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European Journal of Operational Research 165 (2005) 307–313
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH
www.elsevier.com/locate/dsw

On the fallacy of averages in project risk management

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Received 1 October 2002; accepted 1 July 2003
Available online 1 June 2004

Abstract

Managers recognize the presence of *uncertainty* in the estimates of the various parameters of their projects, but usually circumvent the required analysis (which can be demanding) by replacing the random variables by their averages. This paper argues against such practice. It demonstrates that gross errors can be committed in cost estimates and in the bids based on them.

Keywords: Project planning; Resource allocation; Stochastic work content

1. Introduction

An important issue that looms high in the management of real life projects is that of *risk* and *uncertainty*. For a lucid discussion of the need for new paradigms in project planning and control due to the increased complexity of projects, especially relative to uncertainty, see Williams [16]. Whole books are devoted to the subject of risk and its management, see for instance Down et al. [3] and Chapman and Ward [2]. 'Risk' is taken to be synonymous with 'variability', which is best estimated by the variance of the project completion time, or cost, or resource consumption, etc.

Concerns about risk are everyday worries of project managers. They recognize the uncertain nature of their undertakings. To them, uncertainty is a fact of life in their estimates of resources, cost, and time. The issue is not that of *recognition*, but rather of *measurement*, and of how to *cope* with uncertainty in resource allocation and in managing the risk inherent in the estimates made relative to cost and time.

The issues that are raised due to uncertainty are exemplified by the following questions: How to estimate the cost and determine the bid for the project with a certain degree of confidence? What is the sensitivity of the project completion time to variations in the parameters of an activity (or a subset of activities)? More importantly, at least to the practicing project manager, *what to do* in case of unsatisfactory progress? [1] In other words,

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[1] We do not concern ourselves here with other approaches to cope with risk in project undertakings, such as the establishment of "warning signals" at certain key events, or assuming insurance against certain eventualities; etc.

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doi:10.1016/j.ejor.2004.04.003

suppose that the risk of a particular activity (or subset of activities) defaulting on its completion time (or cost estimate, or resource needs) is unacceptable, what can be done to reduce the risk, if not completely eliminate it?

It is indeed time that the research community which has devoted so much effort to resolve (optimally or near optimally?) the problems arising in project planning and control assuming certainty in the estimated parameters, rise to the challenge of dealing with uncertainty, since most of the fruits of the research that assumes certainty undergo major changes before they can be implemented in practice, if implemented at all.

The literature on the issue of project management under uncertainty is witnessing a recent explosion; see Krishnan [8] and Herroelen and Leus [5] for reviews; see also Herroelen and Leus [6] for a "robustness" optic of behavior under uncertainty, Huchzermeier [7] for a "real options" approach, and Bhattacharya [1], Down [3], Oorschot [11], Repening [12], Sieger [13], and Tatikonda [14,15] for analysis of various aspects of the problem and its implementations in various fields of endeavor.

1.1. The nature of uncertainty

It is the thesis of this paper that uncertainty resides in two domains. The first is "external" to the activity, such as the weather conditions, worker absenteeism, and equipment failure. The second is "internal" to the activity and resides in estimates of its *work content* (or "effort"). Traditionally the focus has been on the former aspect with little attention to the latter. And yet there are many projects, especially those with appreciable research and development content, in which the "internal" factors play the dominant role. We concede that R&D projects are often prototype activities with a great deal of uncertainty on how to even approach them, let alone estimate their work content. Still, *some* estimate must be made concerning the anticipated total effort to be expended on such a project, which shall indeed be modified later as the project progresses. Uncertainty then is typically expressed in the form "it requires between l and u man-weeks", with or without knowledge of the probability distribution of the work content. In the case of total ignorance of the shape of the probability distribution, we are content with a statement on its upper and lower bounds and assume a uniform distribution between these two points.

In the face of such uncertainty in the work content the manager still has to decide on the resources to be devoted to the activity. The duration of the activity then becomes the *consequence* of the resources allocated to the activity, not the *source* of the uncertainty. This optic changes the view of risk management in a radical fashion because now the decision is concerned with the optimal resource allocation (with its concomitant cost) in order to achieve the desired objective; namely complete the project within the prescribed due date (in order to avoid any penalty of tardiness) and with minimal cost of resources.

We do not suggest that one ignores the external factors; indeed, they must be taken into consideration, sooner or later. But we wish to focus on the internal factors because the uncertainty stemming from them is the form of uncertainty that can be "managed" *via* the proper allocation of resources *dynamically*. They have been ignored for too long, and it is time to correct the deficiency.

1.2. The focus of this paper

We do not propose to respond in this paper to all the issues mentioned above. Rather, we limit ourselves to an exposition of the fallacy of working with averages in estimating the expected project cost and the bid based on it.

Many so-called "practical" managers—if they ever concern themselves with uncertainty and random events—replace the random variables such as the work content by their *expected values* (averages). This is misleading (in the sense of giving the wrong result), hence impractical.

It is unfortunate indeed that the PERT model, introduced in 1959 [9], which initiated the whole field of project planning and control, did exactly that (i.e., replaced the random durations by their expected values to determine the so-called "critical path"). This established a precedence, and left a legacy with which we have been living for too long.