

AN EXPLORATION OF THEORETICAL CONCEPTS AND METHODS FOR ASSESSING RISK IMPACTS ON THE VARIABILITY BETWEEN CONTRACT SUM AND FINAL ACCOUNT IN DESIGN AND BUILD PROJECTS

Keren Larkin¹, Henry Odeyinka and Robert Eadie

School of the Built Environment, University of Ulster, Jordanstown Campus, Newtownabbey, Belfast BT37 0QB

Design and Build procurement has been steadily increasing in popularity over the past number of years. Although it can provide some advantages, it can also lead to being a risky procurement method for both owner and contractor if the risks are not identified in advance and managed throughout. Therefore the overall aim of this study is to identify, assess and model the risk factors impacting the variability between the contract sum and final account in client-led and contractor-led Design and Build projects. The work presented in this paper is at the preliminary stage of the research programme and it looks into the possibility of developing a methodology for assessing risk impacts on the variability between contract sum and final account in design and build projects. As a first step, a detailed review of literature was made to establish the growing use of design and build procurement and the risk inherent in this procurement method. Secondly, different perspectives of risk were examined using the cognitive model of risk so as to position this study in the wider context of existing body of knowledge in this domain. The insights gained from the foregoing steps then helped in devising a methodological framework for assessing the variability between the contract sum and final account in client-led and contractor-led Design and Build projects.

Keywords: contract sum, design and build, final account, risk, variability

INTRODUCTION

Smith *et. al.* (2006), state that the construction industry has had a very poor reputation for coping with the adverse effects of change, with many projects failing to meet deadlines and cost and quality targets. Change is inevitable in construction, it cannot be eliminated and if it is not dealt with properly it can have detrimental effects on time, cost and quality targets. According to Lock (2007), the ever-present elements of

¹ larkin-k1@email.ulster.ac.uk

Larkin K; Odeyinka H and Eadie R (2012) An exploration of theoretical concepts and methods for assessing risk impacts on the variability between contract sum and final account in design and build projects *In: Smith, S.D (Ed) Procs 28th Annual ARCOM Conference, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 337-346.*

risk and uncertainty mean that the events and tasks leading to the completion of a project can never be foretold with complete accuracy. Lock (2007) also indicates that there are many examples of projects which have exceeded their costs by enormous amounts, finished late or even being abandoned before completion, and that such failures are all too common. Similarly, Burtonshaw-Gunn (2009) states that the failure to deal effectively with risk can lead to significant cost overruns, schedule delays and the inability to achieve the desired project technical objectives.

According to Flanagan and Tate (1997) clients want certainty of price, projects constructed within budget and no surprises. Flanagan and Tate (1997) state that the budgeted cost determined at the pre-contract stage of any construction project forms the basis of the contract sum and it is the amount established for the project, which is not expected to be exceeded. Flanagan and Tate (1997) indicate that a contingency sum should be included in the cost budget to cover unforeseen items and all eventualities which can occur during the construction of a project. This should ensure the completion of all projects within the cost budget. However according to Winch (2010) and Walker (2002) evidences abound in construction management literature which indicate that it is very difficult to find a project in which the initial contract sum is not exceeded at completion. Similarly, Magnussen and Olsson (2005) state that studies of major projects show that cost overruns are not uncommon, Odeyinka (2000) state that this could be due to the risk factors inherent in construction. The overall aim of this study is to investigate how risk factors impact on the variability between the contract sum and final account on client-led and contractor-led design and build projects, with a view to developing predictive models that can help the construction contractors to evaluate the impacts of risks eventuating at project level on final account. This study is at the preliminary stage and the work done to date and the proposed future works are presented in this paper. Essentially, a two-fold objective is the subject of this paper. The first is to explore the existing body of knowledge and risk theories in order to position this present study in the existing body of knowledge. The second is to explore the methods for evaluating risk impacts on the variability between contract sum and final account in client-led and contractor-led design and build project.

DESIGN AND BUILD PROCUREMENT

Gidado and Arshi (2004) indicate that although there has been a continuous increase in the use of Design and Build (D&B) over the last 15 years, recent research suggests that contractors may lack proper understanding of managing the varying types of design processes and that it is not uncommon to observe communication breakdowns on D&B projects, as well as misinterpretation of client goals or wrong interpretation of design documents. According to Oztas and Okmen (2004), D&B has been rising in popularity due to the advantages it can provide in terms of project duration, project cost and innovative solutions of project problems. However, apart from these advantages, D&B can lead to being a risky contract system for both the owner and contractor unless the risks are identified in advance and managed throughout the entire project.

