QUANTIFICATION OF CONSTRUCTION PROJECT RISKS BY ANALYSIS OF PAST DISPUTE CASES

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Most risk assessment models require expert opinions for input data and interpretation of results. This study proposes a risk assessment model that utilizes data from past construction project for analysis of risks. Observations from literature on 'risks management' and 'claim management' identify a causal relationship between risks and claims. Thus, claim documents have potential to provide information on risks. In a claim statement, nature of claims indicates impact of risks, reasons for seeking claims indicate risks that have occurred in the project, and values of claims indicate estimates of the impacts of risks. The model adopts techniques of content analysis and open coding to analyse 276 claims from 28 dispute cases. Number of claims caused by each risk determines the frequency of that risk. Scope variation and execution delay are identified as the most frequent risks. A claim amount expressed as a percentage of contract sum represents quantification of impacts due to risks. Impacts of all risks identified from cases are quantified under ten types of claims. The research outcomes also converge with previous studies. Significant contributions of the study are, the identification of causal relationship between risks and claims and development of the risk assessment model with more objectivity.

Keywords: claim, content analysis, dispute, risk assessment model

INTRODUCTION

This research work is conceptualised on integration of literature on risk management (RM) and claim management (CM). Researchers have proposed many models to identify and assess the risks in construction projects (Laryea and Hughes 2008). General philosophy of majority of these models is to assess probability and impact of risks based on expert opinion. Product of probability and impact assesses the risk exposure and helps in determining critical risks in projects (El-Sayegh 2008). However, such systematic assessment of risks have limited acceptance in practice (Laryea and Hughes 2008 and 2011). A significant limitation of these models is the need of expert opinion for input data as well as interpretation of the results. Studies based on historical data from construction projects and the models that can provide readily results in readily usable terms are rare. Moreover, construction industry does not have a formal and prevalent practice of maintaining database on risk related information. Thus, initial challenge of this study was to identify a source of information from the industry which could provide historical data on project risks.

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Unlike studies on RM, researchers have dealt with CM and dispute management relying mostly on analysis of documents from projects (Love *et al*., 2010, Ramachandra and Rotimi 2015, Semple *et al*., 1994). These documents include claim submissions, arbitration awards and litigation cases. Relevant data extracted from these documents have been analysed to identify and evaluate various types of claims and event or conditions leading to claims, and then to disputes. Moreover, the studies on CM have not delved deeper to analyse the events due to which the phenomenon of claim arises in projects. Literature review on RM and CM has revealed an important link between 'risks' and 'claims'. This link helps to postulate a causal relationship between risks and claims. Identification of the causal relationship between the two phenomena has immense significance as vast amount of CM documents can be now exploited to obtain data for analysis of risks. This study highlights this significance through development of a risk assessment model based on analysis of claims from past dispute cases.

Research Objectives and Scope

The goal of this research work is to develop a risk assessment model using historical data on projects risks and to facilitate quantification of risks in readily interpretable form. Objectives set forth are - (i) to analyse the relationship between risks and claims; (ii) to extract risk related data from claim statements and structure them to facilitate qualitative and quantitative analyses; and (iii) to identify and assess the risks from extracted data. The proposed model is expected to be applicable to all types of claim documents. However, scope of the proposed study is limited to analysis of 276 claims from 28 settled arbitration awards. The focus of this study is to report development of the theory and demonstrate its potential application. Hence, by strategically selecting claims exclusively from settled arbitration awards, issues of possible biasness of stakeholders in preparation of claims are set aside for time being. Arbitration awards are made after rigorous analyses of evidences, testimony of experts and considering views of concerned stakeholders. Thus, for all practical purposes the arbitration awards give a true account of events leading to claims and justified assessment of impacts due to these events on projects.

The research work is presented broadly in two stages. First, summary of observations from literature along with arguments are presented to postulate that risks and claims have causal relationship. Second, based on the causal relationship, a risk assessment model is proposed. Comparison of fundamental aspects of the new risk assessment model with the existing models is also presented in the discussion section.

