

# Uncertainty Variables on Cost Estimation in Project Construction

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**Abstract:** Cost and time are the main factors management aspects of a construction project. In implementing the project, the contractor is always trying to minimize the costs incurred in order to obtain maximum benefit. To achieve it, there needs to be a cost estimation process that aimed to estimate how much it costs needed to complete the project. In addition, the cost estimation process can also be a reference in determining the offer price, in estimating costs, many uncertainty factors that will occur during the implementation of construction projects. Risk is something that can never be avoided in a human activities, including the activities of project development and construction projects. Because in each of the activities, such as construction, there must be many uncertainties. Uncertainty factor is what ultimately led to the emergence of a risk on an activity, to avoid losses due to risks, estimators need to allocate contingency costs.

**Keywords :** Uncertainty, cost estimate, construction project, project cost, estimator, contractor

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Date of Submission: 26-12-2017

Date of acceptance: 11-01-2018

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## I. Introduction

The initial step in realizing a construction project is to understand the nature of the dynamic and complex projects. Construction project is a mission, undertaken to create a unique facility, product or service within the specified scope, quality, time, and cost (Chitkara, 2004). Construction activities are implemented only once and generally occur within a short period of time. Each stage of the activities has a different timescale and necessary cost estimates. The cost estimate aims to predict the magnitude of the costs incurred to implement an activity in the future. Conceptual cost estimation is one of the most critical tasks in the early stages in the life cycle of a building project (Trost et al., 2003).

Cost estimate is a prediction of quantities, cost, or price of resources required by the scope of an asset investment option, activity, or project. As a prediction, an estimate must address risks and uncertainties (AACE, 2007). The cost estimate is performed in line with a series of project activities, beginning with the estimate until detailed estimate at this stage of the procurement and implementation. In estimating the magnitude of the cost project, the amount of costs to be incurred at the time of construction cannot be known for certain. It is very closely related to the existence of variables that cannot be estimated with certainty, or the existence of uncertainties during the construction phase, so that it leads to variability in the unit price. For example, price fluctuations of materials, equipment and wages will also cause variability in the quantity of work, and create a difference between the quantities of work performed in the field and that stated in the Bill of quantity. All construction projects, regardless of type and size, involve many significant uncertainties and risks through all their construction phases, from the start up to the completion of the project. AACE (2007) defined uncertainty as unknown future events that cannot be predicted quantitatively within useful limits. Flyvbjerg et al. (2002) found that project costs have been underestimated in approximately 90% of cases, and that the actual costs turned out to be on average 28% more than the estimated costs. There are many uncertain variables during project implementation that dynamically affect the project duration and cost (del Caño & de la Cruz, 2002). Flyvbjerg et al. (2004) suggested that larger projects experience greater cost overruns on a percentage basis.

## II. Theory of Cost

Cost is one important aspect of the cycle of business activities and the construction industry. Contractors who do not have an understanding of the components of costs, including indirect costs will increase the risk of failure (Shelton, 2002). According to Hansen (2005), the cost is the cash or the value of cash equivalent that is sacrificed for goods or services that are expected to provide benefits currently or in the future for the organization. As a business field that is classified as a high risk business, the success of construction activities must be very sensitive to changes in costs. It is now becoming very important to be noticed by the actors in the business field. Under such conditions, the ability and success of the contractors to survive tight competition in the industry will depend highly on how well they are able to overcome the uncertainty, especially

in the aspect of costs. In this kind of competition, contractor success is reflected in his or her ability to win auctions and completing construction projects, while generating enough profits.

According to AACE (2007), cost is the amount measured in money terms, cash expended or liability incurred, in consideration of goods and services received. From a total cost management perspective, cost may include any investment of resources in strategic assets including time, monetary, human, and physical resources. Generally, contractors who can successfully handle the cost of uncertainty are in a position to produce accurate cost estimates. As a guideline, the more accurate the resulting cost estimates, the lower will be the risk due to changes in the costs faced by the contractor. With reduced risk, the contractor can reduce the cost of risk, which could ultimately result in more competitive price offer. In an auction, contracting bid price includes components of direct and indirect costs. Cost is a wealth, in the form of cash or noncash, sacrificed for goods and services which are expected to provide current or future benefits for the organization (Hansen et al., 2009).

Ahuja (1994) said that the types of estimation for the various phases of activities in construction projects can be divided into several groups as follows:

### **1. Order of Magnitude**

Estimation is conducted to assess the feasibility of a project to be implemented or to make a selection from several alternative designs. At this time, the estimate made using the data or information available is very limited so that the accuracy of the resulting value gives a very wide range, varying from + 50% to -30%. Order of magnitude estimation method uses several criteria such as the floor area of the building, volume of work, and such other criteria.

