ARE WE ADDING RISK TO OUR PROJECTS BY MIXING OBJECTIVE ASSESSMENTS OF COMPOUND CONJUNCTIVE AND DISJUNCTIVE PROJECT RISKS WITH INTUITIVE APPROACHES?

Alex Collins Arthur[1] and Stephen D. Pryke

[1] *Bartlett School of Construction and Project Management, University College London, UK*

Various forms of quantitative analytical tools and techniques have emerged through the evolution of construction risk management systems but their full benefit on project performance are yet to be realised. Construction risk analysts continue to rely on statistical and probability tools in their risk data presentation whilst risk management decision-making process tends to reflect the use of intuition rather than rationality. Drawing theories and concepts from systems thinking, and behavioural sciences, the implications of applying quantitative analytical tools and techniques within an instinctive construction risk decision-making context is evaluated. The analysis of construction risk management decision making systems, and discussions relating to the instinctive processing of statistics and probability data, reveals evidence associated with the incompatibilities of mixing objective and subjective approaches to project risk assessment and response. The inference being that, effective instinctive construction risk management practices may require data formats that are compatible with instinctive decision processing. In conclusion, the research provides conceptual analytical evidences for stimulating further investigations into the appropriate format for construction risk management data analysis and presentation.

Keywords: instinctive decision making, probability prediction, risk, statistical data, systems thinking.

INTRODUCTION

Kahneman (2011) identifies two systems of thinking and decision making; the *fast* system which relies on instincts and subjective methodologies, and the *slow* system involving the application of rational tools and cognitive analysis. Kahneman goes further to illustrate this by contrasting the decision processes of analysing a picture of an angry woman versus calculating a multiplication equation. Whilst the analysis of the picture occurs spontaneous and effortless, through the modelling of the decision flow in patterns similar to previous exposures (Benthin *et al*, 1993), the processing of the mathematical equation involves slow and deliberate effort of the mind and body through the recollection of the relevant cognitive programme, decomposition of the equation into sequential order, tensing of the muscles, increase in blood pressure, and dilation of the eyes. Again, the *fast* system appears to be constantly active and difficult to tame unlike the *slow* system which requires conscious effort to activate. Decision procession of the *slow* system usually originates from the *fast* system in the

[1] Alex.Arthur.10@ucl.ac.uk

Arthur, A and Pryke, S (2014) Are we adding risk to our projects by mixing objective assessments of compound conjunctive and disjunctive project risks with intuitive approaches? *In:* Raiden, A B and Aboagye-Nimo, E (Eds) *Procs 30th Annual ARCOM Conference, 1-3* September 2014, Portsmouth, UK, Association of Researchers in Construction Management, 1399-1408.

form of perceptions, impulses and impressions which requires further analysis to validate them into beliefs and actions (Kahneman, 2010). Table 1 below describes the main differences between the two systems.

Table 1: Differences between fast and slow systems of thinking and decision making (The fast system has been named the "Experiential system", and the slow system as the "Analytic system") - Slovic et al (2010:24)

Experiential system (*fast system*)	**Analytic system (*slow system*)**
1. Holistic	1. Analytic
2. Affective: pleasure- pain oriented	2. Logical: reason oriented (what is sensible)
3. Associationist connections	3. Logical connections
4. Behaviour mediated by "vibes" from past experiences	4. Behaviour mediated by conscious appraisal of events
5. Encodes reality in concrete images, metaphors and narratives	5. Encodes reality in abstract symbols, words and numbers
6. More rapid processing: oriented towards immediate action	6. Slower processing: oriented towards delayed action
7. Self- evidently valid: "experiencing is believing"	7. Requires justification via logic and evidence