RESEARCH BACKGROUND

This section includes comparison of basic characteristics of risks and claims. It is followed by comparison of texts used by researchers to describe risks and sources of claims. These two comparisons analyse the relationship between risks and claims.

A Relook at Definitions of Risk and Claim

Risk

British Standard (BS 6079-3:2000) defines risk as the uncertainty of an event happening that can affect the prospects of achieving business or project goals. Project Management Institute (PMBOK 2013: 310) provides more elaborate definition of risk as an uncertain event or condition that if occurs have a positive or negative effect on one or more project objectives such as scope, schedule, cost and quality. These definitions assert the characteristics of risk noted by Al-Bahar and Crandall (1990) - 'the risk event', 'the uncertainty associated with that event' and 'potential loss or gain'.

Claim

Similar to risk, claim also has many definitions. Following three definitions of claim are used to identify characteristics of claim and putting forward the arguments.

1. Any application by the contractor for payment that arise 'other than under the ordinary contract provisions' (Jergeas and Hartman 1994).
2. A claim is a request for compensation for 'damages incurred by any party to the contract'. Claim represents basis of claim (cause and effect), explains the contractual and legal basis for payment (entitlement), and quantifies the resulting damages (Semple *et al*., 1994).
3. A request by a construction contractor for 'compensation over and above the agreed-upon contract amount for additional work or damages' supposedly 'resulting from events that were not included in the contract' (Ho and Liu 2004). ['Stress' provided].

Consider the phrases from the first definition, '… other than under ordinary contract provisions …' and from the third definition, '… resulting from events not included in the initial contract …' These phrases suggest that claims arise from events/conditions which are different from ordinary events/conditions or not included in the contract. Without being envisaged in the contract there will be some amount of uncertainty associated with these events/conditions during the project implementation. Further, a focus on phrases from the second definition, '… damages incurred by any party …' and from the third definition, '… compensation over and above the agreed-upon contract amount for additional work or damages …' implies that claims are assessment of impact or damages. From these two observations, an inference can be drawn that claims are assessment of impacts of those events/conditions which have uncertainty associated with them. Moreover, claims are raised usually after damages or additional costs have been incurred. To sum up, claims are characterised by 'assessed losses' resulting from 'uncertain events' that have 'occurred' in a projects. Comparison of characteristics of risk and claim shows two important similarities, 'occurrence of uncertain event' and 'consequent loss or gain'. This observations provides an important insight - Are the claims actually assessed impacts of the risks that have occurred in the project?' Following discussion further clarifies this insight.

Comparison of Texts Describing Risks and Sources of Claims

Texts that identify different type of project risks are compiled from research papers. The texts used to describe a particular risk (for instance, scope variation) vary slightly across studies (see Table 1). In next step, texts used to describe sources of claims are also compiled. A comparison of texts pertaining to 'risks' and 'sources of claims' dealing with similar issues in projects illustrates that researchers refer to same phenomenon when they describe 'risks and 'sources of claims'. Table 1 shows the sample illustration of the comparison of texts for risks and sources for claim when issue of scope variation is considered, and the following paragraph describes the phenomenon of scope variation.

Contractors are assigned to execute a project as per the scope defined in the contract, bill of quantities, technical specifications, design and drawings, and quality assurance plans. Often, the contracts are signed before design and detail drawings are finalised leading to uncertainty in the scope of work envisaged in the contracts. Changes in the scope of work also happen during execution due to project site conditions; changes in owners' requirements, technical specifications; etc. Contractors may incur additional costs

because of differences in the contractual and the actual scope of work. They may also raise claims for compensation.

Table 1: Comparison of texts describing 'risks' and 'sources of claims' for scope variation

Risks	Sources of claims	Remarks
Changes of scope, Excessive contract variation, Scope variation (Keci 2015); Incomplete design scope (Al-Bahar and Crandall 1990); Design/project scope change due to extra unspecified work, Specification change (Creedy et al., 2010); Lack of scope definition (El-Sayegh 2008).	Variation initiated by owner, Change of scope, Unforeseen changes (Cakmak and Cakmak 2014); Variations (Yates 1998); Variations due to site conditions, client changes, design errors and external events (Kumaraswamy 1997); Increase in scope (Semple et al., 1994).	Similarities can be observed in texts used to describe 'scope variation' as risk and as source of claim.

