RISK ANALYSIS OF PROJECT SCHEDULING USING MICROSOFT EXCEL

1,2,3,4,5 Civil Engineering Department, Politeknik Negeri Bali.

Bukit Jimbaran, P.O Box 1064, Kuta Selatan, Badung, Bali, Indonesia

Correponding email :
nsuardika@gmail.com

I Nyoman Suardika[1], Kadek Adi Suryawan[2], I Ketut Sutapa[3], I Komang Sudiarta[4], I Made Suardana Kader[5]

Abstract. Scheduling plays a very important role for the successful implementation of construction projects. One of the biggest risks in scheduling is in terms of project costs and duration uncertainty. To anticipate these uncertainties, scheduling methods have been developed using probabilistic duration, including PERT and Monte Carlo Simulation methods. In this research the simulation process was carried out using Microsoft Excel which was integrated with @Risk's add-ins. From the results of the analysis, the project duration obtained from the scheduling model with the CPM method, conventional PERT and Monte Carlo simulation produces an average value that is close to the same. The difference occurs in the standard deviation value, the conventional PERT method produces the smallest standard deviation, followed by a Monte Carlo simulation using the PERT distribution and the last is Monte Carlo simulation using the TRIANGULAR distribution. From the results of the sensitivity analysis, it was found that the dominant input variables that affect the duration of the project are the duration of activities that most often enter the critical path or those that have a great critical index. Meanwhile, project costs are influenced by a combination of the duration of activities on the critical path and activities that have a great direct cost.

1. INTRODUCTION

Projects, especially construction projects, are always full of uncertainty, for example in terms of uncertainty over costs and completion times, which can cause a risk of losses for both contractors and project owners. To minimize the impact of these risks, you need tools to analyze them. Some scheduling methods such as CPM and PDM have not included risk factors explicitly in determining the duration of each project activity, in which they still uses deterministic duration (exact number) which is considered most likely to occur. One alternative is to overcome the above problems by using Monte Carlo simulation method [1,2]. This method uses stochastic input like PERT, but with a choice of various probability distribution curves.

This study attempts to discuss the use of the Monte Carlo method to simulate project scheduling by entering the duration and cost of each probabilistic activity. The models made are then analyzed using the PERT method and Monte Carlo simulation for later compared to the results. The simulation process is carried out using Microsoft Excel which has been integrated with @Risk, an auxiliary application (add-ins) in Microsoft Excel to run Monte Carlo simulations.

The aims of this research are: (a) Compare the duration of the project from various scheduling methods. (b) Knowing the input variables that mostly affect the duration and cost of the project.

This research is expected to be useful for other parties who are interested in risk analysis, including: (a) For contractors, they can make a more realistic project scheduling model, taking into account possible risk factors. (b)

For owners, they can simulate their investment risks, for example to answer the question "how many opportunities for my project to finish on time, and how much does it cost?" (c) For students, this can be used as learning material.

Scope of the problems are: the scheduling model in this study is entirely fictitious, solely for learning purposes in order to better understand the concept of risk analysis simulation especially in project scheduling.