### **2. Budget estimates**

The purpose of budget estimates is to find out how much money should be prepared for the implementation of the project. Budget estimates are not used for controlling project. Budget estimation is carried out in more detail than the previous estimate. Therefore, the values of these estimates range between +30% and -15%. The accuracy is dependent on the quality of information available.

### **3. Detailed Estimates**

Detailed estimates are made for two purposes: first is to submit a bid price for a job; and second, it is used as the basis for the control of a project. Detailed cost estimate can be made after complete data or information from the project such as the availability of the document images, technical specifications and other support requirements are obtained. This estimate will give more accurate results as more complete data and information are available. This estimate can also be done by the owner to know the size of owner cost that can be used as a reference for the bid price submitted by the bidder. The accuracy of these estimates ranged from +15% to -5%.

The main issue in making the estimated detail are to define the scope of work, and to do the grouping for the job. Some steps in preparing the details are as follows:

- (a) Conduct a review of documents and the actual conditions of the project such as an explanation of documents including addenda, field conditions and the level of risk to be faced.
- (b) Describe and classify items employment.
- (c) Calculate the quantity of work in accordance with the units of measurement and types of jobs.
- (d) Calculate the price component of the cost of materials, equipment, and labour.
- (e) Make an analysis of the prices offered by subcontractors and suppliers.
- (f) Calculate the amount of overhead costs, taxes, insurance, and guarantees necessary for the project.
- (g) Calculate the contingency costs, which is the risk associated with the work to be performed.
- (h) Calculate the greatest advantage to be gained from the project.

The initial cost estimates should be as accurate as possible. Accuracy of cost estimation allows the client to examine and determine the funds needed to implement the project (Kaliba et al., 2009). According to AACE (2007), estimates are used primarily as inputs for budgeting cost in value analysis, in decision making in business, in asset and project planning, or in project cost, and in scheduling control processes. The details of the components in the construction cost estimates can be divided into two general categories, namely direct costs and indirect costs.

#### **2.1 Direct Costs**

According to the AACE (2007) detailed cost estimates, can be further divided into two components, namely direct costs, that is, cost of installed equipment, material and labour directly involved in the physical construction of the permanent facility and indirect costs, that is, all costs which do not become a final part of the

installation, but which are required for the orderly completion of the installation and may include, but are not limited to, field administration, direct supervision, capital tools, start-up costs, contractor's fees, insurance, taxes, and so forth.

Direct costs are all costs that become a permanent component of the final results of the project which consists of the following costs.

(a) Cost of materials

AACE (2007) defined material cost as the cost of everything of substantial nature that is essential to the construction or operation of a facility, comprising both direct and indirect costs. Generally, it includes all manufactured equipment such as basic parts. This fee can be calculated in units multiplied by unit price or on a lump sum basis. It is highly dependent upon those involved in the procurement of materials. Apart from the price of materials, the estimator must also take into account other costs such as transportation costs, storage costs, wages unloading, cost of testing materials, the quantity of material available, cost of taxes, payment systems, delivery or arrival date, materials held directly by the owners, and others.

(b) Cost of equipment

According Soeharto (1999), contractors who handle jobs with huge costs and volumes, while the nature of the job involves much construction equipment, the cost of equipment must be determined, whether the procurement of equipment involves renting or purchasing. The cost of this equipment is needed to accommodate tool needs, particularly heavy equipment to be used during the construction phase. Calculation of the cost of equipment can be divided as follows:

(1) Cost of procurement

The cost of procurement of heavy equipment can be calculated based on how the equipment is handled as through ownership, lease, or leasing. In the case of ownership cost, things that should be taken into account are the cost of depreciation, interest charges, insurance, and taxes.

(2) Cost of operations

Cost of operations consists of operator cost, fuel, lubricants, maintenance, replacement tires, and others.

(3) Cost of labour

ACCE (2007) defined labour costs as gross direct wages paid to workers, plus labour burden, field indirect, plus general and administrative cost, and profits. With regard to wages labour, costs to consider include straight-time wages, overtime wages, labour insurance, safety of workers, public facilities for labour, and fringe benefit. Fixed salary of the workers must consider factors associated with the project location, and the type or workforce skills. Wages of workers can be paid based on union wage, one-shop wage, or prevailing wage. The amount of wages to be paid depends on the level of worker productivity, which is strongly influenced by attitude or personal characteristics of the workers, project type, climatic conditions, the complexity, and oversight functions.