Therefore, the claims rooted in the scope variations are basically assessment of impacts of the scope variation risk in projects. Based on comparisons of characteristics of risk and claim, and sets of texts used to report risks and sources of claims, it is postulated that 'claims are actually the assessment of impacts of those risks that have occurred in the project'. This postulate forms the theoretical foundation of this study. At this point, some questions likely to probe the readers are - what is the extent of validity of the causal relationship between risks and claims; how do other risks and claims in the project interact; how to account for those damages against which claims are not submitted; and what are the consequences of settlement or rejections of claims. This research being first step in this direction, the focus is not on addressing all questions. However, some critical questions are answered through development of the model and discussions.

Risks as Source of Change Orders, Claims and Disputes

Researchers have described how claims lead to conflict and disputes (Cheung and Yiu 2006, Kumaraswamy 1997). By extending relationship between risks and claims to conflict and disputes, emergence of disputes due to risks is mapped in Figure 1.

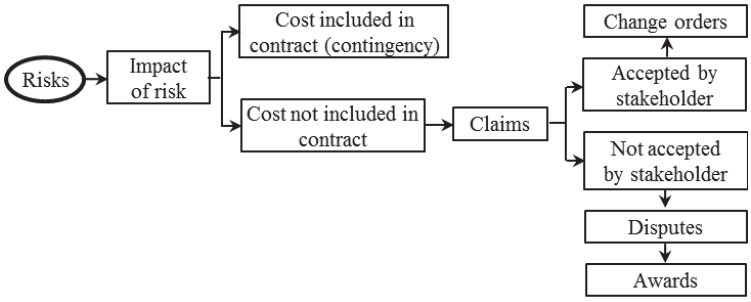

Figure 1: Impact of risks resulting change orders, claims and disputes

If risks occur they can affect a stakeholder at two levels. At one level, some risks are anticipated during estimation and costs of their impacts are included in the contract prices. These impacts are covered by contingency or costs of risks accepted by the stakeholders. At another level, if the costs of impacts due to some risks are not included in the contracts, claims for compensation are submitted after occurrence of risks. A part of claims may be accepted by the counter party through change orders. The counter party may also reject claims due to disagreement over assessment or entitlement of the compensation. Unsatisfactory settlement of claims may lead to conflict and disputes. To resolve disputes, special resolution methods viz. mediation, conciliation, arbitration and litigation are required. The claims which reach the dispute stage pertain to those risks which are difficult to anticipate (these are not included in the contract estimate), quantify and allocate (their assessment and entitlement may be the basis of rejection and disputes).

Therefore, analysis of dispute awards help in focusing on impact of those risks which are most difficult to manage. Difficulty in anticipation, assessment and allocation are the characteristics of critical risks.

Critical Review of Literature on Risk Assessment Models

Risks identified and reported in literature vary from conceptual risk terminology to tangible risk factors. For instance, design risk is a conceptual term represented by tangible attributes such as delay in design finalization by the owner; design errors and changes in designs by designers; changes in specifications by technical consultants; etc. which are rooted into different stakeholders. An objective assessment of risks requires assessment at the level of risk factors (Yildiz *et al*., 2014). In risk assessment through expert opinions, these details are often sacrificed to maintain practical size of questionnaires. Moreover, the scales developed by researchers using 'impact and probability words' also lack consistency (Kent 1964). Even the interpretation of findings of opinion based studies is also non-intuitive and requires help of experts. Besides, researchers have also recognized the existence of interrelationship among risks in actual project scenarios, thus making assessment of isolated risks even less reliable (Zhang 2016). Laryea and Hughes (2008 and 2011) have observed that complex and systematic risk assessment models are rarely used by practitioners in bidding processes and have argued for simpler models with tangible outcomes.

