstood, misapplied and misinterpreted cost element in the bid estimating. [Moselhi 1997, Patrascu 1988].

People having knowledge about different fields like economy, engineering and statistics are using all different definitions and models to explain contingency. Therefore it’s not possible to make a definition of contingency covering all the aspects of different knowledge. Since people from different fields of science work with different aspects of contingency, it might be the best way to define and describe the margins of contingency according to usage in different fields by different definitions.

In its simplest form, contingency is defined as the budget that must be added to the base estimate to account for the work that is difficult or impossible to identify at the time when the offer for such project is being prepared by Oberlender (2000).

US Department of Energy (US Department of Energy Directives 1997; (http://www.directives.doe.gov/pdfs/doe/doetext/neword/430/g4301-1chp11.pdf, latest access: 30/06/2005) defines the contingency as follows.
“Contingency covers costs that may result from incomplete design, unforeseen and unpredictable conditions, or uncertainties within the defined project scope. The amount of the contingency will depend on the status of design, procurement and construction; and the complexity and uncertainties of the component parts of the project. Contingency is not to be used to avoid making an accurate assessment of expected cost. “

Another detailed definition of contingency was made in the **AACE Cost Engineers Handbook** (AACE 1995) as;
“Contingency is a cost element of an estimate to cover a statistical probability of the occurrence of unforeseeable elements of cost within the defined project scope due to a combination of uncertainties, intangibles, and unforeseen/highly

unlikely occurrences of future events, based on management decisions to assume certain risks (for the occurrence of those events)… contingency reflects a management allowance to avoid project cost overruns (within the parameters of risk assumed) to ensure that the owner is not required to re-appropriate additional funds. At the same time contingency should not be too high to create a fat estimate. The assumption of risk for uncertainties involved makes contingency a management decision at senior management level with input from the cost and scheduling/project task force. However, it is important to have a corporate philosophy regarding contingency definition, which is understood and accepted by the owner. "

As stated above there are many different definitions of contingency and some of these stated well what contingency consists of and what contingency should not include [Querns 1989, Samid 1994]. In order to understand what contingency is, maybe it is better to define the most common elements and characteristics of contingency and highlight what contingency is not as Moselhi(1997) did.

According many cost specialists;

- There should be a defined project scope in order to talk about contingency
- Contingency covers unforeseen cost elements within that project scope
- Contingency contains cost elements resulted in uncertainties
- Contingency is related with risk. Higher the risk undertaken by the project management, lower the amount of contingency required or vise versa. Moreover we can say that contingency is an inverse function of risk. (Querns 1989)
- It is to cover additional cost resulted from; unforeseen safety and environmental requirements, design changes, changes in construction market and country conditions, technological

changes, abnormal and unexpected construction and start-up problems and etc…

- Contingency is not a profit at the bidding stage.
- Contingency is not a cash allowance
- Contingency can be defined as a function of uncertainty.

Contingency = f (uncertainty,…,…).

When the definition of the project including what it consists of is made clearly with details then the probable contingency amount lowers. Therefore we can say that contingency is an inverse function of degree of high detail work definition (Figure1). Moreover some specialists like Bulick (1993) and Lorance (1992), considered the amount of contingency as a percentage of the estimated project value depending on some variables like project definition stage.

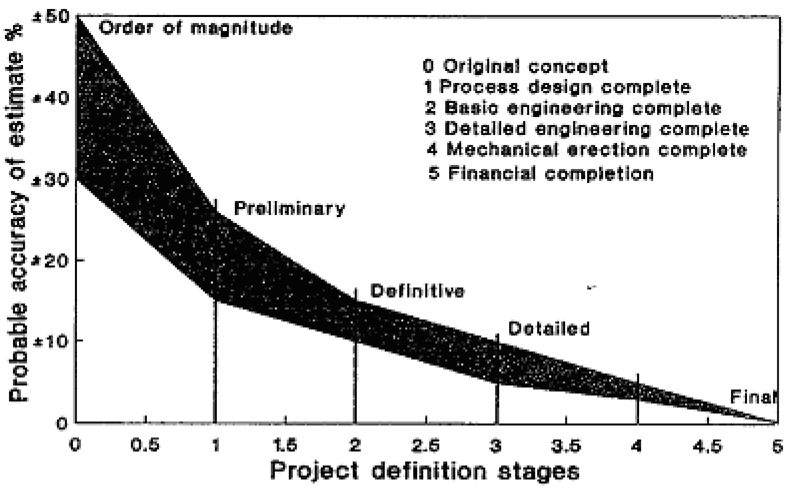


**Figure 1 : Accuracy of the Cost Estimate (Moselhi 1997)**

- Contingency is not intended to cover overhead costs.
- Unpredictable risks should not be included, natural disasters etc…
- Contingency should not include any costs related with escalation.

- It is not an insurance
- It should not include any cost items that had already defined in another cost item like overhead, insurance or some else.

To summarize, it is a must to define and quantify the contingency in detail, in order to not only make a realistic but also a competitive estimate. One of the main reasons for using the contingency amount is that, it will never be possible to identify and quantify all risks related with the projects. Therefore a safety margin covering the unexpected costs should also be put in the cost breakdown while preparing for the tender budget. To determine the margin of amounts some techniques are used.

## 2.2 Contingency Estimation Methods

After the importance of the contingency is understood by the contractors, they have developed different techniques for the estimation of the contingency [Ahmad 1992, Curran 1989, Touran and Wiser 1992]. Contingency estimation for a project at tender stage can be done in many different ways, consisting of different models.

Contingency estimation methods or models can be classified as follows;

1. Predetermined Constant Percentage
2. Experts Judgment
    - Single Percentage for the all cost items
    - Different Percentage for different cost items
3. Probabilistic & Statistical Models
    - Assigning Probabilities to Cost Items
    - Contingency Estimation by PERT

- Monte Carlo Analysis & Regression & Simulations

### 2.2.1 Predetermined Constant Percentage

Not only had some of the Turkish contractors, but also many of the worldwide international contractors use predetermined constant percentage values for the contingency estimation. They prefer not change the contingency value for different kinds of projects. These kinds of companies generally use contingency amounts in between %5 and %10 of the base estimate (Burroughs and Jubtima 2004). Companies that do smaller projects in similar nature generally use this kind of a technique.

### 2.2.2 Experts Judgment

As can be understood from its name, this type of estimation is based on the construction management team's experience, based on feeling and intuition (Moselhi 1997).

#### 2.2.2.1 Single Percentage For All Cost Items

In this type of a model, the estimator tries to identify and quantify the risks related with the subject project by using the historical data of the company and his own experience. The difficulty in using such method to estimate the new contingency amount is, the projects should be the same kind in many aspects so that they can be comparable easily and effectively. Another problem about using this method is that, its high related with the persons feelings at the time of estimating. For example it's possible for the same person to use different values of contingency amount for a subject project from morning to evening. In order to make a fine and accurate contingency estimation using this method, the estimator should be an expert not only in tender preparation but also in remembering the past projects.

#### 2.2.2.2 Different Percentages for Different Cost Items

In fact this method is not very different from the single percentage for all cost items method explained above. The main difference of this method from the previous method is that; this method uses different contingency amounts or percentages (called $C_i$) for different cost items (called $T_i$). The cost of the project including just the contingency amount not the other parameters used in the mark up estimation is formulized as follows;

$$TCC = \sum_{i=1}^{n} T_i \times (1 + C_i) \qquad [1]$$

where

TCC = Total Cost of the Project including just Contingency not the other parameters used in mark up

n = Total number of cost items in the project's bill of quantity

However, using this kind of a contingency estimation does not necessarily mean that we could not calculate the overall contingency for the project. When we divide the sum of contingencies for the all cost items listed in the bill of quantities to the estimated project total cost we get the overall contingency amount of the project.

To formulize;

$$PT = \frac{1}{TC}\sum_{i=1}^{n} T_i \times C_i \qquad [2]$$

where

| | | |
|---|---|---|
| PT | = | Project overall contingecy |
| n | = | Total number of cost items in the project bill of quantity |
| TC | = | Estimated target cost of the subject project |

As can be seen from the formula this method deals with every cost item separately and assigns different contingency amounts to each cost items. Analyzing every cost item in terms of contingency makes the estimator to draw a free body diagram of the cost items and visualize the effects of every cost item on the total body. This method is more detailed than the previous method on the other hand it is time consuming, and by analyzing every cost item separately to give different contingencies may disturb the overall unique behavior of the body.

Rusteika and Boomer (1992) developed a contingency assessment as a percentage of the estimated construction cost similar to different percentages for different cost items method in the Central Artery (I-93) / Tunnel (I-90) (CA/T) project in Boston, Massachusetts. In this project contingency assessment is generally developed by the committee consisting of the project engineer, section scheduler, representatives from claim departments and so on. Rusteika and Boomer (1992) tried to determine the contingency amount by using a method based on the management consultants' experience, which analyzes the risks associated with the subject contract based on factors and criteria. These factors are; design difficulty, geological conditions, economic environment, joint occupancy of site, schedule constraints, period of performance and urban environment. Although it is a fact that these factors are not the only factors that affect the contingency, the idea is that these are the primary factors that can cause significant changes on the project. These factors were assigned to different weights according to its difficulty level in between 0 and 0.15 and different rates showing the level of effect of that item on the overall contingency were consistently used through different types of construction projects. The contingency for the each factor was determined by multiplying the weight by the factor. For the model used in this project, since the total of the rates were 100 and they were fixed, the contingency amount should be between 0% and 15% for every type of project. The limitation of this model is that, the maximum amount of contingency that could be used is fixed to 15%.

### 2.2.3 Probabilistic Models

#### 2.2.3.1 Assigning Probabilities to Cost Items

Assigning probabilities to all cost items can be defined as a differentiated method of assigning different percentage of contingencies to different cost items. Although there are some similarities, they have some differences as the followings (Moselhi 1997);

1. Models in which probabilities are assigned to cost items (also known as Probabilistic itemized model) depends on an Italian economists rule known as Vilfredo Pareto's Law or law of significant few and the insignificant many (80/20 rule).

   Pareto's Law: In the late 1800s, economist and avid gardener Vilfredo Pareto established that 80% of the land in Italy was owned by 20% of the population. He later recognized that 20% of the peapods in his garden yielded 80% of the peas that were harvested. And thus this theory was born (Figure 2) (Pareto's Law, Last accessed 15/05/2005, http://home.alltel.net/mikeric/Misc/Pareto.htm).

This means that in contingency estimating, %80 of the things that triggers contingency are associated with %20 of the defined cost items.

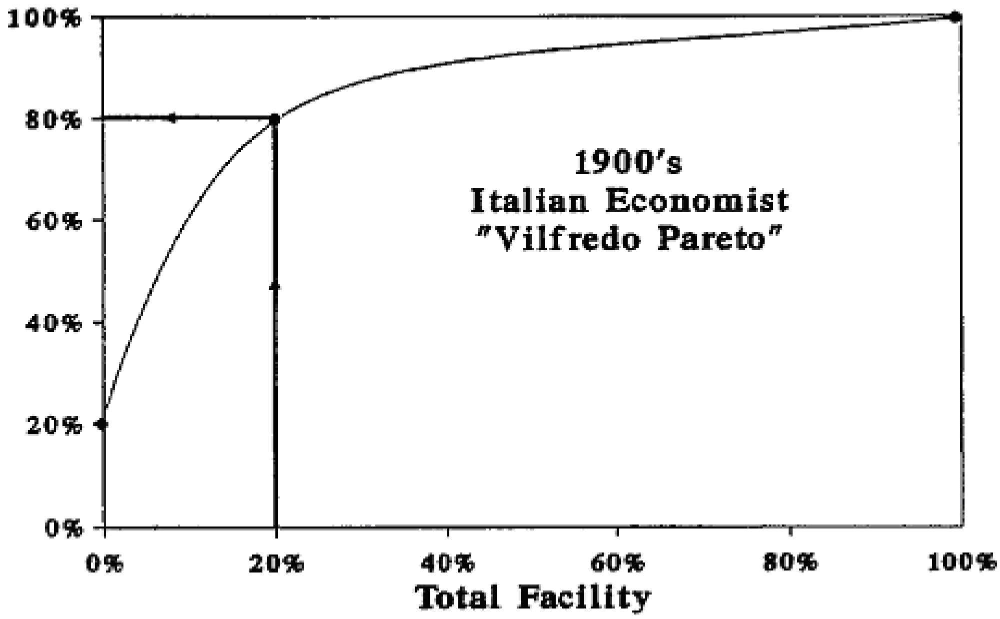


**Figure 2: Pareto Model (Moselhi 1997)**

2. It assigns a contingency amount to each significant cost item however this time rather than giving a percentage value of each cost item for its contingency it allocates a probability value to each significant cost item to define its contingency amount.