Table 1 shows the RICS Contracts in Use (RICS, 2010); the basis of which was a survey carried out in 2007 to determine the main procurement methods currently in use in the UK. The table shows the trends in procurement methods in the UK over a period of 22 years by value of contracts.

Table 1: Trends in Methods of Procurement – by value of contracts.

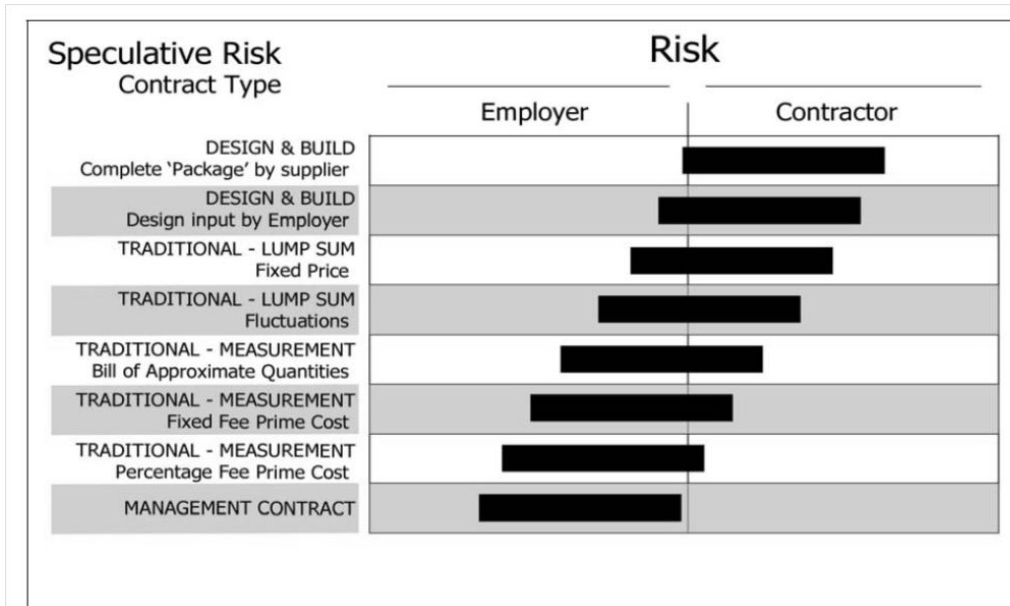
	1985 %	1987 %	1989 %	1991 %	1993 %	1995 %	1998 %	2001 %	2004 %	2007 %
Lump Sum – Firm BQ	59.3	52.1	52.3	48.3	41.6	43.7	28.4	20.3	23.6	13.2
Lump Sum – Spec & Drawings	10.2	17.7	10.2	7.0	8.3	12.2	10.0	20.2	10.7	18.2
Lump Sum – Design & Build	8.0	12.2	10.9	14.8	35.7	30.1	41.4	42.7	43.2	32.6
Target contracts	-	-	-	-	-	-	-	-	11.6	7.6
Remeasurement – Approx. BQ	5.4	3.4	3.6	2.5	4.1	2.4	1.7	2.8	2.5	2.0
Prime Cost Plus Fixed Fee	2.7	5.2	1.1	0.1	0.2	0.5	0.3	0.3	<0.1	0.2
Management Contract	14.4	9.4	15.0	7.9	6.2	6.9	10.4	2.3	0.8	1.0
Construction Management	-	-	6.9	19.4	3.9	4.2	7.7	9.6	0.9	9.6
Partnering Agreements	-	-	-	-	-	-	-	1.7	6.6	15.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: RICS Contracts in Use 2010

As can be seen from Table 1, there has been a dramatic decline in the use of Lump Sum contracts with quantities, from 59.3% of the total value of contracts in 1985 to just 13.2% of the total value in 2007. In contrast, the use of D&B contracts has greatly increased from just 8% of the total value of contracts in 1985 to 32.6% of the total value in 2007. D&B contracts are now used for a bigger value of contracts than any other type of contract, which makes D&B procurement a very important procurement route to concentrate on, especially with regards to risk in D&B projects. Most researchers are in agreement that although D&B procurement can offer some advantages over the traditional methods of procurement, it can turn out to be quite a risky procurement route unless there is appropriate planning and control. For example, Chritamara *et. al.* (2002) state that there are a number of common risks on D&B projects that should they interact with each other, can lead to time and cost overruns on the project.