So sum up the discussion so far, the causal relationship between risks and claims is postulated by comparative analysis of literature on RM and CM. A critical literature review of risk assessment models also highlights the need of a risk assessment model with less reliance on exerts for input data and interpretation of the results. Additionally, Semple *et al*., (1994) have outlined that claim statements contain information on cause and effect (i.e. risk events and their impacts), quantification of risks (i.e. assessment of impact), and entitlement (i.e. risk allocation). Thus, preparation of the claims is actually assessment of impacts due to risks, and by analysing claims risks can be assessed. Following section illustrates the development of a risk assessment model based on the causal relationship between risks and claims.

MODEL DEVELOPMENT

The first research objective is achieved through literature review. The research methodology adopted for the second and the third objectives is illustrated in Figure 2. It includes two steps - data collection and data analysis.

Data Collection though Content Analysis

Techniques of content analysis are adopted to manually extract data through in-depth study of arbitration awards. Content analysis is a research technique used to make replicable and valid inferences from texts to the context of their use (Krippendorff 1980:18). By systematically evaluating texts, qualitative data can be converted into quantitative data. For illustration consider a claim statement, '… compensation for the infructuous expenditure incurred on establishments during the extended period of the contract … due to delay in site handover, unavailability of owner supplied materials and design changes'. The first part of the statement, 'infructuous expenditure on establishment' describes the type of impact on the stakeholder due to those risks whose information is given in the second part of the statement.

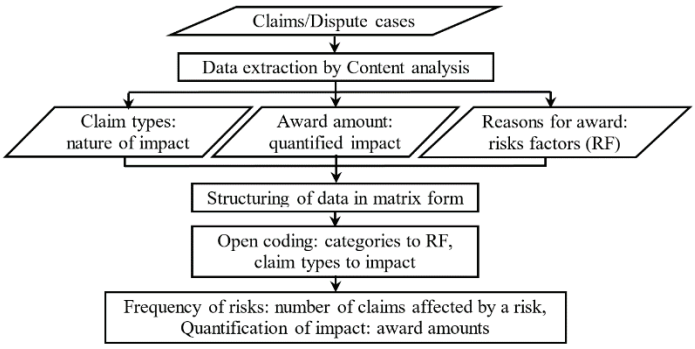

Figure 2: Flow chart showing research methodology for model development

These risks are related to delay in site handover, shortage of materials, and design changes. The claim amount is the quantification of impact of risks in monetary terms. In this study, only reasons and claim amounts accepted by the arbitrator in writing the award have been considered. Table 2 shows the scheme of structuring data in matrix form using Microsoft Excel to map the claims to the reasons provided for claims.

Table 2: Template for extracting and structuring data from dispute cases (INR- Indian Rupee)

Ref.	Claim statements (↓)	Reasons for award (→) Generic description of claims (↓)	Work done beyond BOQ scope C3.R1	Delay in site handover by owner C3.R2	Claim value (INR) x1000	Award value (INR) x1000
C3.1	Claim for prolongation of work for a period of 2 years	Compensation for idle resources and overheads	1	1	2212.8	1222
C3.2	Claim for changing specification after receipt of materials	Compensation for change in scope of work	1	-	3000	1000
	Total (→)	-	2	1	5212.8	2222

In Table 2, claim statements are listed along the column and reasons for making each award as provided by the arbitrators are listed along the row. Each case, claim and reason extracted from the arbitration awards is assigned a systematic unique reference numbers which is retained throughout the analysis to allow tracking of information. In the matrix, cell value of '1' is used to map a claim to a reason when that reason is sighted by an arbitrator as underlying cause of resultant claim. Mapping of reasons with claims in matrix form revealed that a claim could result from one or more reasons and vice versa. This observation suggests many-many relationship between claims and reasons, and subsequently between claims and risks. This exhibits the phenomenon of interrelationships among risks. Columns at right include values of claims, counter claims (not shown in the table) and awards. A convention has been adopted such that positive value is the amount to be paid by the respondent to the claimant. Content analysis of 28 arbitration cases including cumulative 276 claims is carried out. Among 28 cases, 3 cases were closed with nil awards. In only one case, award was in the favour of the respondent. Therefore, data from only 24 cases are included in the final analysis. All cases are obtained from Central Public Works Department (CPWD) of India. CPWD was the respondent in all cases and claimants were different contracting companies of varying sizes. No confidentiality or ethical issues were faced during collection of cases.