Construction project management, being a decision science discipline, likewise employs tools and techniques from the *fast* and *slow* systems in the identification and treatment of project risk events (Lock, 2003; Winch, 2010; Loosemore *et al*, 2006). Construction risk management approaches include instinctive thinking and actions which rely on personal values, feelings, experiences, cultural beliefs (Slovic *et al*, 2002; Slovic and Peters, 2006), and rationality involving the use of scientific techniques in evaluating the probability of occurrence and impact of an uncertainty to establish an appropriate risk management response (Bowden, 2001; Winch, 2010; Lock, 2003). Recent studies have also revealed the application of fuzzy quantitative analytical systems using *linguistic variables* (Byrne, 1995; Cox, 1999; Zeng *et al*, 2007; Khazaeni *et al*, 2012a; Khazaeni, *et al*, 2012b; Kuo and Lu, 2013). Fuzzy set theory was first introduced by Lotfi A Zadeh in 1965 (Edwards and Bowen, 1998) to facilitate quantitative analysis of relationships where mathematical equations may not be appropriate (Cox, 1999; Jain and Martin, 1998). The application usually involve the use of expert knowledge in the subjective quantification of risk assessment factors, in the form of *linguistic words,* for structured and systematic quantitative analysis using *fuzzy logic controller* (Byrne, 1995; Jain and Martin, 1998). Fuzzy logic thus becomes another rational technique with the difference being *linguistic assessment variables* instead of mathematical equations, which are typical of statistical and probability quantitative analysis.

Empirical evidence from the project case studies where fuzzy logic has been applied reveal some benefits in the areas of improved risk identification on complex projects (Kuo and Lu, 2013), addressing the inherent subjectivities of the traditional risk analysis factors of *risk likelihood* and *risk impact* (Zeng *et al*, 2007), and achieving balanced risk allocation (Khazaeni *et al*, 2012a; Khazaeni, *et al* 2012b). Nevertheless, there appears to be limited application of the concept among construction professionals (Edwards and Bowen, 1998), especially at the post contract stages. This may partly be due to the general criticisms of the unfamiliarity of fuzzy logic tools, and a perception of inherent conceptual errors emanating from the systems fundamental philosophy of imperfections (Cox, 1999), and specifically within the construction industry, the disparities between most of the research project case studies and the general risk management setting, in the areas of risk data availability, competency in rational analytical systems, and risk management decision making approaches.

Construction risk data and reports on the other hand, are commonly expressed qualitatively in the form of statements, narratives, scenario, simulation, and quantitatively using statistical and probability tools (Bowden, 2001; Lock, 2003; Loosemore *et al*, 2006, Winch, 2010).

Inbar *et al* (2010), believe that the prime attributes of a decision task and its setting are what determines the choice of an appropriate decision making methodology. Hammond *et al*, (1987, cited in Dane *et al*, 2012) have also argued that decision tasks capable of being decomposed into a structured order are most suited for the rational approach, whilst the processing of non-decomposable decision tasks tend to be effective under the instinctive approach. And with construction risk management decision tasks involving exhibits of decomposition (Lock, 2003), the natural expectation would have been the adoption of equal measure of rational and instinctive approaches. The research findings however, reveal otherwise (Akintoye and Macleod, 1997; Lyons and Skitmore, 2003; Kululanga and Kuotcha, 2010).

A questionnaire survey of 100 general contractors and project management practices in the United Kingdom revealed low level of knowledge and application of rational risk management practices (Akintoye and Macleod, 1997). A similar survey of senior management involved in the Queensland engineering industry in Australia also revealed high incidence of instinctive risk analysis practices by analysts with minimal training in rational risk management systems (Lyons and Skitmore, 2003). Another survey of construction companies in Malawi also discovered limited application of rationality among the large companies, with the risk management practices of the small and medium sized companies dominated by instinctive thinking and actions. The findings from the construction industry appears consistent with other studies conducted within the behaviour science disciplines (Shapira, 1986, cited in March and Shapira, 1987).