These significant cost items in an estimate can be defined as a cost element, whose actual value may vary from its target cost either as an increase or decrease, by such a magnitude that the bottom line cost of the project would change by an amount greater than the critical variance. This critical amount is defined by most of the estimators as a percentage of 2% to 5% according to estimation method used (Curran 1989). The important step after identifying the significant items is that, probability for not exceeding the estimated cost for all the significant cost items should be determined. Most of the time these probabilities are determined by using personnel experience of the estimator or by using historical data in a similar way to that used in program evaluation and review technique. (Hendrickson 1989, Stevens 1990)

To formulize;

$$PT = \frac{1}{TC}\sum_{i=1}^{m}(1 - P_i) \times C_i \qquad [3]$$

Where

| | | |
|---|---|---|
| m | = | total number of significant cost items |
| TC | = | estimated target cost of the subject project |
| $C_i$ | = | every significant cost item |
| $P_i$ | = | every significant cost items probability for not exceeding its estimated cost |

As can be seen from the formula above, in this method only the project risks were considered by using the probabilities, however some specialist thought that this is not enough for estimating a contingency amount, and added opportunity effects on the formula and get;

$$PT = \frac{1}{TC}\left[\sum_{i=1}^{r}(1 - P_i) \times (SC_i)_i - \sum_{j=1}^{g} P_j \times (OC)_j\right] \qquad [4]$$

where

| | | |
|---|---|---|
| r | = | the number of cost items representing risk or loss |
| g | = | the number of cost items representing opportunity or gain |
| $(SC)_i$ | = | the potential risk or cost overrun associated with the *i*th significant cost item |
| $(OC)_j$ | = | potential cost saving or gain associated with the *j*th |

opportunity type cost item

$P_j$ = the probability of occurance of $(OC)_j$

Curran (1989) also stated that its not always easy to quantify the probability values. He proposed a qualitative assessment and then transfer the the input into a qualitative form. The first step is to identfy whether it is that the cost elements actual value be equal to or less than its target. He made scale as in Figure 3 and quantitate the results. He also suggested that whether its not easy to make a choose in between two qualitative assessments according to its likely or unlikely condition we can use a corresponding mid point value (for example in between very and highly 75% or 25%-Figure 3).

| **Likely** | | | | **Equally Likely as Unlikely** | **Unlikely** | | | |
|---|---|---|---|---|---|---|---|---|
| Extremely | Highly | Very | Somewhat | | Somewhat | Very | Highly | Extremely |
| 90% | 80% | 70% | 60% | 50% | 40% | 30% | 20% | 10% |

**Figure 3: Probability Values (Curran 1989)**

**2.2.3.2 Contingency Estimation by PERT**

The well known and mostly used in scheduling, Program Evaluation and Review Technique (PERT) was developed in the late 50's (Aquino 1992). PERT method is mainly based on the central limit theorem in which the summation of a number of totally independent random observations $X_1$, $X_2$,…,$X_n$ from any population each with a variance $V(C_1)$, $V(C_2)$, …, $V(C_n)$ and expected values as $E(C_1)$,$E(C_2)$, …, $E(C_n)$ is an other random variable 'Y' having a normal probability distribution with a variance of sum of the variances of the population

[6] and with an estimated value of summation of the estimated values of the population [5] (Ostwald 2001, Johnson & Wichern 1992).

$$E(C_Y) = E(C_1) + E(C_2) + ... + E(C_n) \qquad [5]$$

$$V(C_Y) = V(C_1) + V(C_2) + ... + V(C_n) \qquad [6]$$

When applying PERT method to the critical path of the project network, mainly three different cost estimates for each item are needed. These costs can be named as; optimistic cost ($E_o$), pessimistic cost ($E_p$) and most likely cost ($E_m$). Since the general population Y has a normal probability distribution, these optimistic and pessimistic values are generally considered to be in ranges of %5 and %95. There are mainly two different ways of obtaining and defining these three values depending on the data available supporting the main estimate. These values can be obtained either in quantitatively based on the historical data or qualitatively based on feelings and experience. When there is not enough data available to support the estimate, the estimator mainly uses his or her experience to determine three costs. Then the expected cost $E_e$ [7] and the variance $V_p$ [8] is calculated as follows:

$$E_e = \frac{\lfloor E_o + E_p + (4 \times E_m) \rfloor}{6} \qquad [7]$$

$$V_p = \left[ \frac{(E_p - E_o)}{3,2} \right]^2 \qquad [8]$$

In case of the estimator or the company has a set of historical data then the expected cost is the arithmetic mean of the sample data set containing $E_1$, $E_2$, …, $E_i$, …, $E_n$ [9].

$$E_e = \frac{E_1 + E_2 + ... + E_i + ... + E_n}{n} \qquad [9]$$

Main problem about this method is that, the methodology is based on the independence between the variables and it requires a huge and correct database. To summarize, for this method, three cost estimates for each cost item with a probability density function is needed in order to calculate the project target cost with its probability density function.

### 2.2.3.3 Monte Carlo Analysis

Monte Carlo simulation was developed by a mathematician called Stanislow Ulan while they were working on nuclear physics. Monte Carlo analysis is mainly used to determine risks/opportunities for projects and also for contingency estimation (Clark 2001, Lorance 1992). In general three cost estimates as optimistic cost ($E_o$), pessimistic cost ($E_p$) and most likely cost ($E_m$) for each of the cost item is estimated and by using a statistical program, combinations of randomly selected values with in the predetermined cost ranges are calculated and the total project cost is obtained. In this way Spooner (1974) and Touran (1992) divided the activities of a sample project into some groups according to their risk level. Since low risk level activities do not have so many uncertainties as the high risk level activities have, single value is put for them in the bill of quantities. In all Monte Carlo analysis, a probability density function is derived and the contingency could be used as a function of confidence level (Smith & Bohn 1999)

Main problem in this kind of risk analysis is that, project risks are generally determined by terms such as high, medium and low. For quantifying these variables, Fuzzy sets were used (Paek et al. 1993). For these kind of systems, identification of the risk elements and quantifying all these elements by Fuzzy sets are not very easily applied by the contractors that, they prefer to use these systems in the projects classified as big and in the high risk level.

One of the advantages of the Monte Carlo simulation is that this model can be used with correlation (Touran & Wiser 1992). But, when large numbers of simulations are carried out, effective computational software and a person with that knowledge has to be needed. Because of time and complexity of the techniques used in the contingency estimating these kinds of estimating tools are not well suited for small projects.

Similar to these, Hong Kong government also introduced a model for over exaggerated contingency amounts called Estimating Using Risk Analysis (ERA) [Mak et al 1998, Mak 2000]. In this model some probabilities were assigned to fixed risk items. On the other hand variable risk events were quantified by the project team members based on experience. Apart from the similar problems of the other probabilistic models resulting from quantification of the variable risk events, this technique was just used for some housing projects in Hong Kong. Calculating the project contingencies by considering the expected number of changes, the effects of delay on costs and the correlation between the costs is calculated in studies by Touran (2003-1, 2003-2)

In a study done by Smith & Bohn (1999), risk modeling techniques are reviewed for their contribution to contingency estimating. At the end of their study they concluded that most of the modeling techniques do not consider the competition affect in their calculation steps, however the small and medium contractors' decision on the amount of the contingency is mainly dependent to their competence level and desire. This idea seems to be valid just in the local markets, because when we think of the international construction market, small companies are directly eliminated, and the remaining ones (medium and large scale contractors) generally do not venture to submit their offer prices without any contingencies. Because in international contracting not only the market and the project risks determine the success of the project but also the countries risks play an important role on contingency decisions.

Assuming or estimating the correct amount of contingency is not always enough for a project to be addressed as successive. Therefore a good knowledge of contingency management should be used in the construction phase. When we look at the perspective of the project manager, in order to satisfy the project objectives, usage of the budget contingencies and the strategies for contingency management have to be identified clearly. (Ford 2002)

In summary, calculating the contingency amount of the project at the bid stage is one of the difficult jobs that the estimating manager or the project management group should tackle with. When different types of estimating methods are considered, certain methods seem to give more reliable and more accurate results than the others. However the easiest way to assign a contingency amount for a project still seems to be by using the experts' judgments for Turkish contractors. Using risk analysis techniques may give better results than using only the experts judgments in case of a detailed definition of the project is supplied. However we should not forget that if the project is not defined well, then the risk analysis methods could possibly give exaggerated contingency amounts (Burroughs & Juntima 2004). Therefore selection of the calculation method depends on mainly the general situation of the project.

Another technique, that could be applied for contingency calculation is the regression analysis. In order to construct a regression model detailed project data have to be obtained. Different from the risk analysis techniques, regression analysis is based on the actual data, not assuming any probability distributions or any weights for contingency determination. Another advantage of using regression models is that, since the historical data forms the base of the models, the need for a skilled expert on every project is not expected (Burroughs & Juntima 2004).

Although a considerable amount of time and knowledge about the model and the data of projects have to be supplied for the initial steps in forming the model, it might one of the easiest methods to use afterwards. Therefore if enough attention is paid during the model formation, regression models could be easily and effectively used in the contingency estimation processes. These advantages of regression analysis techniques for contingency estimation were the main reasons why this technique was proposed for contingency estimation of Turkish contractors for international projects.

# CHAPTER 3

## THE RESEARCH METHODOLOGY AND THE STRUCTURE OF THE QUESTIONNAIRE

### 3.1 The Research Methodology

In the first part of this study, a survey form was developed in the form of a questionnaire consisting of two parts to compile project data of Turkish contractors. The framework used in this questionnaire was constructed in two stages. First of all a detailed literature review on contingency was performed and initial variables were identified from published sources. A preliminary questionnaire was formed by using the significant factors identified in those sources. The initial factors were identified by analyzing the following studies;

1. Icram-1: Model for International Construction Risk Assesment; By Makarand Hastak and Aury Shaked (Journal of Management in Engineering, Jan-Feb 2000)
2. Political Risks in International Construction; By David B.Ashley and Joseph J. Borner (Journal of Construction Eng. And Management, ASCE 113(3) - 1987)
3. Making a Risk Based Bid Decision for Overseas Construction Projects; By Seung H.Han and James E. Diekmann (Construction Management and Economics 19 – 2001)

4. Risk and Risk Management in Construction: A Review and future Directions for Research; By P.J. Edwards and P.A. Bowen (Engineering Construction and Architectural Management 5/4 – 1998)

After the initial survey form was developed 5 experts who were working on a position related to tendering were interviewed to get feedback on the survey form prepared. During tendering these experts usually generate a table consisting of the general informations and the contract clauses those are crucial for the estimation of the contingency amount. These clauses generally include;

- Source of fund
- Permanent and temporary works
- Amount of the advance payment
- Alternative bids
- Amount of third party insurance
- Type of the currency that the progress payments will be made
- Duration of the project
- Bid – Performance bond amount
- Documents comprising the bid
- Delay penalty amounts (per day and total)
- Type of contract

The contract clauses together with the project, and country conditions played an important role on the contingency decisions of Turkish contractors. By using the experts' opinions and warnings, the questionnaire was modified and the final questionnaire form was formed.

The questionnaire consists of questions about the project, and the country conditions at the same time. Similar to this questionnaire Hastak & Shaked (2000) constructed a framework consisting of mainly three layers (macro level, market level and project level) for the risk assessment in international construction works. Also, Ashley and Bonner (1987) have developed a model for political risk assessment in international construction market. But their study only identifies the impact of political changes and the problems resulting from political decisions in the subject country based on the available data set about that country. Ashley and Bonner (1987) did not consider the effects of country, market and project related impacts on the project and its cost. The same problem is also valid for the Hastak & Shaked (2000). They have defined the risk category of the project whether it is risky or high risky but they did not give any comment about expected/estimated contingency amount to be used under those circumstances.

## 3.2 The Structure of the Questionnaire

The questionnaire used to obtain data from the Turkish construction companies in this thesis consists of mainly two parts (Appendix A).

In the first section;
There are some questions to be answered by the respondent person about the company's age, size, labor force and experience in both local and international market. Moreover there are also some other questions about the type, financial status and some contractual clauses such as penalties of the project. In the first part there are totally 29 questions to be answered mainly about the company and the project. Apart from the first section, the second part consists of 56 questions about the country's political and economical conditions, construction market conditions and opportunities and the project.

In order to make an easy going and understandable questionnaire, a scale consisting of numbers from 0 to 5 with the meanings as shown in Table 1 was used.