Data Analysis through Open Coding

Principles of open coding are adopted to analyse two sets of data - types of claims and reasons for making awards underlying these claims. Open coding is an iterative process of converting textual information into categories that represents a common phenomenon.

Open coding of 'reasons for awards or sources of claims' is done to accumulate similar types of reasons into categories and then map them to risk factors (RF) taking clue from risks reported in the literature. Table 3 shows a sample of coding process. Here, frequency refers to number of claims to which a particular reason was assigned by the arbitrators. Similarly, the data on types of claims were open coded and mapped to 10 major types of impacts that projects have faced.

Table 3: Coding of extracted data from 'reasons for claims' to risks factors (RF)

Ref.	Reasons for award	Frequency	Coding (RF)
C3.R1	Work done beyond contracted scope	2	Scope variation
C3.R2	Delay in site handover by owner	1	Delay in site handover
C3.R8	Price rise due to escalation	1	Inflation

RESULT AND DISCUSSION

A New Expression for Probability of Risk

Opinion based studies use relative frequency indices (FI) to assess probability of risks and identify most probable risks (El-Sayegh 2008). However, these studies are silent about how to interpret the value of an index. For instance, if design risk has assessed frequency index of 60% or 0.6 - what does it imply? Does it mean that in a very large sample of projects, 60% projects will face design risk? If so, what will be the pattern of occurrence of design risk along project duration or across structures within these projects? How does the index value relate to project costs? In reality, some amount of design risks occur in most projects. Therefore, to address the ambiguity inherent in existing expression of likelihood/probability, this study has measured frequency of RFs to assess probability. Frequency is the total number of claims caused by a RF. Higher frequency means that a RF has occurred in more projects as well as it has caused many claims within a project. Practitioners should be wary of a RF with higher frequency as it would cause large number of claims and, very likely, higher costs. From 30 RFs identified in this study, top ten are listed in Table 4.

Table 4: Frequency (Fr.) distribution of Risk factors (RF) affecting claims

Sl.	Risk factors (RF)	Fr.	Sl.	Risk factors (RF)	Fr.
1	Scope variation	106	6	Interest	46
2	Execution delay	102	7	Dispute	35
3	Delay in release of payment	86	8	Over heads and idle resources	34
4	Design related issues	62	9	Inflation (Escalation)	31
5	Poor contract management	53	10	Poor communication	24

Scope variation has affected maximum number of claims being closely followed by Execution delay. In practice, every change in the scope of work directly results in work stoppage, possibly rework, idling and reassignment of resources, and delays in execution. Top five and top ten RFs are mapped to 53% and 85% of claims, respectively. Interest and Dispute risks are typical to projects entering into disputes.

Quantification of Impact of Risks

Similar to probability, studies express impacts of risks as their severity indices (El-Sayegh 2008) but are also silent about how to interpret these indices. Say, if design risk has assessed severity index of 40% or 0.4 - what message does it convey to the practitioners? How these values can facilitate estimation of risk allowances or

contingencies? These indices are not readily interpretable and needs help of the experts. If the assessment models were to give output in terms of costs due to impacts, decision makers will find the results more useful. In this study, arbitration award amount against each claim is assumed as true assessment of the impact due to risks underlying those claims. However, as a claim can arise from more than one risk, the proposed model assesses the impacts of risks under some major types of impacts and not specific to a particular risk. This simulates the actual project scenario of risks having interrelationships where assessment of an isolated risk shall not give a reliable result. The analysed cases were of varying contract sums executed over long periods. Hence, to normalise the effect of sizes of contract sums and inflation across years on risk assessment, each claim amount is expressed as % of respective contract sum.