2. METHODS

Broadly speaking, the sequence of work steps taken in analyzing a risk using a Monte Carlo simulation is as shown in Figure 1.
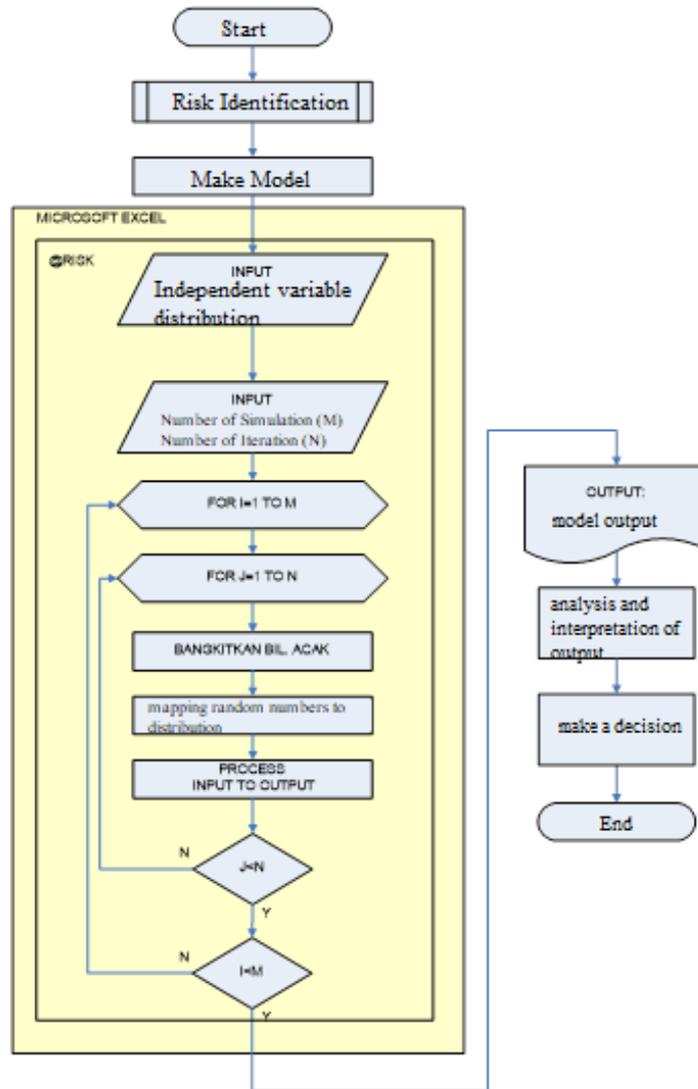

Figure 1: Flowchart of the Research Methods

3. RESULTS AND DISCUSSION

Case Model

The case model discussed in this writing is about project scheduling, which consists of 12 activities. The model is described by AON type of network planning (Activity on Node) as well as PERT / CPM (Figure 1). Input data in the form of: duration of each activity, direct costs of each activity and indirect costs of the project per day with their respective probability distributions. Next, it is simulated by the Monte Carlo method using the @Risk program that has been integrated with Microsoft Excel. The risks to be analyzed relate to the duration of the project and project costs. From the simulation results, an analysis will be conducted to find the relationship between input variables on output (project duration and project costs) and the relationship between the duration of the project and project costs (between output variables).
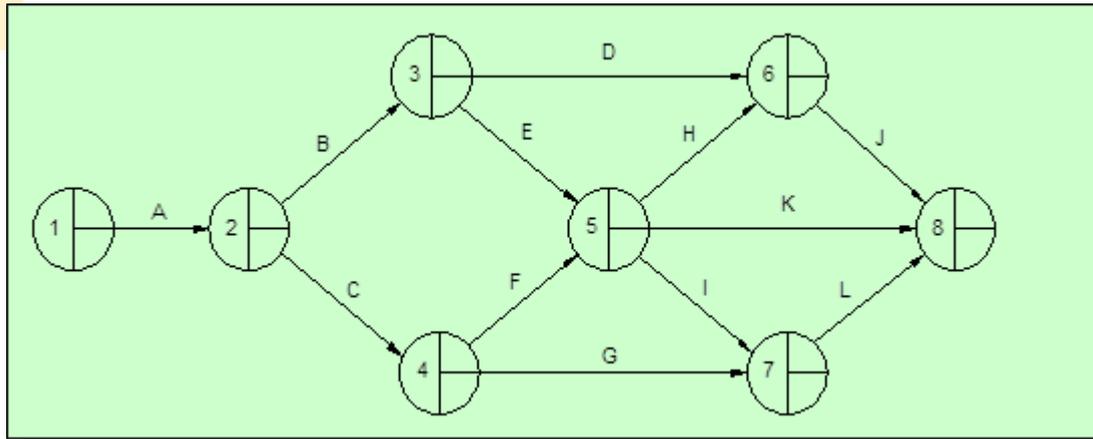
Figure 2: Network Planning Model of the Reviewed Projects

Monte Carlo simulation works based on the principles of probability in statistical science. In the sampling technique, this method uses a random number generator, to create random numbers, which are then mapped into sample input models according to the type of probability distribution specified in the model. Furthermore, the inputs are processed in accordance with the provisions of the model to become output [3,4]. This process is carried out repeatedly (iteration) until the model is considered convergent (no significant changes occur in the model output). The output can then be described in diagrams, e.g. histograms, cumulative frequency distributions, etc. [5,6].