Fig. 1 illustrates the ‘speculative’ risk to a client and contractor for specific procurement methods; speculative risk is that which can be apportioned in advance of the project as decided by the parties in the contract. As can be seen from Fig. 1, under D&B forms of procurement the risk lies predominantly with the contractor, however there is some difference between the two forms of D&B procurement, under client-led D&B the risk is more evenly proportioned between client and contractor than under contractor-led D&B.

Fig. 1: Risk Apportionment between Client and Contractor



Source: Davis *et. al.* (2008)

COST OVERRUN IN CONSTRUCTION

According to Le-Hoai *et. al.* (2008) time and cost are the two main concerns of construction management. There are many factors which relate to delay and cost overruns and vary along with types of project, locations, sizes, and scopes. McCaffer and Edum-Fotwe (2005) state that while construction has previously been happy to encourage the practice of budget uncertainty with the use of contingency, there is now evidence to suggest that major clients are demanding more cost certainty. Similarly, Davey (2000) argues that it is not uncommon to find that the final costs of projects grow beyond the proposed estimates at the start. To some degree, construction has come to consider this as inevitable, and so it is all too willing to accept this as the norm. Inevitably, there is a real problem with projects exceeding their contract sum, with this being the subject of many studies. According to Magnussen and Olsson (2005), studies of major projects show that cost overruns are not uncommon. Also in their study of large transportation infrastructure projects, Flyvbjerg *et. al.* (2002) discovered that 9 out of 10 projects fall victim to cost overruns, and on average, actual costs are 28% higher than the cost estimate, they conclude that it is a global phenomenon observed over a long period of time.

According to Yabuku and Ming Sun (2009), cost and time overrun of construction projects has consistently attracted the attention of construction professionals all around the world and the situation in the UK is no different, as there have been reports of projects overrunning cost and time. In their investigation into cost and time control of UK projects, Yakubu and Ming Sun (2009) conducted a survey on 150 construction consultancies and 100 construction companies and found that more than 50% of both contractors and consultants experienced a cost overrun on more than 10% of their projects.

Winch (2010) states that evidences throughout construction management literature indicate that it is very difficult to find a project in which the initial contract sum is not

exceeded at completion. Similarly, Magnussen and Olsson (2005) state that studies of major projects show that cost overruns are not uncommon, Odeyinka (2000) state that this could be due to the risk factors inherent in construction.

RISK IN CONSTRUCTION

Risk is present in all construction projects; this is reinforced by Latham 1994, who states

“No construction project is risk free. Risk can be managed, minimised, shared, transferred, or accepted. It cannot be ignored”.

It is widely acknowledged that the construction industry is both more risky and uncertain than most other industries. This makes the subject of risk a very important factor to be considered in construction projects. It is the general consensus that when risks occur on construction projects it can have detrimental effects on the main project objectives of time, cost and quality (Burtonshaw-Gunn, (2009).

According to Winch (2010), there are four schools of thought on the relationship between risk and probability; Objectivist school; Logical school; Subjectivist school; and Behavioural school. Winch (2010) looks at a cognitive approach to risk, where the occurrence of any event is either certain, impossible or somewhere in between the two. Fig. 2 illustrates the cognitive theory of risk and makes a clear distinction between when a probability distribution can be assigned to the occurrence of an event and the condition where it is not possible to assign a probability distribution. This approach is divided up into four categories; known knowns – when a risk source has been identified and a probability can be assigned to the occurrence of a risk event; known unknowns - when a risk source has been identified but a probability cannot be assigned to the occurrence of a risk event; unknown knowns - when someone knows about the risk source and the associated probabilities but it is keeping the information private; and unknown unknowns - when a risk source has not been identified and therefore the risk event cannot be known. In contrast to this, Williams (1996) looks at risk as being two dimensional, and states that risk can be measured by the probability of risk occurrence and the impact of occurrence. Whilst William's (1996) view has been widely held in project management literature, it has not differentiated the various risk categories identified by the cognitive theory of risk (Winch, 2010).