Impacts are observed under the ten different heads (see Table 5). IV-Interest over delayed payments appeared in all 24 cases with mean value of 4.5% of contract sum. II-Cost of extra work and VIII-Cost of unpaid work together have impact of 9.5% of contract sum. II and VIII are directly related to scope variation risk which is mapped to maximum number of claims. Overheads and resource idling are noted in 19 projects with mean of 4.5% of contract sum. The impact of all risks averaged over 24 projects is 18.7% of contract sum. While other models provide non-intuitive outcomes for risk impact assessment, this model quantifies the impacts as percentage of contract sum which can be readily used by decision makers.

Table 5: Mean (M) award amounts as percentage of contract sum; (see under table for label)

Label	I	II	III	IV	V	VI	VII	VIII	IX	X	Total
N	18	14	15	24	4	3	19	10	12	14	24
M (%)	1.1	3.0	2.6	6.9	1.2	7.5	4.5	0.5	1.2	6.5	18.7

Legend: I-Cost of arbitration , II-Cost of extra work, III-Escalation amount, IV-Interest over delayed payments, V-Refund of levy of compensation, VI-Loss of profit, VII-Overheads and idling of resources, VIII-Refund of recoveries made from bill, IX- Refund of conditional rebates deducted, X-Unpaid work. N is the number of cases in which particular claim was accepted. M is the mean value of impact assessed over N cases calculated from each award expressed as percentage of respective contract sum.

Comparison of Results with Other Studies

El-Sayegh (2008) has put inflation; delay in material supply and approval; change in designs among top ten critical construction risks in UAE. Kartam and Kartam (2001) have found delayed payment on contract and defective design to be among five most significant risks in Kuwaiti construction industry. These findings are similar to frequent RFs shown in Table 4. The research team of the proposed study is also conducting risk assessment study in Indian construction industry based on opinion survey. Trends from opinion of 43 experts with average experience of over 15 years show that design risks, quality and rework risk, scope variation risk, time-over run risk and inaccurate feasibility assessment as the five most critical risks. These findings support the findings of the proposed study.

Limitations of the Study

This study is the first attempt to identify and analyse causal relationship between risks and claims. The theory is in formative stage. RFs identified by the proposed model include only those risks that have affected one or more of 28 projects/cases and are not exhaustive. Due to various forms of contracting and risk allocations, some risks may not

find its way into the claims and hence are not recognised by the model. Intermediate effects and impacts of isolated risks have not been analysed, instead cumulative impacts of all risks are assessed under ten different claims. Future studies with larger and diverse samples will generate comprehensive umbrella of risks and refine the proposed model.

SUMMARY AND CONCLUSION

This study has evolved from linking the literature on risk management and claim management. Necessary evidence and arguments have been presented from the literature to postulate that 'claims are actually assessment of impacts of risks' that have affected the project. In fact, texts used to identify 'risks' and 'sources of claims' are found to be similar. Potential of the postulated theory is demonstrated by developing a risk assessment model based on analysis of claims from arbitration awards. The study has employed techniques of content analysis to analyse 276 claims from 28 arbitration cases. Scope variation, execution delay, delay in release of payment, design related issues and poor contract management are the five most frequent risks causing over 50% of the claims. Impacts of risks are quantified as percentage of contract sum under ten types of claim. Convergence of the findings of the proposed model with the previous studies and a contemporary research substantiates the study.

The most important contribution of this study lies in attempt to identify the causal relationship between risks and claims. The study has opened up a new world of possibilities for research on risk management using data from previous projects. Proposed approach reduces reliance on experts for adopting a risk assessment model. The model also illustrates that defining frequency of risks in terms of number of claims these risk may affect is more objective assessment of probability of risks. The model is also able to quantify the impacts of the risks in terms of percentage of contract sum, thus making the results of risk assessment readily interpretable. With limited volume of data analysed so far, the theory has not been supported by statistical analysis. To encompass more types of risks and to address intricate questions related to assessment of individual risks and their interactions, future studies can be taken up.