To answer these questions the respondent should select the best appropriate choice from the scale considering the conditions at the tender date. If the question is not applicable with the subject project then the respondent should mark 0. When the respondent thinks that the question totally fits the idea that they had thought at the date of tender preparation then the respondent should mark 5 if vice versa then the respondent should mark 1. When the respondent thinks that the idea in the question is either wrong or true then the respondent should mark 3. Depending on the level of agreement with the question the respondent also has an option to maker levels of 2 and 4 for the questions.

**Table 1: Scale used in the Questionnaire**

| Scale No | Meaning |
|---|---|
| 0 | Not Applicable |
| 1 | Totally Wrong |
| 2 | Wrong |
| 3 | Either Wrong or True |
| 4 | True |
| 5 | Totally True |

The questionnaire was designed to understand and model the factors behind contingency decisions of Turkish contractors for international projects. In general the framework of the questionnaire can be summarized as the follows;

**Part 1**

General information about the company

1- Type, size and the experience of the company
2- Total amount of projects that the company finished in local and international market

3- Whether the company has already done a job in the subject country or not

General information about the project

1- Type of the project
2- General conditions about the contract (Project duration, method for progress payments, advance payment amount, contract type, financing, profit amount, insurance and contingency amounts, position of the company in the project, delay penalties, bid-performance bond …)

**Part 2**

General information about the country that the project will be implemented

1- Political conditions (Political stability, bureaucratic delays, instability because of changes in laws and orders, hostilities with the neighboring countries …)
2- Financial \ economical conditions (Monetary inflation, income, money transfer, financial stability, tax systems, import\export conditions …)
3- Social conditions (Ethnic and other kind of fractionalizations, level of telecommunication, general behavior of people to foreigners …)

General information about the market that the project will be implemented

1- Relation between the both parties (Employer and the contractor)
2- Quality and availability of materials
3- Quality and availability of local subcontractors
4- Quality and availability of skilled labor
5- Future market opportunities
6- Labor productivity \ cost

General information about the project that will be implemented

1- Contractual clauses (Safety and environmental clauses)
2- Experience of the consultant \ employer
3- Agreement terms in between the partners (Designer – contractor, in between the partners of the partnerships)
4- General conditions of the construction site (Weather, security level, ground conditions, etc)
5- Construction method
6- Quality and detail of the contract documents

This questionnaire consists of the factors that were thought to have significant effect on the contingency estimation. It is also possible to enlarge the questions listed in the questionnaire but then it would be more difficult and time consuming to fill out the questionnaire which may also decrease the accuracy of the answers given by the respondents.

# CHAPTER 4

## THE RESULTS OF THE QUESTIONNAIRE, AND THE MODELS

### 4.1 An Overview of the Study

The questionnaire developed was sent to 48 Turkish construction companies which were bidding for international projects and had previously responded to inquiries about the research related to construction management. In the explanation part of the questionnaire the purpose and the details of the questionnaire was explained and companies were requested to have the questionnaires completed by professionals specialized in estimating and tendering. 25 questionnaires from 23 (48%) companies were completed and returned.

In addition to these, the questionnaire was also emailed to all Turkish construction companies having international experience and which are members of Turkish Contractors Association excluding the ones that the questionnaire was send previously. But only one reply was obtained by this way.

### 4.2 Results of the Questionnaire

Experience was the first factor included in the questionnaire. The level of experience of the companies responded to the research is given in Table 2. As it can be seen from the Table 2, more than 75% of the contractors, that provided the data for this study, have a construction experience of at least 15 years.

**Table 2: Experience of the Contractors**

| Years of Experience | No of Companies | Percentage |
|---|---|---|
| 0-15 Years | 6 | 23,08% |
| 15-25 Years | 5 | 19,23% |
| 25-35 Years | 6 | 23,08% |
| 35-45 Years | 7 | 26,92% |
| 45-55 Years | 1 | 3,85% |
| 55-65 Years | 0 | 0,00% |
| 65-75 Years | 1 | 3,85% |
| **Total** | **26** | 100,00% |

First 10 years of these 15 years of experience can be regarded as a time, spend in the local market in order to gain some experience and knowledge about the construction industry because most of the experts interviewed agree that its better to start working in the international market after having a stable and powerful position in local market so that the company can use the political force of his own country in resolving the claims with the foreign country.

In order to visualize the size and capacity of the companies that provided data for the study, Table 3 that is showing the number of companies with their total value of completed works in Turkey was constructed. From the table (Table 3) it can be observed that the companies provided data for this study had almost a homogenous distribution in terms of the total value of the works completed in Turkey.

Total value of completed works for more than half of the Turkish construction companies that attended the survey was over 200 M$. And also more than half of these companies have reached a total completed work budget in local construction market of 1 billion dollars (Table 3).

**Table 3: Total Value of Completed Works in Turkey**

| Total Value Of Completed Projects $ (in Turkey) | No of Companies | Percentage |
|---|---|---|
| 0 - 50.000.000 $ | 5 | 19,23% |
| 50,000,000 $ - 200,000,000 $ | 7 | 26,92% |
| 200,000,000 $ - 1,000,000,000 $ | 6 | 23,08% |
| > 1,000,000,000 $ | 8 | 30,77% |
| **Total** | **26** | 100,00% |

However in the international construction market, total value of completed works for more than half of the Turkish companies that provided data for the study was below 100 M$, showing that total value of completed works in Turkey for these contractors is still larger than the works that were completed in abroad (Table 4).

**Table 4: Total Value of Completed Projects in Abroad**

| Total Value Of Completed Projects $ (Abroad) | No of Companies | Percentage |
|---|---|---|
| 0 - 25.000.000 $ | 7 | 26,92% |
| 25,000,000 $ - 100,000,000 $ | 9 | 34,62% |
| 100,000,000 $ - 500,000,000 $ | 5 | 19,23% |
| > 500,000,000 $ | 5 | 19,23% |
| **Total** | **26** | 100,00% |

At first glance, another important parameter that has to be considered about contingency seems to be the type of projects. Almost 40% percent of the projects that were used as a data for this study were transportation projects (Table 5). Size and duration of the projects could also be considered as other important parameters which may affect contingency decisions. Average value of the 26 projects that the data for this study was collected from was nearly 62,000,000 USD $ with a minimum cost of 10,000,000 USD $ and a maximum cost of 400,000,000 USD $ worth infrastructure project. Total construction duration of the projects varies in between 12 months to 36 months.

**Table 5: Type of Projects**

| **Type Of Project** | **No of Projects** | **Percentage** |
|---|---|---|
| Infrastructure Projects | 8 | 30,77% |
| Housing Complex - Residential Projects | 5 | 19,23% |
| Transportation Projects | 10 | 38,46% |
| Industrial Projects | 3 | 11,54% |
| **Total** | **26** | 100,00% |

How the projects, that the data for this study was collected from, were tendered, and their contract type were summarized in Table 6. In this study, %69 of the projects was unit price contract type. The remaining projects (%31) were Lump Sum. Majority of the projects (54%) was tendered by pre-qualification and only 8% of the projects were tendered by invitation. The remaining projects (38%) were tendered by using post qualification procedures.

**Table 6: Contract Types and Way of Tendering**

| Project No | Way of Tendering | Contract Type |
|---|---|---|
| Project 1 | Post Qualification | Unit Price |
| Project 2 | Post Qualification | Unit Price |
| Project 3 | Post Qualification | Lump Sum |
| Project 4 | Pre Qualification | Lump Sum |
| Project 5 | Post Qualification | Lump Sum |
| Project 6 | Pre Qualification | Unit Price |
| Project 7 | Pre Qualification | Unit Price |
| Project 8 | Pre Qualification | Unit Price |
| Project 9 | Pre Qualification | Lump Sum |
| Project 10 | Post Qualification | Unit Price |
| Project 11 | Post Qualification | Unit Price |
| Project 12 | Pre Qualification | Unit Price |
| Project 13 | Post Qualification | Unit Price |
| Project 14 | Post Qualification | Unit Price |
| Project 15 | Pre Qualification | Unit Price |
| Project 16 | Pre Qualification | Unit Price |
| Project 17 | Pre Qualification | Unit Price |
| Project 18 | Pre Qualification | Unit Price |
| Project 19 | Pre Qualification | Unit Price |
| Project 20 | Post Qualification | Unit Price |
| Project 21 | Pre Qualification | Lump Sum |
| Project 22 | By Invitation | Unit Price |
| Project 23 | Pre Qualification | Lump Sum |
| Project 24 | Post Qualification | Lump Sum |
| Project 25 | By Invitation | Unit Price |
| Project 26 | Pre Qualification | Lump Sum |

In the tenders where pre-qualification procedures were applied, the contractors were asked to submit their pre-qualification documents first to ensure the owner that they had the ability and the capability of doing the work in means of both technical and financial aspects. Occasionally the pre qualification documents and the financial offer were submitted at the same time (post qualification procedure).

Apart from the other parameters, one of the most important factors about international contracting and contingency estimation of these projects is the location of the project. It is not easy to mobilize and construct a work in a location that you have no information about before; therefore most of the contractors select the countries, where they can easily access, supply material and labor force and etc. Moreover the security level of the country, the behavior of the living people towards the foreigners, and the attitude of the employer are also important for the determination of the contingency level.

The data of this study included 26 projects located in 21 different countries from Middle East, Europe and Asia. These countries include Afghanistan, Algeria, Bulgaria, Germany, Iraq, Ireland, Jordan, Kazakhstan, Lebanon, Pakistan, Poland, Qatar, Romania, Russia, Syria, Tunisia, Turkmenistan, Tajikistan, United Arab Emirates (Dubai), Ukraine, and Uzbekistan.

The amounts of contingencies used for 26 projects in this study were between 0% and 30% of the calculated projects cost. In 75% of these projects, contractors preferred to use a contingency amount less than 10 percent of the calculated project cost. There is only one project, which was constructed in Iraq, with a contingency amount larger than 15% of the total calculated project cost (Table 8). Most of the time, when the unknowns and the difficulties of the works increase, contractors increase their contingency amounts. The range in the values of contingencies that Turkish contractors use for different projects and countries confirms that, Turkish contractors do not only work in the very risky environments (Iraq, Afghanistan, etc), but also in other areas where the risk is less (Germany, Ireland, and etc…).

**Table 7: Contingency Amounts**

| Contingency Amount | No of Projects | Percentage |
|---|---|---|
| 0.00% - 5.00% | 10 | 38,46% |
| 5.00% - 10.00 % | 10 | 38,46% |
| 10.00% - 15.00% | 5 | 19,23% |
| > 15.00% | 1 | 3,85% |
| **Total** | **26** | 100,00% |

In this thesis, in order to analyze and make a model for contingency estimation, statistical concepts correlation and regression analysis were used to determine the relationship in between variables and contingency. After the regression models were obtained, a neural network model was also constructed to check the need for a non-linear interaction term between the variables and the contingency. The prediction performance of the regression and the neural network model were compared to decide whether regression models were sufficient. The results of the correlation analysis, regression and the neural network models can be found in the following sections.

### 4.3 Correlation Method Used and Results

When we have two variables, and would like to make an analysis in between these two variables then the analysis in between those variables may focus on (Zou 2003);

a) Any association between the variables,
b) The value of one variable predicting the other variable, and
c) The amount of agreement.

The aim of making a correlation analysis is to measure the linear or non linear relationship between two or more variables for example, to what degree does one variable go up (or down) in relation to changes in the other variable (Zou, 2003).

The main objective of the correlation analysis is to gain the strength of the relationship in between two variables (Krzanowsk, 1988) (Rodriquez, 1982). All correlation coefficients can range from -1.00 to +1.00 and they have mainly two important characteristics (Zizzi, 2005);

a) Direction
b) Magnitude

As mentioned, correlation coefficients can be either negative or positive. Positive correlation values indicate that when one variable increases the other also tends to increase. Negative correlation values indicate that when one variable decreases the other variable also tends to decrease. The value of -1.00 represents for a totally perfect negative correlation whereas a value of +1.00 represents a totally perfect positive correlation.

The strength of the correlation in between two variables can be calculated by taking the absolute value of the correlation coefficient. Therefore whether the coefficient is negative or positive if they have the same absolute value then their strength is the same. However their tendency with the other variable may vary because they might have different signs therefore different directions.

In order to visualize, following scatter plots (Figure 4 & Figure 5) illustrates several situations of correlations. The scatter plots presented in Figure 4 and

Figure 5 may be the best way to understand how the correlation coefficient changes as the linear relationship between the two variables are altered.

