# WEAK MANAGEMENT OF THE PREDICTABILITY OF CONTINGENCY ALLOWANCE IN CONSTRUCTION PROJECTS IN NIGERIA

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Establishing an accurate amount or percentage allowance to cover unpredictable changes in the construction project budget should be a genuine concern of the project team members. Different studies have shown that contingency allowance has neither been adequate nor technically predictable. The study assessed the practice of professionals in the management of contingency and determines the percentage contingency that is predictable on construction projects in Nigeria. In order to achieve the objectives, the sample selected for this study is quantity surveyors in government, institutions and consulting organisations. Data of past projects were collected from 21 organisations and included information of 99 projects of varying sizes and contract type. Analysis of variance, correlation and multiple regression were used to compare groups and for exploring relationships among variables in proposing a model. The proposed model using standard multiple regression predicted 10.10% contingency allowance on consultant's estimate. The study revealed that about 60% of the respondents do not formally manage and report contingency in their organizations alluding to the fact that an intuitive 5% allowance contingency is not only inadequate but also weakens the purpose of contingency allowance.

Keywords: contingency, Nigeria, quantity surveyor, regression model, variation.

## INTRODUCTION

Improving programme efficiency and effectiveness in organizations requires the use of performance measurement in assessing project performances, both in terms of the financial and non-financial aspects. According to Takim, Akintoye and Kelly (2003) performance measurement is the regular collecting and reporting of information about the inputs, efficiency and effectiveness of construction projects. In Nigeria, not much has been reported on the estimating and management of the construction contingency. This is evident in the number of cases of project cost over runs in which relationship between contingency and final construction cost is hardly reported. According to Bent (2005) project managers mostly treat contingency as a ‘slush fund’. Importantly, clients and development agencies are becoming more informed about construction project management, the effectiveness of which is of utmost concern and contingency is a key factor of consideration. It has become necessary to simultaneously manage

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Bello WA and Odusami KT (2013) Weak management of the predictability of contingency allowance in construction projects in Nigeria *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 969-978.

company and risk (Turskis, Gajzler and Dziadosz, 2012). It is expected that the quality of a project depends to a large extent on the skills and experience of project team leaders; managerial system and the procedures adopted during the construction process (Takim et al, 2003).

In construction and engineering projects plans and cost estimates are usually drawn to ensure that the work is carried out to the desired quality, within allowed time, and within budget. In a construction project and from the owner's point of view, contingency is the budget that is set aside to cope with uncertainties during construction. Touran (2003) posited that it is common to assign contingency value to both cost and schedule because project uncertainties can affect project schedule as well as cost. Contingency allocation has been the subject of various research and various methods of contingency calculation and allocation have been described in several sources. One of the more common methods of budgeting for contingency is to consider a percent of estimated cost, based on previous experience with similar projects. According to Baccarini (2004) contingencies are often calculated as a percentage addition on the base estimate, typically derived from intuition, past experience and historical data. Any serious changes to this budget that is not catered for by contingency may hamper the progress of work or even lead to abandonment of the project which the client never wishes. Current research efforts are being geared towards achieving effectiveness in planning and management. It is a common practice to add a percentage allowance on the base estimate as contingency, which is mostly not effective. Therefore, the aim of the study is to assess the management of contingency predictability by analyzing the significant difference between contingency sum applied to the construction cost estimate and variations. Also included in the objective is defining contingency and assessing the opinion of quantity surveyors in the management of contingency allowance on projects that they have handled in Nigeria construction industry.

Therefore, an assurance of a reliable and effective construction contingency is essential to client's satisfaction on the estimated final construction cost. Increasing clients' satisfaction is achievable through better project management actions, effectiveness of the team leader, viability and feasibility of procedures and stability of the project environment. Specifically, the study will assist consultant quantity surveyors in their estimating practice which benefits clients to have a reliable cost estimate for their projects.

