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**Kassem, M & Al-Bazi, A**



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# Portfolio Risk Management: A Simulation-Based Model for Portfolio Cost Management

Mohamad Kassem [a] and Ammar Al-Bazi [b]

[a] Teesside University, Middlesbrough, UK
[b] Coventry University, Coventry, UK
m.kassem@tees.ac.uk, aa8535@coventry.ac.uk

## Abstract

We present a simulation-based risk model to analyse the impact of multiple risks on the cost performance of portfolios. The model considers the combined impact of risks affecting the work packages of portfolio's projects and the probabilistic occurrence of each risk. We test the model in a portfolio composed of four construction projects and we show that the model is able to: predict the effect of identified risks on the portfolio cost performance and aid the decision making process of responding to risks. The limitation of the proposed model is that it calculates the impact of risks at a specific date when each risk has a defined probabilistic distribution. In future work we will consider the dynamic nature of risks to enable the model to cope with the changing attributes of risks.

Keywords: Monte Carlo simulation; risk; risk management; portfolio

## 1. Introduction

Cost and time over-runs are the two major negative impacts of risks on projects in the construction, oil and gas and IT industries. Indeed risks are inherent in any project and portfolio in the construction and engineering industry (Kerzner, 2009; Xie et al, 2012). A risk is defined by the ISO 31000 as the 'effect of uncertainty on objectives'. Most organisations in the construction and engineering industry operate in portfolio environment where numerous projects are simultaneously running. All portfolio definitions (Pinto, 2010; Buttrick, 2009; Aitken et al. 2000) suggest that it is a group of projects and/or programmes and/or business activities that support organisations in meeting their strategic goals and objectives. Time and cost overruns are currently among the major negative impacts of risks on portfolios (Xie et al., 2012; Uryasev et al., 2010). According to PMI (2008) Portfolio Risk Management (PRM) includes the processes concerned with conducting risk identification, analysis, response development, as well as monitoring and control of the risks. Central to the entire discipline of Project Portfolio Management (PPM) is the concept of Portfolio Risk Management (PRM) (Aritua et al., 2009; Kerzner, 2009). Previous studies on PRM have exclusively focussed on either the selection and prioritisation of projects (Petit, 2011) or the risk identification stage (Olsson, 2008). There is still lack of quantitative PRM methodologies and tools.

In this paper we present a simulation-based model that enables the estimation of the impacts of multiple risks on the cost performance of portfolios. We also empirically test the model using a portfolio of four construction projects. The following two sections respectively describes the proposed model and illustrates the results from the case study.

## 2. Simulation Based Model

One of the major challenges for projects and portfolios is to meet their allocated budget and guarantee a net profit margin for the organisation involved. A portfolio's mark-up is defined as the different between Contract Portfolio Price (CP) and the Portfolio Cost (PC) (1).

$$\boldsymbol{MU = CP - PC} \quad (1)$$

For the organisation to make a profit, the total impact of all risks affecting the cost of their portfolio should be lower the mark-up of portfolio. The model considers the impacts of all risks on the cost of each project within the portfolio and compares the result with the mark up available (2).

$$\boldsymbol{EPC = PC + \{(CP - PC) \times [(RF1 \times Ran1) + (RF2 \times Ran2) + \cdots + (RFn \times Rann)]\}} \quad (2)$$

All the variables in (2) are considered at work package level and explained below:

- Execution Cost (EPC): is the execution/expected work package cost that considers the impact of all portfolio's risks.
- Risk Factor (RFi): It is the impact of each risk factor on the different work packages composing the portfolio's projects. For the proposed model, these will be expressed in terms of financial or cost impacts.
- Risk Impact ($Ran_i$): is a random number extracted from a probabilistic distribution that best model the probability of occurrence of each risk.

## 3. Case Study

A portfolio case study of four construction projects is used to test the proposed PRM model. The total value of the portfolio is just less than $ 34.9 million. The risks affecting the different work packages and their impact on the 10% mark-up were identified using interviews with project managers. The common risks identified are: design changes; incomplete design; not meeting the client's specifications; weather condition; soil condition; unstable labour productivity; material and equipment delays; space clashes; equipment and device failure; installation mistakes and distributed teams. The financial impacts of risks were identified with the support of project managers. The probability of occurrence for most risks was modelled using PERT (Programme Evaluation and Review Technique) distribution as no historical data

for the identified risks were available (Garlick, 2007. p.182). Figure 1 and Figure 2 show that there is 90% of probability for making a profit of $972k (Min) and $1.741k (Max).