For example in the Figure 4, Variable X & Y have a correlation coefficient of 1, meaning a perfectly positive relation is valid.

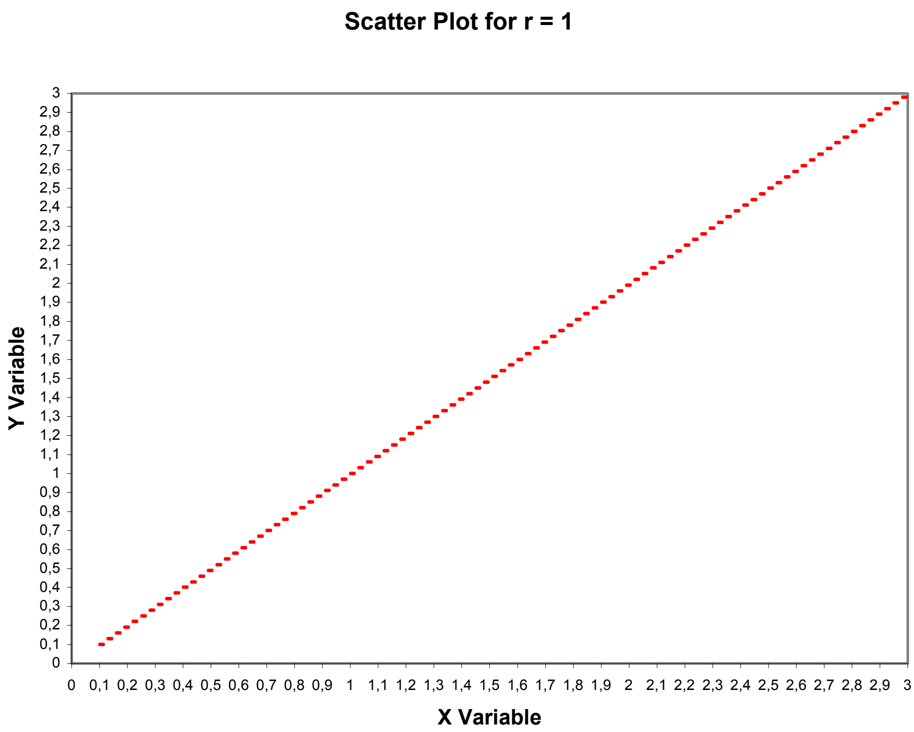


**Figure 4: Scatter plot for r=1.00**

However in the Figure 5 Variable X & Y have a correlation coefficient of -1.00, which means a perfectly negative relation.

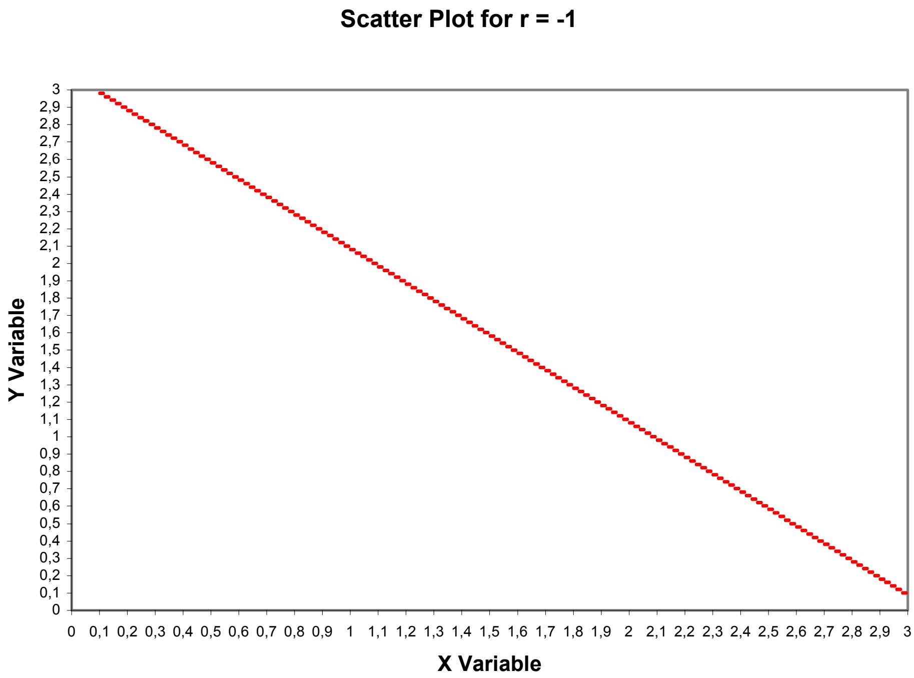


**Figure 5. Scatter plot for r=-1.00**

Although there are some types of correlation methods and coefficients, the most widely used type of correlation coefficient is Pearson's Correlation Coefficient (r), which is also used in our study. For a data set with two variables, x and y, the sample estimate of the correlation coefficient is calculated as;

$$r = \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \overline{x})^2 \sum_{i=1}^{n}(y_i - \overline{y})^2}} \qquad [10]$$

where;

$\overline{x}$ = Average value of x

$\overline{y}$ = Average value of y

The Pearson Correlation Coefficient is also known as the sample-linear correlation coefficient or product – moment correlation coefficient (Neter J, 1990). It was first introduced by Galton in 1887 (Galton 1887, Galton 1888) and developed by Pearson (Pearson K 1896). Pearson's correlation coefficient requires both variables to be measured on an interval or ratio scale and the calculation is based on the actual values (Altman, 1991).

To summarize the correlation properties;

1. $-1.00 \leq r \leq +1.00$
2. The larger the absolute value of r, the stronger the linear relation
3. Sign of the coefficient tells the direction of the relationship
4. r is dimensionless
5. Its value is valid only with in the range of values of x and y

In our data pool, we have totally 56 questions in the second part and 29 questions in the first part. By using a statistical computer program called SPSS, we have calculated the Pearson Correlation Coefficients of not only the variables obtained from the questionnaire but also the country ratings obtained from ICRG. Some variables such as companies' partnership type, project type, condition of additional payments due to changes in costs, type of tendering, type of financing and the companies position (main contractor, partner of a JV and etc…) in the tender were categorical variables. For these variables dummy variables were used for correlation analysis. As an example; for project type four dummy variables were used for industrial projects, transportation projects, infrastructure projects and housing projects. If the project type was industrial, the industrial dummy variable was equal to 1 and all other project type dummy variables were equal to zero, and so on. When we have checked the results, the contingency amount seems to have a significant correlation with 14 different variables. These variables are;

1. Country Risk Rating (Composite Risk Rating from ICRG-PRS Group)
2. Advance Payment Amount

3. Type of Contract (Unit price or Lump Sum)
4. Frequent changes in Law and Orders
5. Condition of the labor laws in the country related to contractors workforce
6. Street Violence – Civil War
7. Availability of material in the local market providing the desired quality and properties
8. Problems about stating the responsibility of the each partner in JV or Consortium agreements
9. Contractual Clauses about safety and environmental conditions
10. Possibility to finish the project on time
11. Level of congestion at site
12. Security conditions in the site
13. Attitude of the people living in the country to foreigners
14. Level of preparation for the tender

Tables 8 to 21 display Pearson correlation coefficients, significance values, and the number of cases with non-missing values (N) for the 14 variables. This significance values obtained from the SPSS can be used for the determining the importance of the correlations between the variables and the contingency (Ott 1988). The variables that had a correlation coefficient, which was significant at 0.05, were considered as significant variables in our study.

In the first correlation result given in Table 8, the correlation coefficient between contingency and country rating was –0.713. Since –0.713 is relatively close to 1, this indicates that contingency and country rating are negatively correlated. The significance of each correlation coefficient is also displayed in the correlation table. For the correlation between the contingency amount and the country rating, the significance level or p-value was 0.000, which indicates that contingency amount and country rating are significantly negatively correlated. As country rating increases contingency decreases.

**Table 8: Correlation Result 1**

| | |
|---|---|
| **Correlation Results** | |
| **1. Contingency & Country Rating** | |
| - Pearson Correlation | -.713(**) |
| - Sig. (2-tailed) | .000 |
| - N | 26 |
| ** Correlation is significant at the 0.01 level (2-tailed). | |

Country rating values were the composite risk ratings, which were taken from the publishing's of PRS Group (ICRG 2004). In these ratings it is observed that high rankings were used for the low risk level countries and low rankings for high-risk level countries

In the second correlation result given in Table 9, Pearson correlation coefficient between the contingency amount and the advance payment amount was -0.476, which shows a negative correlation. Moreover the significance level was 0,016, which indicates that when the amount of advance payment increases, the amount of contingency decreases.

**Table 9: Correlation Result 2**

| | |
|---|---|
| **Correlation Results** | |
| **2. Contingency & Advance Payment** | |
| - Pearson Correlation | -.476(*) |
| - Sig. (2-tailed) | .016 |
| - N | 25 |
| * Correlation is significant at the 0.05 level (2-tailed). | |

In the third correlation result given in Table 10, Pearson correlation coefficient between the contingency amount and the contract type was 0.427, which shows a positive correlation. In this correlation in order to classify the contract types “0” was used for unit price contracts and “1” was used for lump sum type contracts. Moreover the significance level of the correlation was 0.03 that indicates that when the contract type is 1, the contingency amount is larger. Its meaningful that in lump sum contracts since the contractor is responsible for the completion of works without an increase in the project cost, it’s the contractors responsibility to foreseen all the unexpected events that will occur during the work. Therefore contractors increase their contingency margin to be in the safe side in Lump Sum contracts.

**Table 10: Correlation Result 3**

| **Correlation Results** | |
|---|---|
| **3. Contingency & Contract Type** | |
| - Pearson Correlation | .427(*) |
| - Sig. (2-tailed) | .030 |
| - N | 26 |
| * Correlation is significant at the 0.05 level (2-tailed). | |

In the fourth correlation result given in Table 11, Pearson correlation coefficient between the contingency amount and the question 4 of section 2 of the questionnaire was 0.428, which shows a positive correlation. In this correlation in order to classify the results of the question 4, the numbers in the scale were used. For example, the increase in the scale number (max 5) shows that the contractor frequently observed changes in laws and orders in the country at the tender preparation period. Moreover it is seen that the significance level was

0.029, which indicates that when the level of changes in laws and orders increase, the contingency amount also increases.

**Table 11: Correlation Result 4**

| | | |
|---|---|---|
| **Correlation Results** | | |
| **4.** | **Contingency & Section II - Question 4** | |
| - | Pearson Correlation | .428(*) |
| - | Sig. (2-tailed) | .029 |
| - | N | 26 |
| | * Correlation is significant at the 0.05 level (2-tailed). | |

In the fifth correlation result given in Table 12, Pearson correlation coefficient between the contingency amount and the question 17 of section 2 of the questionnaire was 0.408, which shows a positive correlation. Also the significance level was 0.039, which indicates that when the level of working conditions to be supplied by the contractor increases, the contingency amount also increases. This result is not surprising because it is not possible for a foreign company to have a wide knowledge about the labor law of the country; and most of the contractors add a safety amount to their contingency amount for this variable.

**Table 12: Correlation Result 5**

| | | |
|---|---|---|
| **Correlation Results** | | |
| **5.** | **Contingency & Section II - Question 17** | |
| - | Pearson Correlation | .408(*) |
| - | Sig. (2-tailed) | .039 |
| - | N | 26 |
| | * Correlation is significant at the 0.05 level (2-tailed). | |

In the sixth correlation result given in Table 13, Pearson correlation coefficient between the contingency amount and the question 19 of section 2 of the questionnaire was 0.581, which shows a positive correlation. The significance level of the correlation was 0.002, which indicates that when the coefficient used to indicate the strength of street violence occurrence in the country increases the contingency amount also increases. It's not easy to work in an area where there is street violence because in a situation like this nobody exactly knows what the conditions will be or the problems that they will face with the day after tomorrow. Therefore when the contractors decided to work in these kinds of areas, they definitely add some extra amount for the unforeseen events that will result from this disorder.

**Table 13: Correlation Result 6**

| **Correlation Results** | |
|---|---|
| **6. Contingency & Section II - Question 19** | |
| - Pearson Correlation | .581(**) |
| - Sig. (2-tailed) | .002 |
| - N | 25 |
| ** Correlation is significant at the 0.01 level (2-tailed). | |

In the seventh correlation result given in Table 14, Pearson correlation coefficient for the contingency amount and the question 24 of section 2 of the questionnaire was 0.421, which shows a positive correlation. The significance level of the correlation was 0.032, which indicates that when the problems related to materials that provide the desired quality and properties increases the contingency amount also increases.