(4) Cost of subcontractors

This fee is calculated for purposes of procurement of subcontractors by main contractors due to the transfer of a particular type of specific job skills. Some of the factors for the main contractor to watch in the choice of subcontractors involved are system estimation carried out by subcontractors, capability of the subcontractor, and the analysis of proposals submitted by the subcontractor.

## **2.2 Indirect costs**

Indirect costs are costs that support the work, but not listed as the nature of the current job payment, such as the following:

a) Overhead costs

Overhead divided into general overhead, the costs incurred for operational company, but cannot be distributed into work packages. These costs include such costs as office rental, salaries, and benefits paid to all directors, employees (employee facilities, insurance), cost of utilities (electricity, water, telephone, and other retributions), marketing, depreciation, and others.

Project overhead is the indirect costs which are spent for the purposes of the project and allocated proportionately to the work packages, such as the cost to estimate, the cost to participate in the tender, the cost for the project guarantees (bid bonds, performance bonds), the cost of labour insurance, equipment, materials, licensing, and the cost of utility used by the projects.

b) Contingencies

Contingency cost is an important item in the cost estimate used to compensate for unforeseen uncertainties and risks against underestimating budgets for the construction phase. In addition, contingency is directly related to the accuracy of base estimates because it is included in the cost estimate, which is prepared

before the start of project execution (Molenaar, 2005). The Association for the Advancement of Cost Engineering (AACE, 2007) defines contingency as an amount added to an estimate to allow for items, conditions, or events for which the state, occurrence, or effect are uncertain and that experience have shown would most likely result, in aggregate, in additional costs. These costs are allocated to anticipate over the lack of information and errors in interpreting the information obtained, giving rise to an uncertainty. This can be one of the risks to be faced in future implementation of a project. Allocation of these costs should be minimized, by making the best and complete estimate of the uncertainties, or in the case of deficiencies of such information, by asking directly the project owners or stakeholders. Its aim is to get value for the right offer. If the contingency allocation is too low, then it may be too rigid and set an unrealistic financial environment, which may result in unsatisfactory performance outcomes (Touran, 2003).

This cost allocation should be minimized by contractors, by doing their best to estimate the complete vagueness or lack of information, by asking directly the owner of the project or related parties. Hendrickson (2003) stated that the majority of construction budgets provide a reserve for contingency costs or unexpected costs incurred during the construction. According to Latupeirissa et al. (2007), there is a common perception related to uncertainties and risks that have been identified by the respondents. The common perception is reflected in the answers of the respondents who agreed that contingency costs are a move prepared in anticipation of uncertainty and the risks. A total of 42 respondents (67%) gave the same answer about contingency costs.

c) Profitability

The purpose in analyzing the benefits estimator is the maximum expected profit. The advantages can be defined as something obtained over the risks faced. The value of benefits can be added to the value of the estimates made.

### III. Uncertainty Variables in Construction Projects

In preparing cost estimates on construction projects, there are things that cannot be expected with certainty (that is, unforeseeable), or which cannot clearly stated (intangible), or cannot be predicted (unforeseen); all these can be categorized as an uncertainty. Uncertainties can cause losses that can lead to increased costs, time delays, and reduced project quality (Simu, 2006). During project implementation, there are many uncertainty variables that dynamically affect duration of activity, and hence cost (Leu et al., 2001). Many uncertainties associated with international construction arise from differences in culture, economic conditions, specifications or standards, legal frameworks, and productivity levels (Dikmen & Birgonul, 2006).

The history of the construction industry is full of projects that were completed with significant cost overruns (Molenaar, 2005). In the face of uncertainty, many components of costs need to be allocated to one component of indirect costs that is contingency costs. In allocating for contingency cost it is necessary that the estimator has the assessment capabilities, to avoid cost overruns or the occurrence of low cost estimates, resulting in the loss (cost underrun). The uncertainty variables that influence project cost estimate obtained from other studies are shown in following Table 1.1.

**Table. 1.1.** The Uncertainties Variable That Influence Project Cost Estimate Based on Other Studies

	Uncertainty Variables	Authors/ Years																	Frequency						
		Yeo (1990)	Kalayjian (2000)	Han et al (2001)	Chimwaso (2001)	Pakkala (2002)	Chan et al (2003)	Frimpong (2003)	Ghosh et al (2004)	Thevendran et al (2004)	Harbuck (2004)	Long et al (2004)	Ren et al (2004)	Bing et al (2005)	Chan et al (2005)	Azhar et al (2008)	Broadbent et al (2008)	Long et al (2008)		Nega (2008)	Creedy et.al (2010)	Memon et al (2011)	Subramanyan et al (2012)	Doloi (2013)	
1	The inflation rate	x															x								2
2	exchange rate	x		x																					2
3	Social and cultural conditions		x				x	x						x											4
4	Work ethics and religious beliefs.	x																							1