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REFERENCES

Al-Bahar, J F and Crandall, K C (1990) Systematic risk management approach for construction projects. *Journal of Construction Engineering and Management*, **116**(3), 533-546.

Cakmak, E and Cakmak, P I (2014) An analysis of causes of disputes in the construction industry using analytical network process. *In*: *Second World Conference on Business, Economics and Management*, 25-28 April 2013, Antalya Turkey.

Cheung, S O and Yiu, T W (2006) Are construction disputes inevitable? *IEEE Transactions on Engineering Management*, **53**(3), 456-470.

Creedy, G D, Skitmore, M and Wong, J K W (2010) Evaluation of risk factors leading to cost overruns in delivery of highway construction projects. *Journal of Construction Engineering and Management*, **136**(5), 528-537.

El-Sayegh, S M (2008) Risk assessment and allocation in the UAE construction industry. *International Journal of Project Management*, **26**, 431-438.

Ho, S P and Liu, L Y (2004) Analytical model for analysing construction claims and opportunistic bidding. *Journal of Construction Engineering and Management*, **130**(1), 94-104.

Jergeas, G F and Hartman, F T (1994) Contractors' construction claim avoidance. *Journal of Construction Engineering and Management*, **120**(3), 553-557.

Kartam, N A and Kartam, S A (2001) Risk and its management in the Kuwaiti construction industry: A contractor's perspective. *International Journal of Project Management*, **19**(6), 325-35.

Keci, J (2015) Public private partnership for infrastructure projects: mapping the key risks. International Scholarly and Scientific Research and Innovation, 9(9), 2729-2739.

Kent S (1964) Words of estimative probabilities. *Studies in intelligence*, **8**(4), 49-65. Available from https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/books-and-monographs/sherman-kent-and-the-board-of-national-estimates-collected-essays/6words.html [Accessed 22nd July 2017].

Krippendorff, K (1980) *Content Analysis: An Introduction to its Methodology 2nd Edition*. Newbury Park: Sage Publications, Inc.

Kumaraswamy, M M (1997) Conflicts, claims and disputes in construction. *Engineering, Construction and Architectural Management*, **4**(2), 95-111.

Laryea, S and Hughes, W (2008) How contractors price risk in bids: Theory and practice. *Construction Management and Economics*, **26**(9), 911-24.

Laryea, S and Hughes, W (2011) Risk and price in the bidding process of contractors. *Journal of Construction Engineering and Management*, **137**(4), 248-58.

Love, P, Davis, P, Ellis, J and Cheung, S O (2010) Dispute causation: Identification of pathogenic influences in construction. *Engineering, Construction and Architectural Management*, **7**(4), 404-23.

PMBOK (2013) *A Guide to the Project Management Body of Knowledge (PMBOK guide) 4th Edition*. Atlanta: Project Management Institute (PMI) Inc.

Ramachandra, T and Rotimi, J O B (2015) Mitigating payment problems in the construction industry through analysis of construction payment disputes. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, **7**, 1-8.

Semple C, Hartman, F T and Jergeas, G (1994) Construction claims and disputes: Causes and cost/time over runs. *Journal of Construction Engineering and Management*, **120**(4), 785-95.

Yates, D J (1998) Conflict and Dispute in the development process: A transaction cost economic perspective. *In*: *Fourth Annual Pacific Rim Real Estate Society Conference*, 19-21 January 1998, Curtin University of Technology Perth.

Yildiz, A E, Dikmen, I and Birgonul, M T (2014) Using expert opinion for risk assessment: a case study of construction project utilizing a risk mapping tool. *Procedia Social Behaviour Sciences*, **119**, 519-528.

Zhang, Y (2016) Selecting risk response strategies considering project risks interdependence. *International Journal of Project Management*, **34**, 819-30.