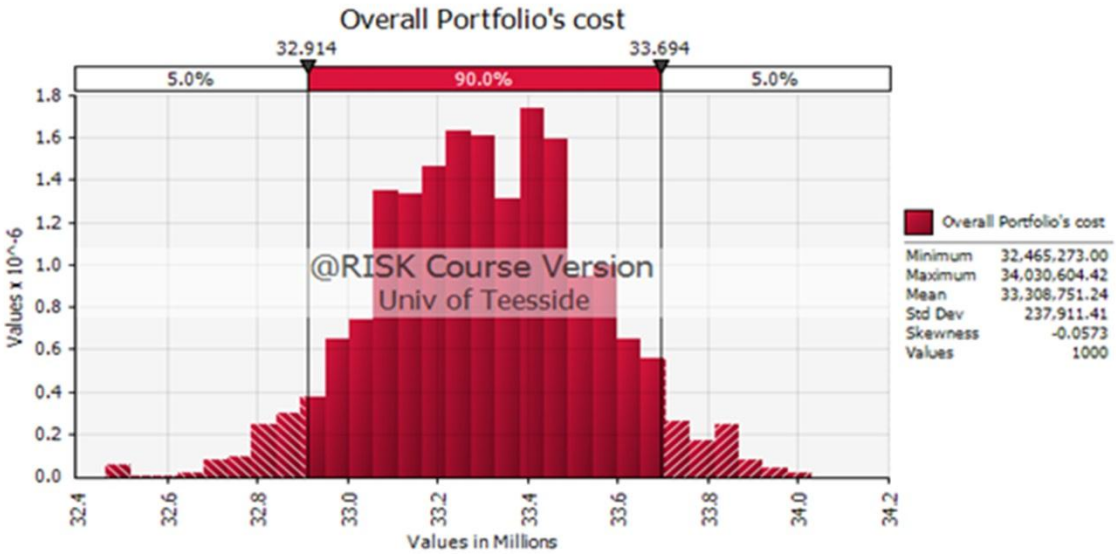


Figure 1 Portfolio cost's probabilistic distribution

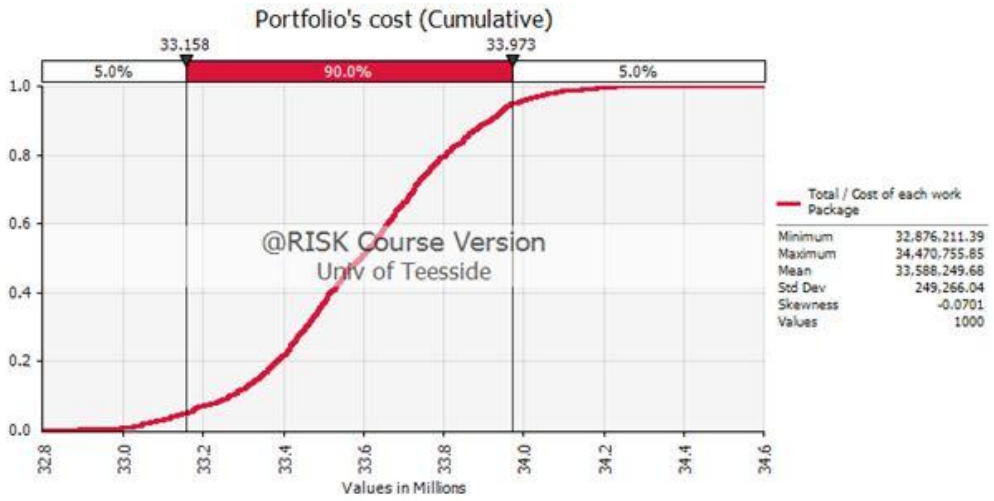


Figure 2 Portfolio cost's cumulative probability

There are risks inherent in portfolio environments and could not happen if the projects are conducted in isolation (Olsson, 2008). When these risks were included in the model, the results (Figures 3 and 4) showed that there is 90% probability of making a loss of $567k. These scenarios demonstrated that the model is capable of modelling the combined effect of risks on the financial performance of portfolio and providing meaningful data for the following risk analysis stage.