## PREVIOUS WORK

Different authors and researchers including Odeyinka (1987); Ramus and Birchall (1996); Mak, Wong and Picken (1998, 2001); Ashworth (1999); Smith (1999); Harris and McCaffer (2001) consider the assessment of construction risks and its management. Construction contract delivery is a complex undertaking, which is characterised with uncertainties and risk. According to Odeyinka (1987) risk is inherent in any construction project right from inception through its completion. According to Turskis et al (2012) risks that emerge from inability to keep deadlines and remain within the budget are important to all participants of an investment process. Ashworth (1999) posited that risk can be mathematically predicted, whereas uncertainty cannot. The new management paradigm based on process management fosters identification and quantification of risk ( Turskis, Gajzler and Dziadosz, 2012).

## Understanding Contingency Allowance

Patrascu (1988) observed that contingency is probably the most misunderstood misinterpreted and misapplied word in project execution. Contingency can and does mean different things to different people. Ahmad (1992) and Baccarini (2004 & 2005) agreed on this observation and sought for clear understanding of the term contingency. Moselhi (1997) believes that there is no standard definition for contingency. From various authors contingency could generally be defined as a reserve of money allowed above the base estimate amount to reduce the risk of overruns of project objective (Ranasinghe, 1994; PMI, 2004) and allow for changes that experience shows will likely be required (Clark and Lorenzoni, 1985; AACE, 2000) so as to achieve a specific confidence level (AACE, 2000; PMI, 2000) within the scope of the project. In spite of the variations in the definition of contingency in the literature especially the contingency inclusions and exclusions, contingency fund or reserve is not intended to cover changes in scope or schedule, profit, overhead, Acts of God, force majeure situations, earthquakes. This is articulated from various sources (Ahmad, 1992; Moselhi, 1997; AACE, 1992; Ranasinghe, 1994; Chen and Hartman, 2000; Touran, 2003; Baccarini, 2004, 2005; Parsons, 1999; PMI 2004).

Contingencies are crucial to achieving project objectives. According to Yeo (1990) the objectives of the contingency allocation are to ensure that budget set aside for the project is realistic and sufficient enough to contain the risk of unforeseen cost increases. Therefore, any realistic contingency must serve as a basis for decision making concerning financial viability of the variations, and a baseline for their control (Akinsola, 1996).

Moselhi (1997) posited that contingency estimated with intuition and percentage addition ranges from 1 to 5% and rarely exceeds 10%. Parsons (1999) stated the purpose of contingency allowance as to improve the accuracy of cost estimates by compensating for inherent inaccuracies. This is provided in form of contingency allowance. This is expressed as:

Total Estimated Cost (TEC) = Estimated Cost + Contingency Allowance.

As the project becomes better defined more items are included, the estimated cost grows, and the contingency becomes lower, reflecting the reduced degree of uncertainty at that phase of the project. Ideally, the TEC will remain constant throughout a project.

## Management of contingency fund

At the commencement of the construction phase of a project, most of the risk associated with the contract should result from change order growth, which is to be accounted for by the contingency included in the budget. According to Akinsola (1996) any realistic contingency must serves as a basis for decision-making concerning financial viability of the variations, and a baseline for their control. The problems to be solved at this phase would be how to accurately forecast the final cost of these contracts at any given time (Rowe, 2006). This is the responsibility of the authority that manages the contingency. The peculiar nature of construction projects and its characteristics make exact budget needs impossible to forecast accurately and budget contingencies are critical to meeting project objectives. Ford (2002) found that contingency management practices are not organised by clearly defined procedures compared to many other managerial tasks, such as estimating and scheduling. He further relates contingency management to managerial performance but not directly to project performance. It is thus, important to assess the skills possessed by would-be project manager in order to hinge the performance of the contingency and the entire project on the managerial performance of the required skills. Odusami (2002) identified decision making as the most critical important skill for project managers. Communication, leadership and motivation, and problem solving were also ranked accordingly with negotiation skill being the least ranked but rated important. A manager that performs well in these skills would mostly perform in managing the contingency fund. Therefore, according to Ford (2002), the effectiveness of contingency management can strongly influence project success and contingency management is an important project management issue. Baccarini (2004) reported that substantial number of cost practitioners and project managers do not formally manage project cost contingency. Most contingency fund would be exhausted before the completion of the project requiring additional fund. This is a problem that managers are to solve. According to Ford (2002) improving contingency management requires the understanding of how managers make decisions on performance. Managers respond to this challenge by simplifying projects, building and applying models, and improving mental models (Ford 2002).

