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ORIGINAL ARTICLE

Management of construction cost contingency covering upside and downside risks

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Abstract Many contractors are of the opinion that adding contingency funds to the tender price of a project may lead to loss of the tender. This research is a trial to put an end to this incorrect opinion. A more mature attitude to risk would recognize that contingency exists to be spent in order to avoid or minimize threats and to exploit or maximize opportunities. This research proposes an approach for determination and monitoring of Cost Contingency Reserve (CCR) for a project. Control of CCR is interfaced with Earned Value Management. Application to a real project is carried out. Post-mitigation simulations show that value of CCR is 2.88% of project cost but there is a potential saving due to opportunities. The project is monitored after eight months from its assumed start date with one assumed emergent risk. The final results are as follows: CCR is enough to cover project current and residual threats and the contractor has a considerable amount of money that will be transferred to his margin at project closure assuming the project will not be exposed to additional emergent risks. A contractor can balance project upside risks and its downsides to increase his chance to win tender of the project.

1. Introduction

Risk is defined by PMBOK Guide [1] as: "An uncertain event or condition that if it occurs, has a positive or negative effect on a project's objectives". Therefore, describing something as a risk means that it may occur in the future (and consequently may not). Project risk includes both threats to the project's objectives (downside or adverse risk events) and opportunities to improve on those objectives (upside or beneficial risk events). These known unknowns are usually recorded in a risk register. On the other hand, there are several types of uncertainty. The most important one is uncertainty about estimated duration and cost of project activities. No schedule is correct in every detail. Also, it is very difficult to decide on the appropriate level of detail to include in a cost estimate. The recommended way [2] to generate the estimating uncertainty is to estimate each item of work using a minimum, most likely and maximum value. The analysis is performed as part of the risk analysis process. The budget values corresponding to a chosen confidence level

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will form part of the Performance Measurement Baseline (PMB) which is an approved integrated budget plan for the project work, with which project execution is compared.

Cost Contingency Reserve (CCR) or specific risk provision is a response to deal with threats. It is the amount of budget set aside to cover project threats (post-mitigation) [2]. It does not include budget for opportunities. On the other hand, potential opportunity saving is an estimate of the amount of budget that could be reduced if specific opportunities are exploited. This saving (if it occurs) will affect the PMB. The challenge of effective risk management is to turn as many of knowable unknowns into known unknowns as is practical through creative risk identification. On the other hand, unknown unknowns (emergent risks) as highlighted by [2] are events or outcomes that cannot possibly be predicted until they occur. Non-specific risk provision is the budget set aside in excess of the specific risk provision to enable achievement of the project objectives in the face of as yet unidentified risks. Management reserve (MR) consists of specific and non-specific risk provisions. Based on the definitions given above, it is clear that in order to determine and monitor CCR of a project the study has to cover, in addition, management of project uncertainties, opportunities and emergent risks. This is, obviously, because of the interrelationship between these mentioned components of risk management. The objectives of this paper are to propose an approach for setting and control of CCR and to explore its applicability.

The methods used for contingency estimation are generally divided into deterministic and probabilistic classes. The traditional percentage is a deterministic method which is most traditionally employed for determination of CCR. A simple percentage contingency based upon the estimate of project cost or based upon subcomponents of project cost is chosen. This method involves setting a percentage, usually between 5% and 10% of total project cost to cover contingencies. A percentage addition results in a single-figure prediction of estimated cost which implies a degree of certainty that is not justified. This exposes the contractor to the problem of either overcompensating for risk or more likely, of underestimating risk.

Another approach for determination of CCR is named "Expected Value method". It assumes that individual risks to the project are identified, along with their impact value (in pounds) together with the probability of their occurrence. Generally, risks are classified into fixed and variable. Fixed risks represent events that will either happen in total or not at all. Variable risks are those events that will occur but the extent is uncertain. For each risk, the maximum and average risk value is calculated. The contingency represents the sum of the average values of individual risks. This approach to contingency setting was outlined by [3] in the study called Estimating using Risk Analysis (ERA). The accuracy of contingencies for ERA projects was found to be significantly superior to non-ERA projects.

The approach known as Method of Moments [4] further extends the Expected Value approach by expanding the role of probability in the calculation of individual risks. In this method, rather than simply calculating an average and a maximum value for each individual risk, each cost item is represented by a triangular probability distribution. For each cost item, the Expected Value (EV) is calculated simply as an average of the maximum, most likely and minimum values. The standard deviation of the cost elements is also calculated. Assuming the total project cost (the sum of EV for individual cost items) follows a normal distribution based on the central limit theorem, z scores (from probability tables for a normal distribution) can be used to find contingency at a given level of confidence. The Method of Moments offers many of the same advantages as the Expected Value approach over the traditional method. One advantage this method has over the Expected Value approach is that the final project cost is described as a continuous probability distribution rather than as a static figure.

In contrast to deterministic methods, probabilistic methods involve assigning probability distribution functions to project cost components and then, through a summative process, developing a probability distribution function for the overall project cost. The methodology begins with breakdown of the overall cost into component elements. Then, each cost element is described as a probability distribution which would describe all of the actual values achieved for that cost element if the exact same project were conducted many different times. Both the data informing the distributions as well as the choice of distributions themselves are rarely based upon objective view. In fact, Smith et al. [5] argued that in order for the technique to be practically useful, it is necessary to rely on the "gut feeling" because the scale and scope of the simulation itself makes further precision irrelevant. Subsequently, Monte Carlo simulation (MCS) is applied which essentially represents repeating construction of the project through a very large number of trials $\geqslant 1000$ in which a value is chosen for each cost component based upon the shape and parameters of the probability distribution. For any given trial, all of the chosen values for the individual cost components are mathematically combined to get a project cost. This process is then repeated for the remaining trials and a probability distribution based upon the overall project cost is generated. However, Smith et al. advocated the triangular distribution to be employed due to its simplicity and because the quantification of risk is often being attempted at the beginning of the project when there is not enough information available to more thoroughly characterize the risk. Contingency is to be set at 50% probability level (median). This approach often yields a contingency value of less than 5%. It is obvious that MCS is more effective over other methods. It is an easy-to-use, understandable, simple and practical tool. It can easily accommodate estimating uncertainties, threats, and opportunities.

Regarding monitoring of CCR during project execution, Ford [6] developed two contingency management strategies: (1) an aggressive strategy which reallocates funds quickly, use contingency to correct schedules before many unforeseen events have been discovered and applies funds early to improve the facility; (2) a passive strategy which reallocates funds slower, postpone using contingency until it must be used to meet critical objectives, and uses little funds for improvement until objectives are met. Managers are simultaneously encouraged to not spend funds early to effectively manage risk and spend funds at the project's end to assure timely completion but also to spend funds early to improve the facility and possibly not spend funds at all (excess contingency). Results of the paper show that research in contingency management and construction strategies must explicitly include the dynamic interactions among system components to capture critical drivers of performance.

APM [2] discussed interfacing of Earned Value Management (EVM) and risk management (RM) for monitoring and control CCR as follows. EVM relies on the establishment of