Probability Distribution Of Input Variables
All input variable probability distributions use Triangular Distribution. Especially for the duration of the activity, it was also tried to use PERT Distribution with the intention to compare the results both with conventional PERT calculations and with Triangular Distribution.

Analysis Of Simulation Results
Simulation is done 3000 times, using options: Latin type Hypercube sampling (stratified sampling technique), Random Generator Seed: fixed = 1 (selection of this fixed type for the analysis scenario later, so that the generated sample is not changing in each simulation, so that changes in the simulation results are purely just caused by changes in input data on the variable being reviewed).

Comparison between Project Duration of Various Scheduling Methods
Project duration will be compared from various methods and scheduling assumptions, both using the CPM method, conventional PERT, Monte Carlo Simulation and "What if" scenario. The comparison results are summarized in Table 1.
If we look at the numbers in table 3.2 above, at a glance it can be seen that the conventional PERT method has the best distribution, but that result can be biased because the PERT method only takes into account one critical trajectory, whereas in fact, what often happens is more than one critical trajectory. The assumption of the PERT method which considers each activity to be independent of each other, is also not always appropriate, because it could be that one activity has a correlation with other activities. Monte Carlo simulation methods, on the other hand, can take into account the correlation between these activities.

Table 1. Comparison between project durations with various methods and assumptions

Methods and Assumptions	Average project duration	Standard Deviation
CPM	25.000	NA
PERT Conventional	24.000	1.050
Montecarlo simulation		
triangular without correlation	25.403	1.275
triangular with correlation	25.242	1.323
PERT without correlation	25.417	1.116
PERT with correlation	25.260	1.170
"What if" simulation		
Optimistic	18.000	NA
Most Likely	25.000	NA
Pessimistic	32.000	NA

NA = Not Available

Distribution Graph

Frequency distribution of model variables can be displayed in the form of Histograms or Cumulative Distribution. The histogram describes the frequency distribution of the input and output variables of the model, which shows how often the value of a variable is at a certain price, while Cumulative Distribution shows the probability of the value of a variable below or equal to a certain price. Examples of Histograms and Cumulative Distribution from simulation results are presented in Figure 3 and Figure 4.
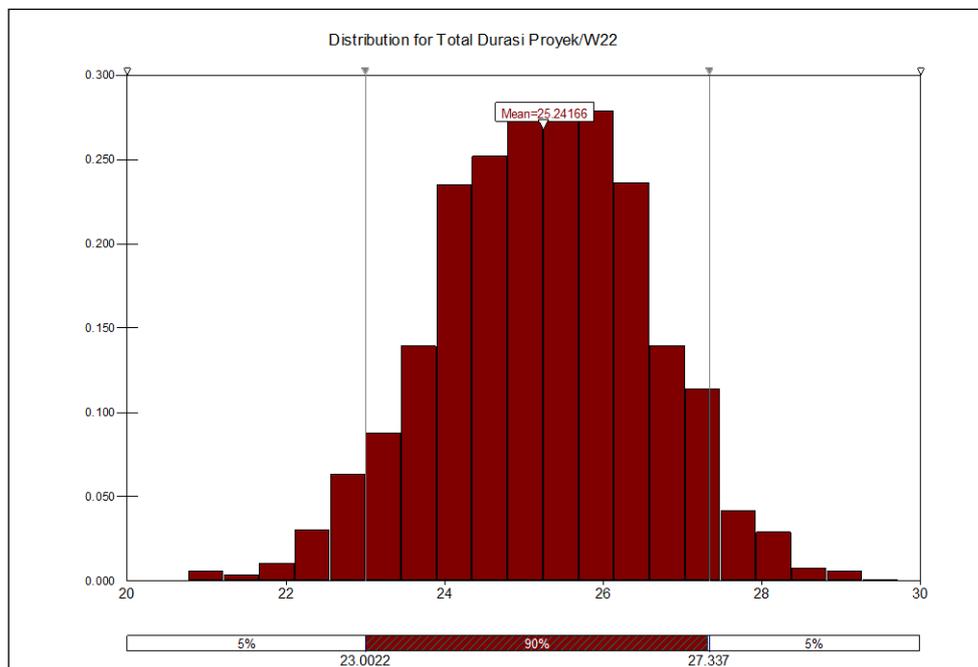