## DATA COLLECTION

The research sample selected for this study was guided by typical cases of a population that can provide the requisite data and information among professionals in the construction industry. The primary data for this study were obtained through structured questionnaire administered to experienced professional and practising quantity surveyors in government, institutions and consulting organisations. Most of these organisations have projects across the country hence, are representative of what obtains in the entire population of the study. The secondary data for this study were obtained from records of past projects in the organisations to get cost data variables required for research analysis. A closed-ended method of structured questionnaire was adopted for generating information and data for the study. A three points scale of ‘1’, ‘0’, and ‘-1’ representing ‘Yes’, ‘Not really’ and ‘No’ was also used for the assessment of the attitude of cost experts on the management of contingency during the course of the project and for the assessment of its accuracy after the completion of the project. A data collection schedule which contains 14 variables extracted from the records of completed projects or on-going projects nearing completion. Computer based statistical tools such as Frequency distribution of respondents; Mean Score, Descriptive statistics, Correlation, Regression, and Analysis of Variance ANOVA were used for processing the research data. Inferences drawn from this sample was used to make conclusions.

### Results and Discussions

Fifty-three representing seventy-six percent response rate of a total of seventy copies of questionnaire administered to quantity surveyors and or cost expert in three different organisations (government, institutions and consulting) in the construction sector were returned. The sample size comprised government establishment representing 18%, institutional representing 16% and consulting firms representing 66% of the sample size respectively. The sample also sought for the age of the organisations in which 11 representing only 21% of the respondents being less than ten years old and the remaining 79% were between 11 and above 40 years in age. All the respondents are academically qualified with a total of 40 university degree holders representing 65% of the returned questionnaires with 18% having their degree at

Masters Level. Others are Higher National Diploma holders representing 25% of the respondents. Of the 53 respondents surveyed 60% are professionally qualified as member of the Nigerian Institute of Quantity Surveyors four (8%) of which are fellows of the institute indicating that a large percentage of respondents have adequate understanding of the professional practice in the management of contingency among quantity surveyors in Nigeria.

*Assessment of Respondents' practice on Management of Contingency*
Respondents were asked whether contingency is formally managed and or reported throughout the project. Interestingly 40% of the respondents stated that their organisation formally manage and report contingency throughout the project but a larger percentage 60% do not really manage or report contingency on their project. This suggests that there is a significant room for improvement in organisations' approach to construction cost contingency. In discussions, some of the respondents declared that contingency is actually treated as a slush fund. It was also revealed that distinguishing between contingency and additional work is a problem because additional work is being treated as unforeseen work to be accounted for by contingency. Another related question was asked on review of the accuracy of contingency at project completion. The same percentage that manage and report contingency also review the accuracy of contingency at completion. Indicating that only 40% of respondent actually review contingency accuracy 60% do not really do this. Table 1 summarises the results.

*Table 1: Results of Contingency Management and Accuracy of Contingency Review*

| | Contingency Management | | Review of Accuracy of Contingency | |
|---|---|---|---|---|
| | Frequency | Percent | Frequency | Percent |
| No | 6 | 11.3 | 5 | 9.4 |
| Not really | 26 | 49.1 | 27 | 50.9 |
| Yes | 21 | 39.6 | 21 | 39.6 |
| Total | 53 | 100.0 | 53 | 100.0 |

## Presentation and Analysis of Project Cost Data

Having established that most construction projects lack adequate management from the opinion of the respondents, it would be appropriate to further assess quantitatively the effectiveness of managing the contingencies allowed on projects. Data were received from 21 organisations and included information relating to 99 projects of varying sizes and contract type. The data obtained were statistically analysed. The first statistical analysis carried out was the use of scatter plot diagram to identify outliers in which four projects were removed from a total of 103 projects which put the total number of projects for analysis to 99. The next step was to check the variability between the projects using analysis of variance ANOVA to detect whether the 99 sample size would not violate the assumption of homogeneity of variance and if the ninety-nine projects are statistically significantly different. The variables used were total variation (including fluctuations) on estimated contract value (i.e. less contingency sum) and the contingency sum. The same analysis was carried out on the percentage of the variation on estimate and percentage of contingency on estimated contract value. A one-way between groups analysis of variance was conducted on the ninety-nine sample projects in which the significant value (Sig.) for Levene's test indicated that the assumption of homogeneity of variance was not violated and the ANOVA table revealed that there is statistical significant difference between the projects. From the foregoing the accuracy and or effectiveness of contingency in absolute term is the difference between the percentage variations and percentage contingency on the projects. That is, 11.62% - 5.53% which gives 6.09%, a result that is even higher than the percentage contingency. Revealing that contingency sum is less than the total approved variation hence, not effectively managed.