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5	The physical condition				x			x										x	x	x	x	x	8
6	Interpretation and implementation of government policy on construction sector	x																					3
7	Scale / scope of project	x	x							x									x			x	6
8	The project site				x					x											x	x	7
9	The implementation period	x																					2
10	Managerial ability of the team involved																						6
11	Availability and the working relationship between the Contractor with the supplier																						3
12	Technical problem	x																					3
13	Price fluctuations		x		x																		6
14	Design changes				x	x			x														10
15	Inadequate planning				x																		6
16	Experience limitation.																						5
17	Financial and economic																						8
18	Contractual and legal																						6
19	Operational																						2
20	Delay																						6
21	Human risk																						5
22	Local government																						1
23	Permit agencies																						1
24	Wrong methods																						4
25	Political																						1
26	Additional work																						3
27	Insufficient data collection and survey before design																						2

When determining the amount of the contingency cost at the time of project bidding, contractors often do not specify the uncertainty factors that affect the project cost estimate. Therefore, they need a study to identify and to analyse events that cannot be predicted with certainty or that cannot be stated clearly, which is called the uncertainty factors. To avoid losses or cost overrun, the contractor is expected to estimate the cost of the project to the optimum. According Rauzana (2015a), the most influential uncertainty variables on the estimated cost is the inflation rate.

Choudhry (2004) defined the cost overruns as the difference between the original cost estimate of project and actual construction cost on completion of works of a commercial sector construction project. Contingency cost allocation should be minimized by making the best estimate. To clarify any vagueness or if there is a lack of information about anything, contractors can ask directly the owner of the project or related parties. According Rauzana (2015b), Uncertainty variables in construction projects are affected by economic

factors.

Harbuck (2004) documented three major categories of uncertainty in construction projects as design problems, construction problems, and third party problems. Design problems include design changes, design errors, and ambiguous specifications. Construction problems include differing site conditions, delays, and scope additions. Finally, third party problems include utilities, local government, and permit agencies. Kalayjian (2000) stated that the uncertainty variables in construction projects may arise from ambiguously specified project scope, unclear boundaries of work, inaccurate estimation, and price fluctuations.

Frimpong (2003) added by saying that uncertainty variables in construction projects are affected by improper planning and management experience limitation. On a different but related perspective, Long et al. (2008) said that the uncertainty variables in construction projects are affected by poor site supervision and management and poor project management assistance. Then, Nega (2008) stated that the uncertainty variables in construction projects are affected by change of weather conditions or subsoil conditions. However, Ghosh and Jintanapanant (2004) identified nine critical risk or uncertainty factors, which include financial and economic factors, contractual and legal factors, subcontractor-related factors, operational factors, safety and social factors, design factor, force majeure factors, physical factors, and delay. According Rauzana (2016), Uncertainty variables in construction projects are affected by estimated costs, Implementation and working relationships, and the project documents.

#### IV. Conclusions

From the literature review, research gaps found were based on the differences in the results of studies, because of the differences in the variables of uncertainty used. This has become the basis of this study, namely to identify the variables of uncertainty, and to determine the level of influence of the uncertainty variables, and the relationship between uncertainty variable with contingency costs.

In preparing cost estimates on construction projects, there are things that cannot be expected with certainty (that is, unforeseeable), or which cannot clearly stated (intangible), or cannot be predicted (unforeseen); all these can be categorized as an uncertainty. Uncertainties can cause losses that can lead to increased costs, time delays, and reduced project quality (Simu, 2006). Cost estimate is a prediction of quantities, cost, or price of resources required by the scope of an asset investment option, activity, or project. In estimating the magnitude of the cost project, the amount of costs to be incurred at the time of construction cannot be known for certain. It is very closely related to the existence of variables that cannot be estimated with certainty. In anticipation of losses that will occur as a result of variables that cannot be estimated with certainty or those estimated with uncertainty at the time of estimation, a number of costs need to be allocated as the indirect costs charged to the cost of risk; in this case, costs positioned as a contingency cost.

In the face of uncertainty, many components of costs need to be allocated to one component of indirect costs that is contingency costs. In allocating for contingency cost it is necessary that the estimator have the assessment capabilities, to avoid cost overruns or the occurrence of low cost estimates, resulting in the loss (cost underrun). Contingency cost is an important item in the cost estimate used to compensate for unforeseen uncertainties and risks against underestimating budgets for the construction phase.

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Anita Rauzana" Uncertainty Variables on Cost Estimation in Project Construction." IOSR Journal of Business and Management (IOSR-JBM) 20.1 (2018): 80-86.