Winch (2010) identified three aspects of risk– the probability of risk occurring, the extent of risk occurrence and the impact of the risk occurrence. Using William's (1996) two-dimensional nature of risk, the three aspects of risk can be measured in two different pairs;

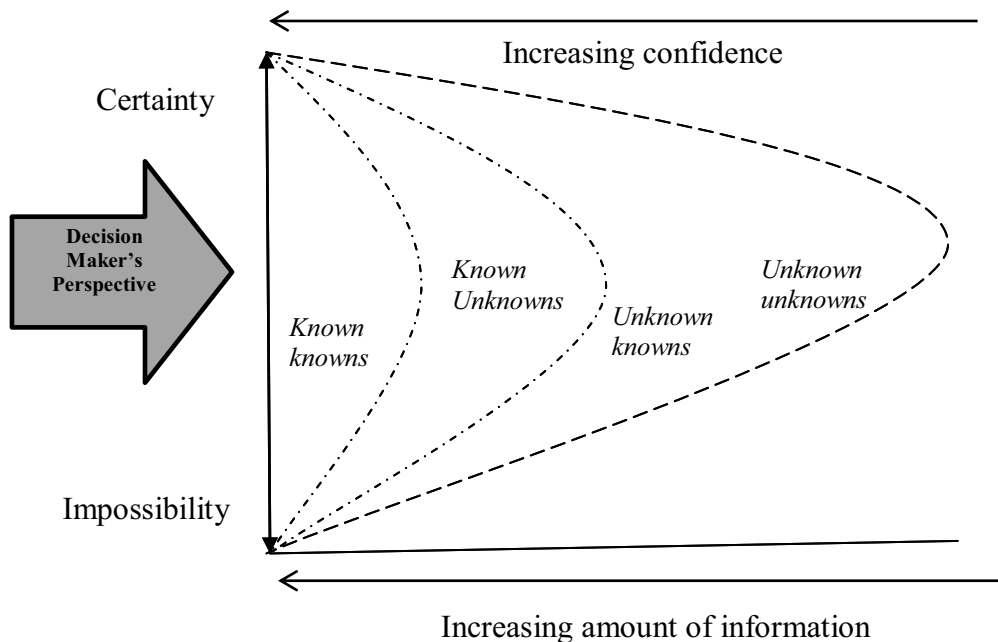
Probability of risk occurrence and the impact of occurrence (subjective)

Extent of risk occurrence and the impact of occurrence (objective)

Smith (2006) submits that combining the probability of risk occurrence with the impact of occurrence will help to determine the degree of risk. Whilst this approach has been adopted widely in dealing with risk in proposed projects, it is considered subjective (Winch, 2010). On the other hand, Smith (2006) considers combining extent of risk occurrence with the impact of occurrence to be based on prior knowledge, i.e. epistemic. This belongs to the objective school of thought which

attempts to predict future events from known data about risk sources; it is associated with the science of statistics and essentially looks at past projects where data is available.

Fig. 2: A Cognitive Model of Risk



Source: Winch 2010

OUTCOMES FROM THE REVIEW OF LITERATURE

It becomes evident from the review of the literature that the use of D&B procurement has been rising in popularity over the past number of years; it can provide advantages in terms of project duration, project cost and innovative solutions of project problems, however, it can lead to being a risky contract system for both the owner and contractor unless the risks are identified in advance and managed throughout the entire project. Fig. 1 illustrated the 'speculative' risk to a client and contractor for specific procurement methods; speculative risk is that which can be apportioned in advance of the project as decided by the parties in the contract. As can be seen from Fig. 1, under D&B forms of procurement the risk lies predominantly with the contractor, however there are some differences between the two forms of D&B procurement, under client-led D&B the risk is more evenly proportioned between client and contractor than under contractor-led D&B. This insight from the literature therefore suggests that a set of risk factors inherent in both client-led D&B and contractor-led D&B projects would need to be determined in taking the research forward.

Another important outcome of the review of literature on risk theory is the clarity provided by the cognitive theory of risk. The insight gained from the theory suggests that there are risk categories and that while some are not measurable, some are. This insight provided direction for positioning this study within the various risk categories. From the cognitive theory of risk, it becomes apparent that for any meaningful contribution to knowledge, this study will need to focus on the known category of risk. This is because this is the category of objective risk where probabilities can be assigned based on prior knowledge. This therefore defines the focus of this research

in the area of measuring objective risk with regards to the extent of risk occurrence and the impact of occurrence.