*Estimating Percentage contingencies*
In a related research by Bello and Odusami (2012), it was revealed that the mostly applied percentage contingency is 5% or less and application of contingency of 10 percent or more is rare. A further analysis of construction contingency of 5.53% and average variation of 11.62% of the estimated contract sum indicates that contingency covered only 47.59 percent of approved contract variation and thus, did not cater for 52.41 percent of approved contract variation. The variability of variations (V %) 184%, as measured by coefficient of variation (from standard deviation and Mean), is greater than the variability of construction contingency (C%) which has 86%. This confirmed that contingency sum is less than the total approved variation by 6.09%. One-way ANOVA with post hoc test was carried out to establish if there is a significant difference between contingency and the variations (including fluctuation) to establish the effective management of contingency on project delivery.

A one-way between group analysis of variance was conducted to explore the effectiveness of contingency on variation, as applied to all the 99 projects under study. There was a statistically significant difference at the $p < 0.01$ in the two variables [$F (42, 56)=6.02$, $p=0.01$]. The effect size calculated using eta squared was 0.82 which indicated a very large effect. Table 2 shows the summary of the results.

ANOVA

*Table 2: Statistical Difference between Total Variation and Contingency*

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 526208.063 | 42 | 12528.763 | 6.021 | .000* |
| Within Groups | 116519.603 | 56 | 2080.707 | | |
| Total | 642727.665 | 98 | | | |

**Significant at p<0.05*

The result of the analysis indicated that contingency allocated is not producing the result that is intended on project delivery hence, contingency applied on projects is not effectively managed.

*Regression Model and Results*
In this section, the predictive ability of the identified project variables is explored so as to develop a model for predicting contingency on construction projects. A simple regression equation for a dependent variable X1 is presented in the form;

$$X1 = \beta0 + \beta2X2 + \beta3X3 + \beta4X4 \text{ ----------------------------- (eqn i)}$$

Where, β0, β1, β2, β3 and β4, are constants derived from the regression coefficients after the analyses and X2, X3 and X4 are the independent variables corresponding to Consultant estimate, Planned duration and Gross floor area respectively. Standard multiple regression was used to explore the interrelationship among Consultant estimate, planned duration and Gross floor area in predicting the total variation of 99 projects sample. The following equation was developed from the model displayed in Table 3 from which the coefficient of the predictor independent variable was extracted.

From the model equation (i) Substituting, the coefficient we have;

X1 = -15.235 + 0.101 X2 + 0.436 X3 + 0.003 X4 --------------------- (eqn ii)

X1 =Total Variation on the Project (Future Contingency) X2 =Consultant estimate X3 = Planned duration (weeks) and X4 = Gross floor area. (m2)

*Table 3: Extract of Coefficients Table from Standard Multiple Regression*

| | | Unstandardized Coefficients | | Standardized Coefficients | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|
| Model | | B | Std. Error | Beta | | Tolerance | VIF |
| 1 | (Constant) | -15.235 | 14.125 | | .284 | | |
| | Consultant's Estimate | .101 | .053 | .408 | .060 | .181 | 5.537 |
| | Planned Duration | .436 | .580 | .119 | .454 | .332 | 3.011 |
| | Gross Floor Area | 2.942E-03 | .003 | .160 | .315 | .330 | 3.027 |

*Dependent Variable: Total Variation (incl. fluctuation) on Estimate*

*Evaluating the Model*

Looking at the model summary Table 4, the R Square reads 0.415 which indicates that the model was able to predict 41.5 per cent of the variance in the variation using these three independent variables. This prediction is quite respectable if other factors that influence the contract variation are included in the model. Also, looking at the significant for the model the consultant estimate is significant at $p < 0.10$ but other two variables are not. The results of the multiple regressions also report the ANOVA to assess statistical significance. The model is statistically significant at $p<.005$.