**Table 14: Correlation Result 7**

| **Correlation Results** | |
|---|---|
| **7. Contingency & Section II - Question 24** | |
| - Pearson Correlation | .421(*) |
| - Sig. (2-tailed) | .032 |
| - N | 26 |
| * Correlation is significant at the 0.05 level (2-tailed). | |

In the eight correlation result given in Table 15, Pearson correlation coefficient between the contingency amount and the question 37 of section 2 of the questionnaire was 0.472 with a significance level of 0.015. This means that when the responsibility of the each partner in the project is not clear then the contractors increase the contingency amount.

**Table 15: Correlation Result 8**

| **Correlation Results** | |
|---|---|
| **8. Contingency & Section II - Question 37** | |
| - Pearson Correlation | .472(*) |
| - Sig. (2-tailed) | .015 |
| - N | 26 |
| * Correlation is significant at the 0.05 level (2-tailed). | |

In the ninth correlation result given in Table 16, Pearson correlation coefficient between the contingency amount and the question 40 of section 2 of the questionnaire was 0.553 with a significance level of 0.003. This indicates that as the difficulty in applying the safety and environmental clauses of the contract, increases, the contractors increase the contingency amount.

**Table 16: Correlation Result 9**

| **Correlation Results** | | |
|---|---|---|
| **9.** | **Contingency & Section II - Question 40** | |
| - | Pearson Correlation | .553(**) |
| - | Sig. (2-tailed) | .003 |
| - | N | 26 |
| | ** Correlation is significant at the 0.01 level (2-tailed). | |

In the tenth correlation result given in Table 17, Pearson correlation coefficient between the contingency amount and the question 42 of section 2 of the questionnaire was 0.420 with a significance level of 0.033. This significance level indicates that when it is less probable to finish the project within the specified duration, contractors use higher contingency amounts.

**Table 17: Correlation Result 10**

| **Correlation Results** | | |
|---|---|---|
| **10.** | **Contingency & Section II - Question 42** | |
| - | Pearson Correlation | .420(*) |
| - | Sig. (2-tailed) | .033 |
| - | N | 26 |
| | * Correlation is significant at the 0.05 level (2-tailed). | |

In the eleventh correlation result given in Table 18, Pearson correlation coefficient between the contingency amount and the question 44 of section 2 of the questionnaire was 0.502, which shows a positive correlation. The significance level of this correlation was 0.009, which indicates when the site is expected to be congested contractors use higher contingency amounts.

**Table 18: Correlation Result 11**

| **Correlation Results** | | |
|---|---|---|
| **11.** | **Contingency & Section II - Question 44** | |
| - | Pearson Correlation | .502(**) |
| - | Sig. (2-tailed) | .009 |
| - | N | 26 |
| | ** Correlation is significant at the 0.01 level (2-tailed). | |

In the twelfth correlation result given in Table 19, Pearson correlation coefficient between the contingency amount and the question 49 of section 2 of the questionnaire was 0.528 with a significance level of 0.006. This indicates that when the construction site is not secure, the contractors increase the amount of contingency.

**Table 19: Correlation Result 12**

| **Correlation Results** | | |
|---|---|---|
| **12.** | **Contingency & Section II - Question 49** | |
| - | Pearson Correlation | .528(**) |
| - | Sig. (2-tailed) | .006 |
| - | N | 26 |
| | ** Correlation is significant at the 0.01 level (2-tailed). | |

In the thirteenth correlation result given in Table 20, Pearson correlation coefficient between the contingency amount and the question 53 of section 2 of the questionnaire was 0.510, which shows a positive correlation. The significance level of the correlation was 0.008, indicating that when the attitude of the people to foreigners in the country is negative; the contractors increase the contingency amount.

**Table 20: Correlation Result 13**

| **Correlation Results** | | |
|---|---|---|
| **13.** | **Contingency & Section II - Question 53** | |
| - | Pearson Correlation | .510(**) |
| - | Sig. (2-tailed) | .008 |
| - | N | 26 |
| | ** Correlation is significant at the 0.01 level (2-tailed). | |

In the last correlation result given in Table 21, Pearson correlation coefficient between the contingency amount and the question 55 of section 2 of the questionnaire was 0.558 with a significance level of 0.003. This indicates that when the contractors are not prepared for the tender properly with the sufficient detail they increase the contingency level in their cost estimating.

**Table 21: Correlation Result 14**

| **Correlation Results** | | |
|---|---|---|
| **14.** | **Contingency & Section II - Question 55** | |
| - | Pearson Correlation | .558(**) |
| - | Sig. (2-tailed) | .003 |
| - | N | 26 |
| | ** Correlation is significant at the 0.01 level (2-tailed). | |

The next step of this study concerns development of a model to estimate contingency using the determined significant parameters.

### 4.4 Regression Model & Results

Regression analysis is a statistical tool for evaluating the relationship of one or more independent variables $X_1$, $X_2$, $X_3$, ..., $X_n$ to a single, continuous dependent variable Y. This analysis is generally preferred when the independent variables can not be controlled (Kleinbaum et al. 1988). These models are used to predict one variable from one or more other variables. The purpose of regression is different from the correlation. In correlation analysis the purpose is to examine the direction and the strength of the relationship where as in regression relative impact of a predictor variable on a particular outcome is evaluated (Zou et al. 2003).

Linear regression models estimate the equation of the best fit line in the data pool. The simplest and the quickest way is drawing a line by eye in the scatter plot. However this method is not a trusted way of doing the analyses, therefore a technique called least squares method is used instead. The least square line is the line that has the smallest sum of squared vertical distances from the observed points to the line (Kleinbaum et al. 1988). Basically the simplest form of a regression analysis consists of one dependent (Y) and one independent variable (X), and since the model simply fits to the equation of the best fit line it can be written as;

$$y = \beta_0 + \beta_1 x \qquad [11]$$

where $\beta_1$ is the slope of the straight line showing the change in dependent variable for a unit change in the independent variable, and $\beta_0$ is the point where the line crosses y axis at x=0.

But this is not the only case. There is also multiple regression analyses method to be applied for the cases where there is again only one dependent variable but more than one independent variable. To formulize, a general view o multiple regression is as follows;

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + ... + \beta_n x_n , \qquad [12]$$

where $\beta_0, \beta_1, \beta_2, \beta_3, ..., \beta_n$ are the regression coefficients that are to be calculated after the analyses and $X_1$, $X_2$, $X_3$, ..., $X_n$ are the independent variables. These independent variables can be not only basic single variables but also can be functions consisting more than one variable.

### 4.4.1 Selection Method for the Adequate Regression Equation

In this study, steps followed for determining the adequate regression equation in order to have the adequate results and prediction performances are as follows;

1 Specify the initial regression model
2 Specify a strategy for Selecting Variables
3 Conduct the specified analyses
4 Evaluate the performance of the model chosen.

**STEP 1: Specifying the Initial Regression Model**

In this study initial regression model was the preliminary model that all other models will be derived from. In our initial regression model, we had 14 different independent variables derived from correlation analysis and one dependent variable as contingency. These independent variables, were the ones that were thought to have significant effect on contingency, were coming from results of questions related with the following items listed below;

1. Country Risk Rating (Composite Risk Rating from ICRG-PRS Group)
2. Advance Payment Amount
3. Type of Contract (Unit price or Lump Sum)
4. Frequent changes in Law and Orders
5. Condition of the labor laws in the country related to contractors workforce
6. Street Violence – Civil War
7. Availability of material in the local market providing the desired quality and properties
8. Problems about stating the responsibility of the each partner in JV or Consortium agreements
9. Contractual Clauses about safety and environmental conditions
10. Possibility to finish the project on time
11. Level of congestion at site
12. Security conditions in the site
13. Attitude of the people living in the country to foreigners
14. Level of preparation for the tender

At this stage our regression model (Model 1) was in the following form;

$$y = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \ldots + \beta_{13} x_{13} + \beta_{14} x_{14}$$

[13]

**STEP 2: Specifying Strategy for Selecting Variables**

Another important decision to find the adequate model in this study was the strategy for selecting the variables. The number of variables remained in the final model were also determined by this strategy. Generally this strategy is done in two different ways in regression analysis. First one is forward regression modeling in which the user adds one single variable in each forward step, and the other one is the backward elimination in which a variable is deleted at every backward step. In this study backward elimination method is used. In this kind of technique, by using just the necessary parameters model that fits the data is formed.

In backward elimination method, all of the variables are entered in a single step and one variable at a time is removed from the model based on the pre selected removal criteria. In this study variables were removed starting from the initial regression equation depending on significance of the F test value. Steps followed in this study performing the backward elimination can be summarized as follows;

1. Determination of the regression equation containing all the independent variables
2. Calculation of the F test statistic of the each variable entered in the model by using the following equation;

$$F_{test\,i} = \left(\frac{\beta_i^{\,2}}{S_{\beta_i}^2}\right) \qquad [14]$$

Where;

| | | |
|---|---|---|
| $F_{test\,i}$ | = | F test value for the variable *i* |
| $\beta_i$ | = | Coefficient of the variable *i* in the given model |
| $S_{\beta_i}$ | = | Standart error for the variable *i* |

3. Focus on the lowest F test value
4. Compare the lowest F test value with the predetermined critical F value. If the F test value is smaller than the predetermined critical F value, then remove the independent variable from the list and run regression again, vice versa stop regression analysis.

In the SPSS program, in order to remove a variable from the model probability of 0.10 for the F value were used.

At the start of the elimination, the first model was formed by 14 independent variables and 1 dependent variable. In Table 22 variables entered to the regression Model 1 are listed with their F test values. In the first model the minimum F test value was 0.031 and came from the question 44 of section 2 (Table 22).

**Table 22: F Test Values for Regression Model 1**

| Model | Variables Entered | F test Value |
|---|---|---|
| 1 | Country Rating | 10.668 |
| | Advance Payment Amount (%) | 0.487 |
| | Type Of Contract | 2.064 |
| | Question No: 4 Section: 2 | 0.086 |
| | Question No: 17 Section: 2 | 1.445 |
| | Question No: 19 Section: 2 | 0.285 |
| | Question No: 24 Section: 2 | 0.339 |
| | Question No: 37 Section: 2 | 0.671 |
| | Question No: 40 Section: 2 | 0.976 |
| | Question No: 42 Section: 2 | 0.131 |
| | *Question No: 44 Section: 2* | *0.031* |
| | Question No: 49 Section: 2 | 0.300 |
| | Question No: 53 Section: 2 | 0.078 |
| | Question No: 55 Section: 2 | 0.714 |

The F critical value was 3.26 for Model 1 (Probability of F for Removal = 0.100) and since the minimum F test value 0.031 was smaller than this value, variable called *Question No: 44 Section: 2* was deleted from the main model.

The regression was run again with 13 independent variables this time and Model 2 was formed. F test values for the variables entered the second model can be seen in Table 23.

**Table 23: F Test Values for Regression Model 2**

| Model | Variables Entered | F test Value |
|---|---|---|
| **2** | Country Rating | 12.098 |
| | Advance Payment Amount (%) | 0.977 |
| | Type Of Contract | 4.251 |
| | Question No: 4 Section: 2 | 0.156 |
| | Question No: 17 Section: 2 | 1.564 |
| | Question No: 19 Section: 2 | 0.386 |
| | Question No: 24 Section: 2 | 0.513 |
| | Question No: 37 Section: 2 | 0.708 |
| | Question No: 40 Section: 2 | 1.050 |
| | Question No: 42 Section: 2 | 0.119 |
| | Question No: 49 Section: 2 | 0.319 |
| | *Question No: 53 Section: 2* | *0.077* |
| | Question No: 55 Section: 2 | 0.922 |

The F critical value was 3.29 for Model 2 (Probability of F for Removal = 0.100) and since the minimum F test value 0.077 was smaller than this value, variable called *Question No: 53 Section: 2* was deleted from the second model. After this, the regression was run again with 12 independent variables this time and Model 3 was formed. F test values for the variables entered the third model can be seen in Table 24.

**Table 24: F Test Values for Regression Model 3**

| Model | Variables Entered | F test Value |
|---|---|---|
| 3 | Country Rating | 13.796 |
| | Advance Payment Amount (%) | 1.239 |
| | Type Of Contract | 4.647 |
| | Question No: 4 Section: 2 | 0.193 |
| | Question No: 17 Section: 2 | 1.702 |
| | Question No: 19 Section: 2 | 0.408 |
| | Question No: 24 Section: 2 | 0.623 |
| | Question No: 37 Section: 2 | 0.703 |
| | Question No: 40 Section: 2 | 1.065 |
| | *Question No: 42 Section: 2* | *0.128* |
| | Question No: 49 Section: 2 | 0.442 |
| | Question No: 55 Section: 2 | 0.932 |

The F critical value was 3.23 for Model 3 (Probability of F for Removal = 0.100) and since the minimum F test value 0.128 was smaller than this value, variable called *Question No: 42 Section: 2* was deleted from the main model. After this, the regression was run again with 11 independent variables this time and Model 4 was formed. F test values for the variables entered the fourth model can be seen in Table 25.