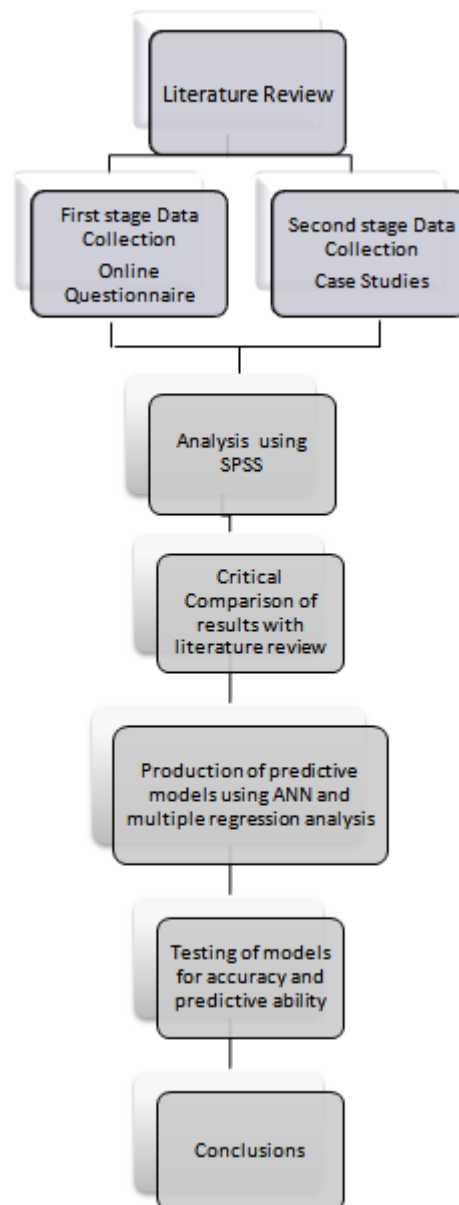
PROPOSED RESEARCH METHODS

Fig. 3 shows the proposed research methods. Following a detailed review of related literature, the primary data needed for the research will be gathered in two stages. Firstly a UK-wide online questionnaire survey will be administered to industry professionals. The questionnaire will seek to gather information on recently completed or on-going client-led and contractor-led D&B projects. The purpose of the questionnaire will be to gather information on the risk factors involved in these D&B projects. There will be a set of identified risk factors from construction management and economics literature which impact on the variability between contract sum and final account.

The data for the research will be obtained from professionals who have first-hand experience on completed D&B project with regards to the extent and impact of occurrence of risks on the project. Respondents will be asked to score on a Likert-type scale, the identified risk factors using two dimensional scaling of both the extent and the impact of occurrence on the selected project. This will involve an epistemic approach to risk as respondents will be expected to do their scoring based on their experience of past projects. From this information the significant risk factors that impact on the variability between contract sum and final account will be determined using mean ranking analysis. The significant risk factors identified will be used in the next stage of the research.

The next stage of the research will involve secondary data collection from case studies. The previous respondents will be asked to provide further information on some client-led or contractor-led D&B projects; other willing respondents will also be approached. This stage of data collection will concentrate on the significant risk factors identified in the first stage of data collection. A project-by-project approach to data collection will be adopted whereby comprehensive data regarding each case study project will be collected. Data from the case studies will be used to develop predictive models for assessing how complex risk factors combine to impact on the variability between the contract sum and out turn cost in client-led and contractor-led D&B projects. Models will be developed using multiple regression analyses and artificial neural networks. The developed models will be validated to determine their predictive ability and practical relevance to the construction contractor.

Fig. 3 Proposed Research Methods



CONCLUSION

As previously stated, two objectives were explored in the work reported in this paper. The first was to explore the existing body of knowledge and risk theories in order to position this present study in the existing body of knowledge. The second was to explore some methods for evaluating risk impacts on the variability between contract sum and final account in client-led and contractor-led D&B project.

From a detailed review of related literature, it can be concluded that the set of risk factors involved in client-led D&B projects will be different from those relevant to contractor-led D&B projects. As such, they will need to be treated separately. It can also be concluded that the cognitive approach to risk provides an insight into the direction of travel of this study. This approach divides risk into four categories; known knowns; known unknowns; unknown knowns; and unknown unknowns. The cognitive theory of risk helps to position this present study in the area of risks which are in the

known knowns category. This then suggests that objective risk would be the focal point of this study as opposed to the subjective risk.