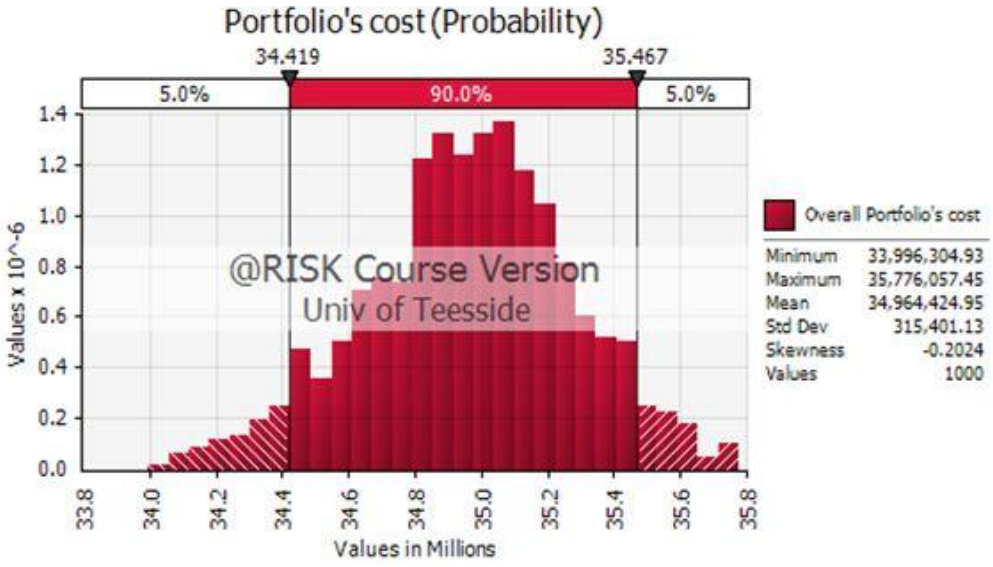


Figure 3 Portfolio cost's probabilistic distribution with inter-project risks

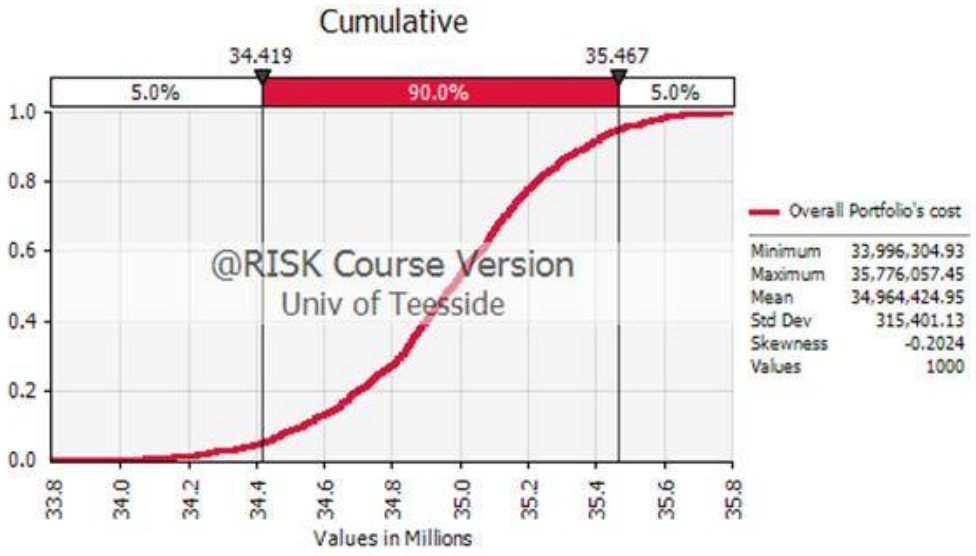


Figure 4 Portfolio cost's probabilistic distribution with inter-project risks

## 4. Conclusions

This paper proposed a simulation-based PRM model. The testing of the model in the case study demonstrated that the model can support the risk analysis stage in PRM. The main limitation of the model is in its incapability of dealing with the dynamicity of risks and needs to be applied several times during the lifecycle of a portfolio and

updated every time the status of identified risks has changed in the risk register (closed, introduced, upgraded or downgraded).

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