**Table 25: F Test Values for Regression Model 4**

| Model | Variables Entered | F test Value |
|---|---|---|
| 4 | Country Rating | 16.085 |
| | Advance Payment Amount (%) | 1.264 |
| | Type Of Contract | 7.547 |
| | *Question No: 4 Section: 2* | *0.264* |
| | Question No: 17 Section: 2 | 1.720 |
| | Question No: 19 Section: 2 | 0.480 |
| | Question No: 24 Section: 2 | 1.469 |
| | Question No: 37 Section: 2 | 0.860 |
| | Question No: 40 Section: 2 | 1.818 |
| | Question No: 49 Section: 2 | 0.339 |
| | Question No: 55 Section: 2 | 1.094 |

The F critical value was 3.18 for Model 4 (Probability of F for Removal = 0.100) and since the minimum F test value 0.264 was smaller than this value, variable called *Question No: 4 Section: 2* was deleted from model. Then, the regression was run again with 10 independent variables this time and Model 5 was formed. F values for the variables entered the Model 5 can be seen in Table 26.

**Table 26: F Test Values for Regression Model 5**

| Model | Variables Entered | F test Value |
|---|---|---|
| 5 | Country Rating | 16.891 |
| | Advance Payment Amount (%) | 1.333 |
| | Type Of Contract | 9.493 |
| | Question No: 17 Section: 2 | 1.578 |
| | Question No: 19 Section: 2 | 0.337 |
| | Question No: 24 Section: 2 | 1.556 |
| | Question No: 37 Section: 2 | 1.129 |
| | Question No: 40 Section: 2 | 1.783 |
| | *Question No: 49 Section: 2* | *0.180* |
| | Question No: 55 Section: 2 | 1.146 |

The F critical value was 3.14 for Model 5 (Probability of F for Removal = 0.100) and since the minimum F test value 0.180 was smaller than this value, variable called *Question No: 49 Section: 2* was deleted from the fifth model. After this, the regression was run again with 9 independent variables this time and Model 6 was formed. F test values for the variables entered the sixth model can be seen in Table 27.

**Table 27: F Test Values for Regression Model 6**

| Model | Variables Entered | F test Value |
|---|---|---|
| 6 | Country Rating | 17.915 |
| | Advance Payment Amount (%) | 1.896 |
| | Type Of Contract | 10.022 |
| | Question No: 17 Section: 2 | 1.487 |
| | *Question No: 19 Section: 2* | *0.530* |
| | Question No: 24 Section: 2 | 2.208 |
| | Question No: 37 Section: 2 | 1.294 |
| | Question No: 40 Section: 2 | 2.252 |
| | Question No: 55 Section: 2 | 1.026 |

The F critical value was 3.10 for Model 6 (Probability of F for Removal = 0.100) and since the minimum F test value 0.530, was smaller than this value, variable called *Question No: 19 Section: 2* was deleted from the sixth model. Then, the regression was run again with 8 independent variables this time and Model 7 was formed. F test values for the variables entered the seventh model can be seen in Table 28.

**Table 28: F Test Values for Regression Model 7**

| Model | Variables Entered | F test Value |
|---|---|---|
| 7 | Country Rating | 21.475 |
| | Advance Payment Amount (%) | 2.195 |
| | Type Of Contract | 12.420 |
| | Question No: 17 Section: 2 | 1.648 |
| | Question No: 24 Section: 2 | 2.506 |
| | Question No: 37 Section: 2 | 1.448 |
| | Question No: 40 Section: 2 | 2.092 |
| | *Question No: 55 Section: 2* | *0.774* |

The F critical value was 3.07 for Model 7 (Probability of F for Removal = 0.100) and since the minimum F test value 0.774, was smaller than this value, variable called *Question No: 55 Section: 2* was deleted from the seventh model. Then, the regression was run again with 7 independent variables this time and Model 8 is formed. F test values for the variables entered the eighth model can be seen in Table 29.

**Table 29: F Test Values for Regression Model 8**

| Model | Variables Entered | F test Value |
|---|---|---|
| 8 | Country Rating | 24.291 |
| | Advance Payment Amount (%) | 2.638 |
| | Type Of Contract | 12.103 |
| | *Question No: 17 Section: 2* | *1.109* |
| | Question No: 24 Section: 2 | 2.237 |
| | Question No: 37 Section: 2 | 1.158 |
| | Question No: 40 Section: 2 | 2.213 |

The F critical value was 3.05 for Model 8 (Probability of F for Removal = 0.100) and since the minimum F test value 1.109 was smaller than this value, variable called *Question No: 17 Section: 2* was deleted from the eighth model. Then, the regression was run again with 6 independent variables this time and Model 9 was formed. F test values for the variables entered the ninth model can be seen in Table 30.

**Table 30: F Test Values for Regression Model 9**

| Model | Variables Entered | F test Value |
|---|---|---|
| 9 | Country Rating | 23.097 |
| | Advance Payment Amount (%) | 4.357 |
| | Type Of Contract | 11.652 |
| | Question No: 24 Section: 2 | 8.650 |
| | *Question No: 37 Section: 2* | *1.772* |
| | Question No: 40 Section: 2 | 2.394 |

The F critical value was 3.03 for the Model 9 (Probability of F for Removal = 0.100) and since the minimum F test value 1.772, was smaller than this value, variable called *Question No: 37 Section: 2* was deleted from the ninth model. After this, the regression was run again with 5 independent variables this time and Model 10 was obtained. F test values for the variables entered the tenth model can be seen in Table 31.

**Table 31: F Test Values for Regression Model 10**

| Model | Variables Entered | F test Value |
|---|---|---|
| 10 | Country Rating | 23.837 |
| | Advance Payment Amount (%) | 4.966 |
| | Type Of Contract | 14.297 |
| | Question No: 24 Section: 2 | 10.077 |
| | *Question No: 40 Section: 2* | 2.157 |

The F critical value was 3.01 for the Model 10 (Probability of F for Removal = 0.100) and since the minimum F test value 2.157 was smaller than this value, variable called *Question No: 40 Section: 2* was deleted from the tenth model. Then, the regression was run again with 4 independent variables this time and Model 11 is formed. F test values for the variables entered the eleventh model and the F value and standard error of the Model 11 can be seen in Table 32 and Table 34 respectively.

**Table 32: F Test Values for Regression Model 11**

| Model | Variables Entered | F test Value |
|---|---|---|
| **11** | Country Rating | 23.177 |
| | Advance Payment Amount (%) | 5.577 |
| | Type Of Contract | 23.674 |
| | Question No: 24 Section: 2 | 15.523 |

The F critical value was 2.99 for Model 11 (Probability of F for Removal = 0.100) and since the minimum F test value 5.577, was not smaller than this value, none of the variables were deleted in eleventh model, which only includes the significant variables.

Table 33 summarizes the backward elimination procedure by showing the excluded variables in each regression model with their F test and F critical values.

**Table 33:Excluded Variables With F Test Values in Regression Models**

| Model No | Excluded Variables | F test | F critical | Method |
|---|---|---|---|---|
| **2** | Question No: 44 Section: 2 | 0.031 | 3.26 | Backward Elimination Method. (Criterion: Probability of F-to-remove >=.100). |
| **3** | Question No: 53 Section: 2 | 0.077 | 3.29 | Backward Elimination Method. (Criterion: Probability of F-to-remove >=.100). |
| **4** | Question No: 42 Section: 2 | 0.128 | 3.23 | Backward Elimination Method. (Criterion: Probability of F-to-remove >=.100). |
| **5** | Question No: 4 Section: 2 | 0.264 | 3.18 | Backward Elimination Method. (Criterion: Probability of F-to-remove >=.100). |
| **6** | Question No: 49 Section: 2 | 0.180 | 3.14 | Backward Elimination Method. (Criterion: Probability of F-to-remove >=.100). |
| **7** | Question No: 19 Section: 2 | 0.530 | 3.10 | Backward Elimination Method. (Criterion: Probability of F-to-remove >=.100). |
| **8** | Question No: 55 Section: 2 | 0.774 | 3.07 | Backward Elimination Method. (Criterion: Probability of F-to-remove >=.100). |
| **9** | Question No: 17 Section: 2 | 1.109 | 3.05 | Backward Elimination Method. (Criterion: Probability of F-to-remove >=.100). |
| **10** | Question No: 37 Section: 2 | 1.772 | 3.03 | Backward Elimination Method. (Criterion: Probability of F-to-remove >=.100). |
| **11** | Question No: 40 Section: 2 | 2.157 | 3.01 | Backward Elimination Method. (Criterion: Probability of F-to-remove >=.100). |

**STEP 3: Conducting the Analyses**

After getting the adequate model from backward elimination, goodness of fit of the model is checked. Our adequate model was;

$$y = 24.727 - (0.337 \times \chi_1) - (0.307 \times \chi_2) + (5.863 \times \chi_3) + (2.230 \times \chi_4) \qquad [15]$$

Where;

| | | |
|---|---|---|
| $y$ | = | Contingency Amount (% of the contract price) |
| $\chi_1$ | = | Country Rating obtained from PRS |
| $\chi_2$ | = | Advance Payment Amount (% of contract price) |
| $\chi_3$ | = | Type of Contract (Lump Sum or Unit Price) |
| $\chi_4$ | = | Availability of materials in the country |

By using the data of the projects in equation [15], the contingency amount was calculated as %29 for the highest risk condition represented by the project from Iraq, and %0 for the lowest risk condition represented by the project from Germany.

**Table 34: Anova Table of Regression Model 11**

| **Model** | | **Sum of Squares** | **df** | **Mean Square** | **F** | **Sig.** |
|---|---|---|---|---|---|---|
| **11** | **Regression** | 740.335 | 4 | 185.084 | 32.362 | 0 |
| | **Residual** | 108.665 | 19 | 5.719 | | |
| | **Total** | 849 | 23 | | | |

After Model 11 has been developed, in order to measure the goodness of fit, the model is used to calculate the contingency values fitted. It has been observed that there is not too much difference in between the calculated contingencies and the actual contingencies. After calculating the absolute value of difference in between the estimated and the actual value of contingency the average percentage error of the model was found as 1,74 by using the following formula.

$$APE = \frac{1}{n}\sum_{i=1}^{n}\left|actual_i - predicted_i\right| \qquad [16]$$

in which;

| | | |
|---|---|---|
| i | = | the project number. |
| N | = | total project number |
| Actual | = | actual contingency amount (% of the contract value) |
| Predicted | = | calculated contingency amount from the model (% of the contract value) |

Although the difference seems to be small we should be aware of that using the same data, which we used here to predict the contingency amounts, forms the foundation of this model. Therefore the behavior of the model for such a data out of the pool should be checked.

**STEP 4: Evaluating Prediction Performance**

In order to evaluate the prediction performance of the model, it's best to use the data that has not been used for modeling. However in this study, in order to get significant results in regression modeling, all the data available was used for the backward regression. Therefore a different technique called cross-validation was used in order to determine prediction performance of the regression model. Prediction performance was calculated by following the steps listed as Sönmez (2004) did;

1. 5 projects were randomly selected as the test samples and a new data set is formed with the remaining project data's. Now, our data pool consists of 21 project data's.
2. New model parameters from the regression analysis are determined by using this 21 project data's.

3. New regression model is used to predict the contingency amount of the projects, which were previously selected as test samples.
4. Formation of test samples by randomly selecting 5 projects at each time continues till all the all the projects were selected as test samples and the steps 1 to 3 were repeated for each the test samples.
5. Average percentage error (APE) was calculated for regression analyses.

Prediction performance of the main regression model fitted with all data and the models developed to evaluate the prediction performance are given in Table 35.

**Table 35: Performance of the Prediction Models from RM 11**

| **Model 11** | **Prediction Performance (APE)** |
|---|---|
| Main Model (Fit) | 1.74 |
| Prediction Model A | 2.16 |
| Prediction Model B | 1.47 |
| Prediction Model C | 1.97 |
| Prediction Model D | 3.44 |
| Prediction Model E | 2.37 |
| Average of Prediction Models (Model A - Model E) | 2.28 |

Although Model 11 was called as an adequate model in our model study, goodness of fit and the prediction performance of the Model 9 and Model 10 were also evaluated since not too much difference was observed in the significance values of the variables in Models 11, Model 10 and Model 9. Since more variables were included in the Model 9 and Model 10 rather than Model 11, it was expected that Model 9 and Model 10 had better goodness of fit values.