The second conclusion from this preliminary study is that the proposed research methods help to clarify the issues involved at the different stages of data collection and risk measurement approaches that need to be considered. It also helps to clarify the data analysis methods that would be useful to accomplish this research as well as considering the appropriate modelling techniques.

FURTHER STUDY

The next stage of the study will be to identify the separate sets of risk factors inherent in both client-led and contractor-led D&B project in preparing for the empirical phase of the research. The primary data needed for the research will be gathered in two stages. Firstly a UK-wide online questionnaire survey will be administered to industry professionals to gather information on the risk factors involved in the two types of D&B projects. The second stage will involve secondary data collection from case studies. This stage will concentrate on the significant risk factors identified in the first stage of data collection. Data from the case studies will be used to develop predictive models for assessing how complex risk factors combine to impact on the variability between the contract sum and out turn cost in client-led and contractor-led D&B projects. Models will be developed using multiple regression analyses and artificial neural networks. The developed models will be validated to determine their predictive ability and practical relevance.

REFERENCES

- Burtonshaw-Gunn, S.A., (2009). *Risk and Financial Management in Construction*. Hampshire. Gower Publishing Limited
- Chritamara, S. Ogunlana, S.O and Bach, N. L. (2002). System Dynamics Modelling of Design and Build Construction Projects. *Construction Innovation* **2**, 269-295
- Creedy, G (2006). *Risk Factors Leading to Cost Overrun in the Delivery of Highway Construction Projects*. PhD Thesis. School of Urban Development. Queensland University of Engineering.
- Davey, K. (2000). Preventing project cost escalation. *Engineering Management Journal* **10**(4), 174-181.
- Flanagan, R. and Tate, B. (1997): *Cost Control in Building Design*. Oxford, Blackwell Science Ltd.
- Flyvbjerg B. Holm M.S. and Buhl S., (2002). Underestimating costs in public works projects. Error or lie? *Journal of the American Planning Association* **68**(3), 279–95.
- Gidado, K. and Arshi, S., (2004). Suitability of Different Design and Build Configurations for Procurement of Buildings. RICS COBRA 2004 Research Conference, Leeds Metropolitan University, 7-8th September 2004, RICS Foundation, UK.
- Greenhalgh, B and Squires, G (2011). *Introduction to Building Procurement*. Oxon. Spon Press.
- Le-Hoai, L. Dai Lee, Y. and Yong Lee, J., (2008). Delay and Cost Overruns in Vietnam Large Construction Projects: A Comparison with Other Selected Countries. *KSCE Journal of Civil Engineering* **12**(6), 367-377.

- Lock, D. (2007) *Project Management*. 9th Edition. Hampshire. Gower Publishing Limited
- Magnusson, O. and Olsson, N., (2005). Comparative analysis of cost estimates of major public investment projects. *International Journal of Project Management*. Vol. **24**, pp. 281–288.
- Lord, W.E., (2008) *Embracing a Modern Contract – Progression Since Latham? COBRA 2008; the construction and building research conference of the Royal Institution of Chartered Surveyors*
- McCaffer, R. and Edum-Fotwe, F.T., (2005). *Managing Intangibles – The Latent Dimension for Competitiveness in Construction*. Proceedings of the 3rd International Conference on Construction in the 21st Century. Advancing Engineering, Management and Technology, Athens, 15-17th September 2005, CITC-III, Athens.
- Odeyinka, H.A., (2000). An evaluation of the use of insurance in managing construction risks. *Construction Management and Economics* **18**(5), 519-524.
- Oztas, A. and Okmen, O., (2004). Risk analysis in fixed-price design–build construction Projects. *Building and Environment* **39**, 229–237.
- RICS, (2010). *Contracts in Use; A Survey of Building Contracts in Use during 2007*. Royal Institution of Chartered Surveyors.
- Smith, N.J., (2006). *Managing Risk in Construction Projects*. 2nd Edition. London. Blackwell Science
- Williams, T.M., (1996). The Two-Dimensionality of Risk. *International Journal of Project Management* **14**(3), 185-186
- Winch, G.M., (2010). *Managing Construction Projects*. 2nd Edition. Oxford. Blackwell Publishing Ltd.
- Yakubu, O. and Ming Sun (2009). Cost and Time Control of Construction Projects: A Survey of Contractors and Consultants in the United Kingdom (UK). *Construction Information Quarterly* **11**(2), 53-59.