*Table 4: Model Summary from Standard Multiple Regression*

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .644 | .415 | .390 | 63.25529943 |

To conclude on the importance of the model, the coefficient (constant) for consultant estimate is estimated to be 10.10% which is an average contingency acceptable in the construction industry. Moselhi (1997) affirmed a contingency ranging from 12% to 25% as reliable, Aibinu and Jagboro (2002), Omoregie and Radford (2006) had suggested 15-20 percent.

Effectiveness of contingency is not just to calculate the percentage addition but its management. Akinsola (1996) posited that any realistic contingency must be a basis for decision making concerning financial viability of the variations, and a baseline for their control. In aggregate contingency allowance has been effective in accounting for variation or in avoiding cost overrun in 36% of the ninety-nine projects studied in this research. Hogg (2003) reported 23% of the 35 projects that he considered; the conclusion is the same: that there is weakness in the approach to contingency assessment and or allocation. According to Ford (2002), the effectiveness of contingency management can strongly influence project success and contingency management is an important project management issue. The findings on management of contingency revealed that a larger percentage do not really manage or report contingency on their project. This position was articulated by many authors including Ford (2002); Hogg (2003) Baccarini (2005) and Rowe (2006).

## CONCLUSIONS

The definitions of contingency by various authors were studied. A more comprehensive definition of contingency is expressed as a reserve of money allowed above the base estimate amount to reduce the risk of overruns of project objective and allow for changes that experience shows will likely be required so as to achieve a specific confidence level within the scope of the project. Few quantity surveyors formally manage and report and or review contingency throughout the project but a larger percentage do not really manage contingency with review and or reporting contingency on their project. This suggests that there is a significant room for improvement in organisations' approach to construction cost contingency. Some quantity surveyors especially those in government and institutions organisations declared that contingency is actually treated as a slush fund. There was a statistically significant difference at the $p < 0.01$ in contingency and variation [$F(42, 56)=6.02$, $p=0.01$]. The effect size calculated using eta squared indicated a very large effect which revealed that result of the analysis indicated that contingency allocated is not producing the result that is intended on project delivery hence, contingency applied on projects is not effectively managed. This is the responsibility of the authority that manages the contingency. The effectiveness of contingency management can strongly influence project success. Total project contingency decreases over the life cycle of a project and contingency management is an important project management issue. A larger percentage of cost experts do not really manage or report contingency on their projects. The model presented in this research estimated the coefficient for consultant estimate at 10.10% which is an average contingency acceptable in the construction industry. The model was able to predict 41.5 per cent of the variance in the variation using three independent variables. This prediction is quite respectable using few handy variables- a limitation to the use of the model as it does not include other variables like complexities of projects; project governance; capabilities and capacities of resources, levels of risks and uncertainties; strategic intent of project leaders among other factors that could influence the contract variation.

## RECOMMENDATION

The importance of forecasting an accurate and effective construction contingency is sine qua non to client's satisfaction on the estimated final construction cost and hence, the construction contract delivery. Contingency sum should be understood as the fund for the client or project manager's authority hence, there should be no fear to declare how much the quantity surveyor forecast the contract to overrun based on genuine estimate. The notion that whether or not there is enough contingency, variation would arise should be discarded and a more proactive and scientific method of estimating and managing a defendable and reliable contingency that records a reasonable savings at completion of the project should be embraced. Contingency should be formally reported and reviewed in comparison with variation during the construction and at the completion of the project; this would enable the cost expert and managers to capture organisational knowledge that leads to improved practice.

## REFERENCES

AACE (American Association of Cost Engineering) (2000) AACE International's risk management dictionary." Cost Engineering", 42(4) 28-31.

Ahmad, I (1992) Contingency allocation: A computer- aided approach. "1992 AACE Transaction" F.5, F.5.1- F.5.5.

Aibinu, A.A. and Jagboro, G.O. (2002). The effects of construction delays on project delivery in the Nigerian construction industry. "International Journal of Project Management", 20, 593-599.