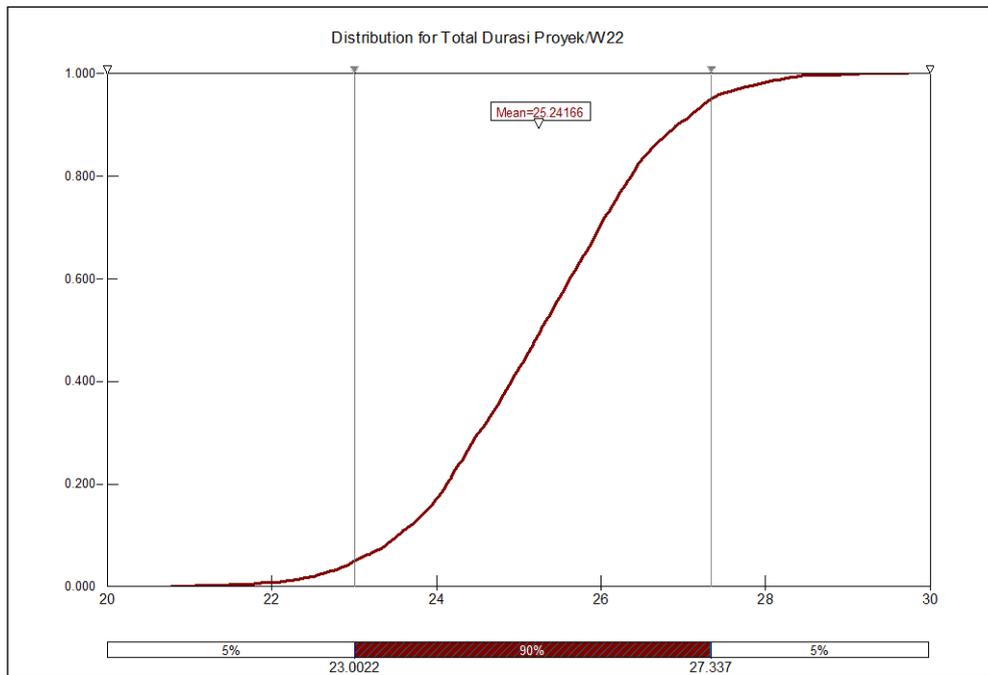Figure 3. Histogram of Total Project Duration