As can be seen from the Table 36, when the number of variables in the model has been increased, goodness of fit of the model has also increased. Although the goodness of fit for the main model was better at Model 9, the worst prediction performance was also belonging to Model 9 among the other models. Additionally, some negative values of contingency were also obtained in Model 9 and Model 10 while the models were used to calculate the contingency values fitted. It was not meaningful to have negative contingency values for the projects in our study. Therefore Model 9 and Model 10 were not considered as other adequate models in our study.

**Table 36: Performance of the Prediction Models from RM 9 & RM 10**

| **Model 11** | **Prediction Performance (APE) Model No:10** | **Prediction Performance (APE) Model No:9** |
|---|---|---|
| Main Model (Fit) | 1.63 | 1.56 |
| Prediction Model A | 2.07 | 1.70 |
| Prediction Model B | 1.44 | 1.49 |
| Prediction Model C | 1.67 | 2.15 |
| Prediction Model D | 3.08 | 3.44 |
| Prediction Model E | 3.16 | 2.82 |
| Average of Prediction Models (Model A - Model E) | 2.28 | 2.32 |

Another important point about the model strategy that was used till now was; only the possibility of linear relationship in between the variables was considered. However there might be a variable with a non-linear relationship between the contingency amount and the variable itself. Therefore it should be checked that whether a pure linear model such as Model 11 is sufficient or is there a need for non-linear terms in the model. For this purpose a neural network model having four independent variables of Model 11 as input variables and contingency as the output variable was constructed. Before going into detail and the results of the neural network model, it might be better to talk about neural network modeling first.

## 4.5 Neural Network Model & Results

Neural networks are adaptive statistical models based on an analogy with the structure of the brain (Abdi 2003).

These kinds of models learn to estimate the parameters of the main population from the examples. Basically a neural network consists of different layers produced by neurons.

Neurons in a neural network can be found in 3 different layers called;

1. Input Layer
2. Hidden Layer
3. Output Layer

Neurons located in the input layer receive data from the outside environment and transfer the necessary information to the hidden layer neurons. Hidden neurons are located in between the input and the output layer. When the data is transferred from the hidden neurons to the neurons located in the output layer, then the neurons transfer the calculated variables to output.

A simple neural network is modeled in Figure 6.

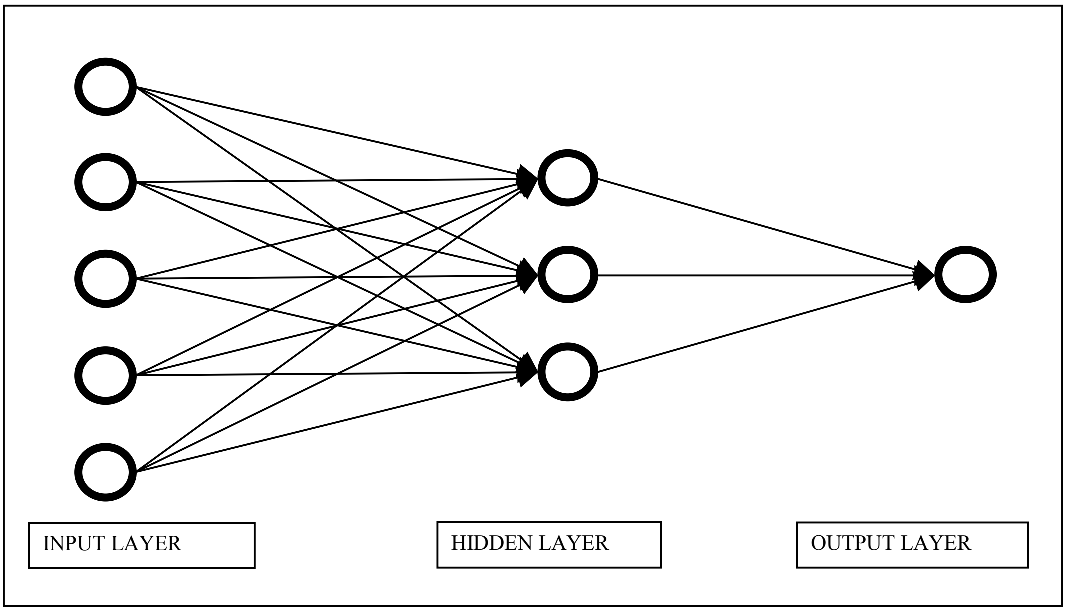


**Figure 6: A Sample NN Model**

In a neural network analysis, number of inputs and the outputs must be specified before starting the model. In our case we have four different variables as input consisting of;

1. Country Risk Rating
2. Advance Payment Amount (% of Contract Price)
3. Type of Contract (Unit Price or Lump Sum)
4. Availability of materials in the country

And one output variable as

1. Contingency Amount

After the input and output layers of the network were specified, the number of neurons in the hidden layer should be defined. There is not a strict method for defining the number of neurons in the hidden layer. In the network model developed to check linear regression model in this study, 5 hidden neurons (calculated as number of input neurons plus the number of output neurons) were used. In Figure 7, the constructed neural network model is given in which W stands for the connection weight of the layers, Σ for the summation of the input values multiplied by the connection weights, and the G for the transfer function.

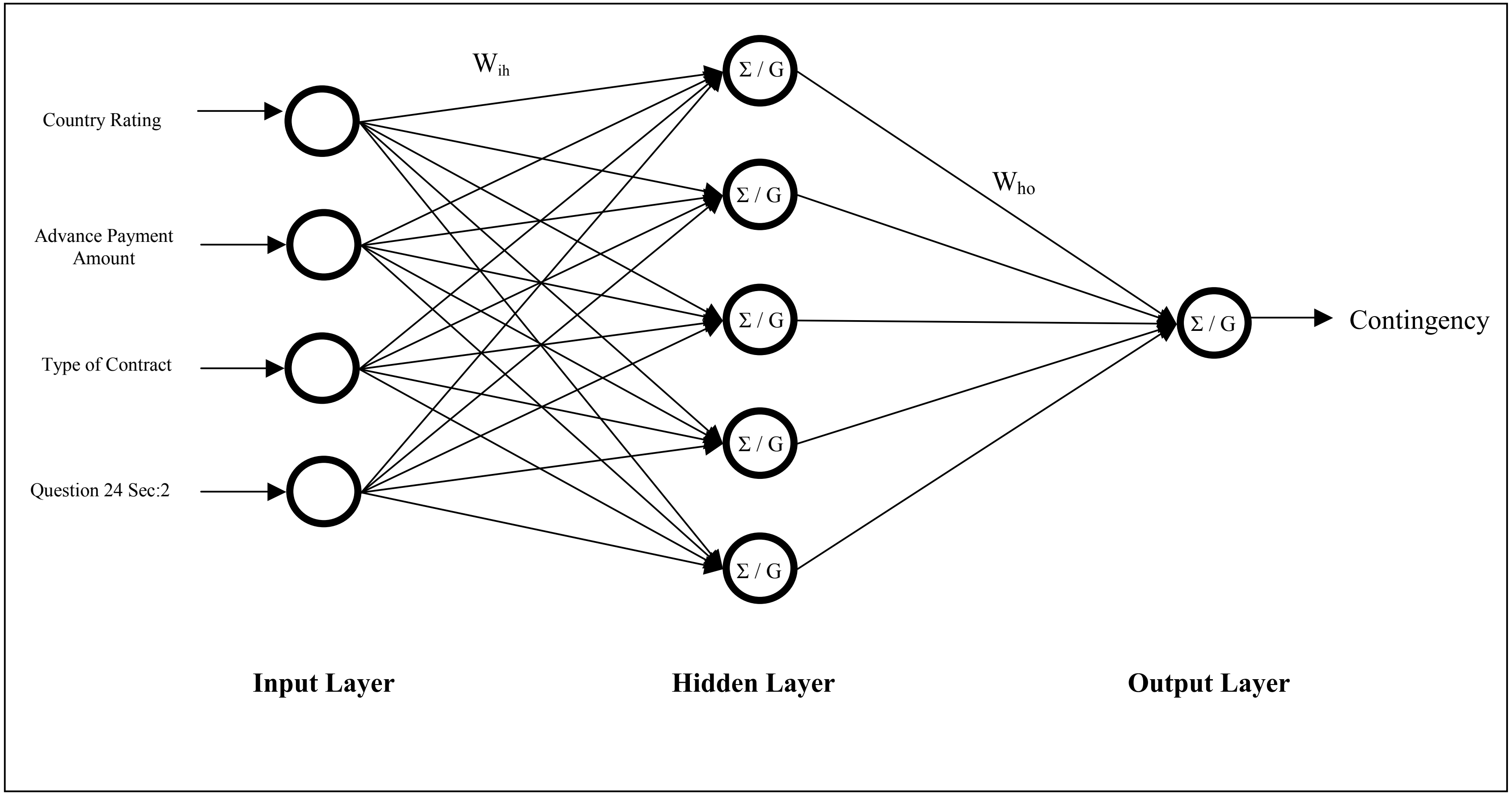


**Figure 7: NN Model used for Estimating the Contingency**

After the inputs and the output were defined in software called Net Maker to construct the main network, it was run 1000 times by using an other software named as Brain Maker. After this the data used for constructing the network were also used as a test sample and the estimated contingency values were calculated for all the projects. The average of the difference of the actual and calculated contingency values in the absolute value gives the goodness of fit of the model. As done in the regression model average percentage was calculated as;

$$APE = \frac{1}{n}\sum_{i=1}^{n}\left|actual_i - predicted_i\right| \qquad [17]$$

in which;

| | | |
|---|---|---|
| i | = | the project number. |
| N | = | total project number |
| Actual | = | given contingency amount (% of the contract value) |
| Predicted | = | calculated contingency amount from the model (% of the contract value) |

Although the fit of the model (Table 37) is not better than the Model 11, it is still possible that the model have a better prediction performance.

**Table 37: Performance of the Main Neural Network Model**

| Neural Network Model | Prediction Performance (APE) |
|---|---|
| Main Model | 1.99 |

### 4.5.1 Evaluating Prediction Performance

In order to evaluate the prediction performance of the model, like in the regression analysis cross-validation is used. Prediction performance is calculated by following the steps listed (Sönmez 2004);

1. 5 projects were randomly selected as the test samples and a new data set is formed with the remaining project data's. Now, our data pool consists of 21 project data.
2. New model parameters from the neural network analysis are determined by using this 21 project data.
3. New neural network model is used to predict the contingency amount of the projects, which were previously selected as test samples.
4. Formation of test samples by randomly selecting 5 projects at each time continues till all the all the projects were selected as test samples and the steps 1 to 3 were repeated for each the test samples.
5. Average percentage error (APE) was calculated for regression analyses (Table 38).

**Table 38: Performance of the Prediction Models for NN Analysis**

| Model from Neural Network Analysis | Prediction Performance (APE) |
|---|---|
| Prediction Model 1 NN | 2.51 |
| Prediction Model 2 NN | 1.71 |
| Prediction Model 3 NN | 2.13 |
| Prediction Model 4 NN | 6.41 |
| Prediction Model 5 NN | 4.80 |
| Average of Prediction Models (Model 1 NN- Model 5 NN) | 3.51 |

When we compare the prediction performances of the neural network and regression models, it’s easily observed that the results found from the regression analysis are better than the ones from neural network analysis. These results confirm that the linear regression model is sufficient and there is no need to add non linear or interaction terms to the model.

# CHAPTER 5

## CONCLUSION

### 5.1 Conclusions

In this thesis, a questionnaire has been designed for the purpose of understanding and modeling the reasoning behind the contingency decisions of Turkish contractors.

As a result of this survey both from the results of the questionnaires and the meeting notes between the companies tender department managers following conclusions were drawn.

- Turkish contractors use contingency, as an insurance against additional costs resulting from the unforeseen events
- If the project is not too big, then instead of calculating contingency amount by considering the probable factors, most of the Turkish contractors use a predetermined constant percent.
- If the project is too big and they behave as a part of consortium or joint venture, they prefer to calculate a new project based contingency amount by using some methods.
- Apart from the exceptions listed above, most of the time they do not change their predetermined contingency amount for different type of projects.

Although a considerable amount of time and knowledge is supplied for the development of the contingency model, the result obtained from the analysis might be one of the easiest methods to use for contingency estimating. The variables remained in the final model was selected according to their significance.