Akinsola, A.O. (1996) Neural networks, model for predicting building projects' contingency allowance. "Proceeding of Association of Reseachers in Construction Management, ARCOM Conference", 11-13 September, 1996, Sheffield Hallam University, England, 507-516.

Ashworth A. (2010) "Cost studies of buildings". 5th ed. Pearson Education Limited Edinburgh GateHarlow Essex CM20 2JE England

Baccarini D (2004). Accuracy in estimating project cost construction contingency- A statistical analysis. In: Robert E and Malcolm B (eds.)," Proceedings of the Construction and Building Research Conference of RICS", 7-8 September 2004, Headingly Cricket Club, Leeds. RICS

Baccarini D (2005). Understanding project cost contingency- A survey. In: Sidwell A.C (ed.), "Proceedings of the Queensland University of Technology Research Week International Conference", 4-8 July 2005, Brisbane, Australia.

Bello, W. A and Odusami K. T. (2012) The effectiveness of construction contingency in contract delivery in Nigeria In: Dean Kashiwagi (ed.), "Proceedings of the construction and building research conference of the Royal Institution of Chartered Surveyors RICS COBRA 2012" 10-13 September 2012, Las Vegas, Nevada USA, 1627-1636

Bent J.A. (2005). 'Are Today's project cost a bunch of bean counters. "The Quantity Surveyor", 50 (1), 26-30

Chen, D. and Hartman, F.T. (2000). A neural network approach to risk assessment and contingency allocation. "AACE International Transactions", Risk.07.01- Risk.07.06

Clark F. D and Lorenzoni A. B. (1985) "Applied cost engineering". New York: M. Dekker.

Ford, D.N. (2002). Achieving multiple project objectives through contingency management. "Journal of Construction Engineering and Management", 128(1), 30-39.

Harris F. and McCaffer R. (2001) "Modern construction management". Blackwell Science Ltd, Blackwell Publishing Company.

Hogg K. (2003). The role of quantity surveying profession in accomodating client risk, "Journal of Financial Management of Property and Construction" 8(1), 49-56.

Mak S, Wong J and Picken D (1998). The effect on contingency allowances of using risk analysis in capital cost estimating: A Hong Kong case study, "Construction Management and Economics", 16, 615-619.

Moselhi, O. (1997). Risk assessment and cntingency estimating, "AACE International Transactions" D&RM/A.06.1- D&RM/A.06.6

Odeyinka, H. A. (1987). "The effect of risk and its management on construction project overrun", Unpublished MSc. Project Report, Department of Building, University of Lagos, Akoka, Lagos, Nigeria.

Odusami K. T. (2002) Perceptions of construction professionals concerning important skills of effective project leaders, "Journal of Management in Engineering", 18(2), 61-67

Parsons,Jr. E L. (1999) "Waste management project contingency analysis". U.S. Department of Energy, Federal Energy Technology Center. Morgantown, West Virginia.

Patrascu A (1988) "Construction cost engineering hand book". New York: M. Dekker.

PMI (Project Management Institution) (2000) "A guide to the project management body of knowledge". Upper Darby PA:PMI

Ramus J. and Birchall S. (1996) "Contract practice for surveyors". 3rd ed. Laxton's. Great Britain

Ranasinghe, M. (1994) Contingency allocation and management for building projects. "Construction Management and Economics",12, 233-243

Rowe, J.F. (2006). A construction cost contingency tracking system (CTS). "Cost Engineering", 48(2), 31-37.

Smith N.J. (1999) "Management risk in construction projects". Blackwell Science Ltd, Editorial Offices:

Takim, R, Akintoye, A and Kelly, J (2003) Performance measurement systems in construction. In: Greenwood, D J (Ed.), "19th Annual ARCOM Conference", 3-5 September 2003, University of Brighton. Association of Researchers in Construction Management, Vol. 1, 423-32.

Touran, A. (2003). Calculation of contingency in construction projects. "IEEE Transactions on Engineering Management", 50(2), 135-140

Turskis Z; Gajzler, M and Dziadosz, A (2012) Reliability, risk management, and contingency of construction processes and projects, "Journal of Civil Engineering and Management", 18:2, 290-298

Yeo K.T. (1990) Risks, classification of estimates and contingency management. "Journal of Management in Engineering", 6(4), 458-470.