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Effect of network's morphology and merge bias correction procedures on project duration mean and variance

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Abstract

Many authors have discussed the source of errors in PERT networks as follows: Uncertainty in the mean and variance calculations of (a) activity's durations and (b) total project duration, and its related distributions. Different corrections formulas and procedures were proposed. In the other hand, there's an existing risk of delay related to the project morphology, in terms of the number of activities, shape and complexity of the project network. However, the relationship of network's morphology and the uncertainty of the whole project's duration are poorly studied. In this research, a set of project networks with different morphology were generated and several methods available in literature (original PERT included) were used to estimate the parameters (mean and variance) of total project duration, then comparing them to the Monte Carlo Simulation as a representation of the reality, and the best and most accurate method(s) were chosen.

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Keywords: Project Management; Networks; PERT; mean; variance; morphology; merge bias

1. Introduction

We understand that due the work's nature, the estimation of activity's duration is uncertain. The authors of PERT (1958) and others (e.g. Malcolm et al., 1959) have adopted the beta distribution parameters (mean and

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variance) to reflect this uncertainty and represent the probable duration of and activity based on assumptions of adjustment to reality, which has been accepted mainly due to the "flexibility" of the distribution (Moder and Phillips, 1970). However, the adoption of these parameters have been previously criticized by authors such as Perry and Greig (1975), Moder and Rodgers (1968) and MacCrimmon and Ryavec (1962 and 1964), due to lack of accuracy. The reality is, that although the distribution of any project network activities' duration has been specified (as beta), the actual distribution of these activities' duration is likely to be unknown. PERT, propose formulas for the approximation of the beta distribution mean and variance that can possibly introduce errors in the total duration of the whole project (MacCrimmon and Ryavec, 1962 and 1964). Many authors tried to correct the PERT formulas for the approximations of the mean and variance of activities' duration, but no empirical results are shown using the network's morphology and the effects on the total duration of the whole project network. Some authors presented corrections for the approximations of the mean and variance, such as:

- Buffa and Sarin (1987), Kerzner (1992, 2009) and Meredith and Mantel (1989, 2009).
- Keefer and Bodily (1983)
- Pearson and Tukey (1965)
- Swanson and Megill (1977)
- Troutt (1989)
- Farnun and Stanton (1987)
- Golenko and Ginzburg (1988)
- Keefer and Verdini (1993)

The PERT procedure for calculating the project completion time distribution (value of the mean and variance of the duration of the activities at the final event) assumes that it is normally distributed. The problem with the conventional PERT method is that it always leads to an optimistically biased estimate of the expected total duration for the project network. The bias arises because in the PERT-CPM all subcritical paths are ignored in the calculations. McCrimmon and Ryavec (1962 and 1964) study this problem and include the most important factors that affect the merge bias problem. The statistical correction of this problem deal with the determination of the maximum value of a set of random variables, that are, not necessarily statistically independent. Several authors have proposed different solutions to the problem, but some of the most representative and mentioned in the literature are the solutions found in earlier papers. Some were chosen for this research, as shown below

- Clark (1961, 1962) and Moder and Phillips (1970) with the Clark's Bias Correction Procedure.
- Fulkerson (1962) "f" estimate.
- Ang et al. (1975) Modified Network Evaluation Technique (PNET).
- And finally, Monte Carlo Simulation (Eckhardt, 1987).

The above solutions claim to be more accurately than original PERT, but none of these has explored the effect of network's morphology on the estimation of the mean and variance of project duration.

In the other hand, a few studies have estimated the effect of morphology in the project duration, such as Tavares et al. (1999 and 2002), and Vanhoucke et al. (2008), among others. These studies propose a set of indicators to describe the morphology of the project network, such as the number of activities, shape and complexity. Currently, the actual project management software includes the study of project networks, but little or no attention has been given to the analysis of the relationship between the morphology and the uncertainty concerning the total duration of the project (Tavares et al., 1999).

The objective of this paper is to develop a comparative analysis of the estimation of the mean and variance and the effect of the morphology in the PERT networks. Two sources of error were analyzed (individual activity times and total project duration estimations) combined with the morphology of the network: 1) the use of beta distribution and the approximation formulas of PERT for the mean and variance for the estimation of the individual