In this study data of 26 different international projects were used. As the number of the available data increases, models with more significant variables and better prediction performances can be obtained by using the procedures in this study. This study gives an alternative way of contingency estimating by using correlation, regression analysis and neural networks.

The study also provides quantified information about the contingency decisions of the Turkish contractors. The results of correlation analysis could be used to concentrate on the significant factors related to contingency decisions. The final contingency model could be used to estimate contingency or to check the contingency amount used for an international project. Understanding of factors affecting the contingency and adequate representation of the effects of the factors on contingency will improve bidding decisions especially during when some uncertainties are present.

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# APPENDICES

## A. SAMPLE QUESTIONNAIRE

### DETERMINATION OF CONTINGENCY FOR INTERNATIONAL CONSTRUCTION PROJECTS DURING BIDDING STAGE

Although determination of contingency is an important stage of bid preparation for international construction projects, the methods that are being used by Turkish contractors for quantification of project contingency are very limited. In this study the methods that are being used by Turkish contractors will be investigated. Factors that affect the country contingency and the significance of these factors will be determined and an alternative method for determining the contingency will be proposed.

Attached questionnaire consists of mainly two sections. Questions in the first section are generally related with the company itself and the tendered project. The proposed project for the questionnaire should be an international construction project.

Companies that have attended more than one tender in a country or attended different tenders in different countries could fill different questionnaires for different projects. Especially its important for us to get information about the projects in different countries for the company.

All the information obtained from the Turkish construction companies and the results obtained will be evaluated under confidentiality terms and just for academic purposes. Therefore the name of the company attended the survey and the name of the subject project does not express any meaning.

| SECTION 1: INFORMATION ABOUT PROJECT & COMPANY | | |
|---|---|---|
| 1 | **For how many years is your company working in construction business area?** | |
| 2 | **Total Value of Completed Works (Abroad) :** | ☐ 0 - 25 Million US Dollars $<br>☐ 25 – 100 US Dollars $<br>☐100 - 500 US Dollars $<br>☐ > 500 Million US Dollars $ |
| 3 | **Total Value of Completed Works (Turkey) :** | ☐ 0 - 50 Million US Dollars $<br>☐ 50 – 200 Million US Dollars $<br>☐200 – 1,000 Million US Dollars $<br>☐ > 1,000 Million US Dollars $ |
| 4 | **Type of Companies Partnership :** | ☐ |
| 5 | **Total Number of Employees in the Company :** | ☐ < 100<br>☐ 100 < ...< 500<br>☐ 500 < ...< 1500<br>☐ 1500 |
| 6 | **Name of the Subject Project :** | |
| 7 | **Type of Project:** | ☐ Pipelines (Oil,Petroleum,etc...)<br>☐ Industrial Projects (Factories etc...)<br>☐ Infrastructure Projects (WWTP, Drinking Water Treatment Projects etc...)<br>☐ Transportation Projects (Railway etc...)<br>☐ Dam Construction<br>☐ Housing Projects (Residentials etc...)<br>☐ Nuclear Plants & HEPP<br>☐ Sea Structures (Harbours etc...)<br>☐ Other please specify … |
| 8 | **Name of the Country:** | |
| 9 | **Total Project Budget:** | |
| 10 | **Progress Payments Exchange Rate:** | ☐ United States Dollars $<br>☐ Euro €<br>☐ Pound £<br>☐ Other, please specify.... |
| 11 | **Duration of the Project:** | Year Month Day |
| 12 | **Date of Tender :** | |
| 13 | **Is there a price advantage for** | ☐Yes ☐No |

| SECTION 1: INFORMATION ABOUT PROJECT & COMPANY | | |
|---|---|---|
| 14 | **Will the contract Price is to be adjusted for rises or falls in cost of labour, goods and other inputs to the works? Any additonal payment due to change in costs (escalation)?** | ☐ Yes (Unconditionally)<br>☐ Yes (Just for some circimstances that the employer gives time extensiton)<br>☐ No |
| 15 | **Advance Payment Amount (%of Contract Amount)** | % |
| 16 | **Performance Bond (% of Contract Amount)** | % |
| 17 | **Delay Damages for the Works**<br>**a – Daily (% of Contract Amount):**<br>**b – Maximum (% of Contract Amount):** | **a –** %<br>**b –** % |
| 18 | **Number of Companies Attended the Tender:** | |
| 19 | **Ranking of the given bid** | ☐ … ( 1-The lowest bid)<br>☐ Not known at the moment |
| 20 | **Time spend for tender preparation** | Year Month Day |
| 21 | **Type of Tendering** | ☐ Pre Qualification<br>☐ Post Qualification<br>☐ By invitation<br>☐ Other, please specify |
| 22 | **Contract Type:** | ☐ Design-Bid-Construct<br>☐ Design Build<br>☐ Other, please specify … |
| 23 | **Type of Payments:** | ☐ Unit Price<br>☐ Lump Sum<br>☐ Cost + Fee<br>☐ Other, please specify... |
| 24 | **Type of Financing:** | ☐ Finance Organizations – Banks (EIB,JBIC,…)<br>☐ Contractors Own Resources<br>☐ Employers Own Resources<br>☐ Other, please specify … |
| 25 | **Role / Position of the Company:** | ☐ Main Contractor<br>☐ Partner of Joint Venture (JV)<br>☐Lead Partner % ☐Partner %<br>☐ Partner of Consortium<br>☐Lead Partner % ☐Partner %<br>☐ Sub Contractor<br>☐ Other please specify… |

<table>
<tr><th colspan="3">SECTION 1: INFORMATION ABOUT PROJECT & COMPANY</th></tr>
<tr><td>26</td><td>If so, other Partners Origin:</td><td>1-<br>2-<br>3-</td></tr>
<tr><td>27</td><td>Is there any ongoing workof your company in the subject country?</td><td>☐Yes<br>☐No</td></tr>
<tr><td>28</td><td>Is this project be the first project that your company will construct in the subject country?</td><td>☐Yes<br>☐No</td></tr>
<tr><td rowspan="3">29</td><td>CONTINGENCY % [1]</td><td>%</td></tr>
<tr><td>INSURANCE %</td><td>%</td></tr>
<tr><td>PROFIT % [2]</td><td>%</td></tr>
<tr><td colspan="3">29. Ratios mentioned in quesiton 29 are to be estimated from the Total Project Amount<br>[1] Contingency amount should not include the PROFIT!.<br>[2] Can be left as it is</td></tr>
</table>

This is the end of Section 1. Please continue to Section 2.

# SECTION 2

# CONTINGENCY RELATED INFORMATION ABOUT THE PROJECT

In the table below, factors that had been thought to have significant effect (at the given tender date) on determination of the contingency is listed. A scale consisting of 5 different numbers with different meanings from “totally wrong” to “totally true” is used to determine the situation of the factor at that time. When the situations at the tender date of the subject project is considered, please select the appropriate choose by putting “x” in the table for each question.

If it is considered that the given description is not related with the subject project then please select “N/A” column by putting “x”.

If the respondent had no information about the condition given in the description column, then please do not select any choose, leave it empty.

Tick only one box for each of the question please.

| SECTION 2: CONTINGENCY RELATED INFORMATION ABOUT THE PROJECT | | | | | | | |
|---|---|---|---|---|---|---|---|
| **No** | **Description** | **(0) N/A** | **(1) Totally Wrong** | **(2) Wrong** | **(3) Either Wrong or True** | **(4) True** | **(5) Totally True** |
| 1 | There are significant fluctuations in the progress payment exchange rate of the project | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2 | There are significant and effective fluctuations in the inflation rate of the country | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 3 | There is economic crisis in the subject country | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4 | Laws and orders in the subject country changes frequently | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 5 | There are some custom and visa problems in the subject country while entering and leaving the country | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 6 | There are some problems in the import and export regulations of the country | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 7 | Money transfer from/to subject country is difficult | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 8 | There is no political stability in the country | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 9 | Occurrence of delays resulting from the bureaucracy is very much | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 10 | Communication system in the subject country is fairly bad | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 11 | There are problems with the neighboring countries | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 12 | Income rate in the country is fairly low | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 13 | Attitude of the laws and courses to the foreigner investors are not the same as natives (worse) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 14 | Tax ratios for the foreign investors are bigger than the ones for native companies in the subject country | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| SECTION 2: CONTINGENCY RELATED INFORMATION ABOUT THE PROJECT | | | | | | | |
|---|---|---|---|---|---|---|---|
| **No** | **Description** | **(0) N/A** | **(1) Totally Wrong** | **(2) Wrong** | **(3) Either Wrong or True** | **(4) True** | **(5) Totally True** |
| 15 | There is discrimination due to ethnics, color, language and etc. in the country | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 16 | There is a considerable problem of bribery and corruption in the subject country | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 17 | Condition of the labor laws in the country related to contractors workforce | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 18 | There had been frequent occurrences of strikes in the construction market | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 19 | There is civil war in the subject country | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 20 | The employer hasn't got enough experience in project management | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 21 | There are problems in availability of construction machines and spare parts in the subject country | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 22 | There are problems in the availability of local subcontractors providing the desired quality of work in the subject country | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 23 | There are problems in the availability of Labor / Foreman providing the desired characteristics in the subject country | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 24 | There are problems in the availability materials providing the desired quality and properties in the subject country | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 25 | Labor rates are fairly high in the subject country | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 26 | Efficiency / Productivity of local labor is fairly low | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| SECTION 2: CONTINGENCY RELATED INFORMATION ABOUT THE PROJECT | | | | | | | |
|---|---|---|---|---|---|---|---|
| **No** | **Description** | **(0) N/A** | **(1) Totally Wrong** | **(2) Wrong** | **(3) Either Wrong or True** | **(4) True** | **(5) Totally True** |
| 27 | There is not so much proposed new projects in the mid and long term | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 28 | Weather conditions in the area where project will be applied is very hard | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 29 | Financial condition of the employer is not well known | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 30 | For the subject project, there is a need for the new access roads to the site area | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 31 | It is almost impossible for the contractor to supply labor force from his own resources in case of a problem | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 32 | Natural disasters are frequently observed in the geographical area where the project be implemented | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 33 | Similar work experience of the contractor is not sufficient | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 34 | It is not possible to finish the necessary project works (drawings & design) on the time stated in the contract | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 35 | Drawings and the Contract are not in detail | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 36 | Applying the clauses of the contract is not such easy | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 37 | In the JV/Consortium agreements, the status and the responsibility of the each partner is not clearly stated in detail | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 38 | In the contract agreement, the function and the responsibility of the employer and the contractor is not clearly stated in detail | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| SECTION 2: CONTINGENCY RELATED INFORMATION ABOUT THE PROJECT | | | | | | | |
|---|---|---|---|---|---|---|---|
| **No** | **Description** | **(0)** N/A | **(1) Totally Wrong** | **(2) Wrong** | **(3) Either Wrong or True** | **(4) True** | **(5) Totally True** |
| 39 | Contractual clauses about the claims and arbitration are not seem to be fair from the contractors perspective | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 40 | It is difficult to correspond to the standard of environmental and job security aspects of the contract | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 41 | It is difficult to correspond to the standard of quality stated in the contract | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 42 | It is almost impossible to finish the constructions works on time | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 43 | Construction methods and the techniques that are planned to be applied are very complex for the subject project | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 44 | Planned site is very crowded and complex | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 45 | There is not enough information about the ground conditions | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 46 | There is a communication gap in between the contractor and the designer | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 47 | There is a communication gap in between the partners | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 48 | It is almost impossible to take over all the work areas on time stated in the contract | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 49 | Construction site is not very secure | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 50 | Its almost impossible to stock materials on the site | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 51 | Proposed project managers and the construction management teams experience level is not so much for such kind of a project | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| SECTION 2: CONTINGENCY RELATED INFORMATION ABOUT THE PROJECT | | | | | | | |
|---|---|---|---|---|---|---|---|
| **No** | **Description** | **(0) N/A** | **(1) Totally Wrong** | **(2) Wrong** | **(3) Either Wrong or True** | **(4) True** | **(5) Totally True** |
| 52 | Attitude of the employer to the foreign investors is negative | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 53 | Attitude towards the foreigners is negative in the subject country | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 54 | Contractor is over loaded when the time of the tender is considered | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 55 | Due to lack of time for preparation of the tender, the contractor has not worked in detail for the project bid | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 56 | The ingredients of the insurance and the expected amount of CAR are different from the ones of the similar projects. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

This is both the end of Section 2 and the questionnaire. Thanks for sharing us the information's.