Figure 4. Cumulative Distribution of Total Project Duration

Sensitivity Analysis

Tornado graph is used to describe the results of sensitivity analysis of input variables on certain output variables. The following are examples of sensitivity analysis results for the total duration of the project and total project costs.
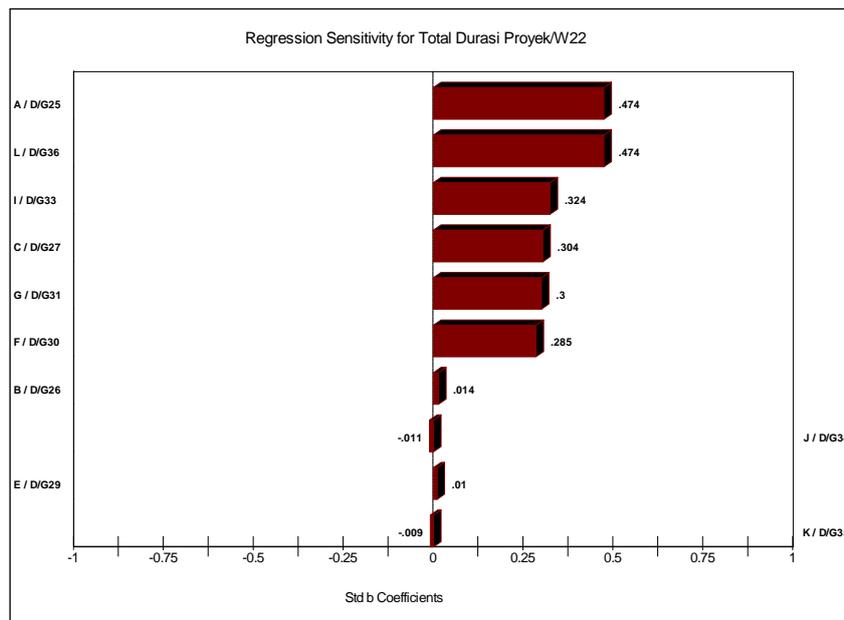

Figure 5. Regression Sensitivity of Total Project Duration

From Figure 5, it appears that activities A and L have a regression coefficient of 0.474, which means that an increase of 1 standard deviation at the duration of the activity will cause a duration increase of 0.474 times the standard deviation of the duration of the project.

4. CONCLUSION

Based on the results and discussion above, the conclusions from this study are: (a) The duration of the project from the scheduling model reviewed, both by the conventional CPM, PERT method, and Monte Carlo simulation produces an average value (mean) which is more or less equal. The difference occurs in the standard deviation value, where the conventional PERT method produces the smallest standard deviation, followed by a Monte Carlo simulation using the PERT distribution and the last is Monte Carlo simulation using the TRIANGULAR distribution. If the correlation factor between activities is included, the standard deviation in the simulation will increase. When there is more than one critical path, the conventional PERT method will give a biased result, because it only takes into account the last critical trajectory, whereas a Monte Carlo simulation can overcome this. (b) From the results of the sensitivity analysis, it was found that the dominant input variables affecting the duration of the project were the duration of the activities that most often entered the critical path or those that had a large critical index. Meanwhile, project costs are affected by a combination of the duration of activities on the critical path and activities that have a great direct cost.

5. SUGGESTION

From the results of this study, it was suggested that: (a) The hardest thing in modeling using Monte Carlo simulation is determining the distribution of model input variables. Therefore, the user should understand the nature or characteristics of the input variables and have sufficient knowledge about the probability distribution used. (b) It is necessary to develop macros (programs with VBA language in Excel) specifically to calculate the duration of the project so that it is more flexible to follow the changes that occur in the network planning model.

6. REFERENCES

[1] Flanagan, Roger and Norman, George. 1993. *Risk Management and Construction.* Oxford: Blackwell Science Ltd.

[2] Hendrickson, Chris. 2003. *Project Management for Construction:* Fundamental Concepts for Owners, Engineers, Architects and Builders. Pittsburgh: Department of Civil and Environmental Engineering, Carnegie Mellon University.

[3] Kezner, H. 1995. *Project Management, A System Approach in Planning, Schedulling, and Controlling.* Fifth edition. New York: Van Nostrand Reinhold.

[4] Soeharto, Iman. 1997. *Manajemen Proyek: Dari Konseptual Sampai Operasional.* Jakarta: Penerbit Erlangga.

[5] Noname. 2002. Guide to Using @RISK: Risk Analysis and Simulation Add-in for Microsoft Excel. Version 4.5

[6] Noname. 2018. Pertmaster – Risk Tutorials. Available at: www.pertmaster.com, acessed 12 Nov 2018.