The reasons expounded for the low application of analytical construction risk management practices include limited availability of construction risk data, limited competency in rational tools and techniques, the size and scope of most construction projects do not provide a benefit-cost justification for investing in rationality, and the lack of appreciation for analytical construction risk management practices (Akintoye and Macleod, 1997; Lyons and Skitmore, 2004; Adams, 2008). Theoretical findings grounded in the behavioural sciences on the other hand, imply that the high incidence of instinctive construction risk management practices may be due to the *spontaneous processing of instinctive thought* (Dane and Pratt, 2007; Betsch, 2008; Betsch and Glockner, 2010; Sinclair, 2010; all cited in Dane *et al*, 2012), which makes for faster responses to complex decision-making, in situations where there is limited structured data (Slovic and Peters, 2006; Bateman *et al*, 2010). Bringing the above together, provides useful insight into the potential benefits of the instinctive approach, in guiding construction organisations in addressing the increasing client and regulatory demands to provide swift and accurate risk management decisions using limited available data (Loosemore *et al,* 2006; Perlow, Okhuysen and Repenning, 2002 cited in Dane *et al*, 2012).

THEORETICAL FRAMEWORK

The paper adopts a critical theoretical review of concepts and empirical findings from systems thinking and analysis (Checkland, 1999; Bertalanffy, 1968; Carmichael, 2006; Walker, 2007), and behaviour sciences (Slovic and Peters, 2006; Slovic *et al* 2010;

Bateman *et al*, 2010; Tversky and Kahneman, 1982a; 1982b; 1982c; Kahneman, 2011; Epley and Gilovich, 2002; Finucance *et al*, 2003; Chapman and Johnson, 2002) in evaluating the implications of mixing tools and techniques from the different systems of thinking and decision making (Kahneman, 2011). The analysis centres on post-contract project risk management in the housing sector, which by virtue of its comparatively, smaller project sizes and scope, makes it typical of instinctive practices (Akintoye and Macleod, 1997). The principles of general systems theory enables conceptual examination of the effects of mixing objective and subjective risk assessment techniques. The behaviour science theories and concepts nonetheless, facilitates the psychological evaluation of the resulting systematic errors.

Systems thinking and analysis

Systems thinking is a classical investigative approach which evaluates subjects by considering the properties of the collective rather than the individual components (Checkland, 1999). The underlying conceptual ideologies emanated from the biological sciences through the discovery of general systems theory in 1966 (Bertalanffy, 1966). Systems thinking being an exploratory approach (Checkland, 1999) however suggests that, it may have existed prior to its formal discovery, as seen in Paracelsus' investigations in medicine, Leibniz's studies in philosophy (Bertalanffy, 1966), and Apostle Paul's analysis of the mission of the Christian Church (Romans 12: 4- 8; 1 Corinthians 12; 12- 31, cited in Arthur and Pryke, 2013).

The basic tenet of systems thinking, is that every system has an objective (Walker, 2007) that establishes a shared identity among the parts, in terms of their functions and purpose (Blanchard and Fabrycky, 1998). And in order to achieve the desired system's output, the components must collaborate during the transformational phases (Walker, 2007). The influence of external forces sometimes causes changes in the internal structure of systems, leading to modifications in the main system's objectives or the micro objectives of the individual components (Walker, 2007). The presence of multiple divergent objectives, then again makes a system vulnerable to cross purpose working, which could be detrimental to project success.

The psychology of instinctive thinking and decision making

Psychometric research findings suggest that the human mind stores records of life experiences (Bateman *et al*, 2010), in the form of sensory inputs associated with sound, smell, visions, ideas and words (Finucance *et al*, 2003). Each sensory record is marked with a positive or negative *affective* feeling, based on the circumstance in which the event occurred (Slovic and Peters, 2006). Slovic *et al* (2010); Kahneman (2011) have argued a connection between *affect* heuristics responsible for the generation of *affective* feelings, and the *representative*, *availability* and *anchor and adjustment* heuristics. The *representative* heuristics evaluates the possibility of a relationship between an event and its parent population by the degree of similarities between the event and the prime attributes of the parent population (Tversky and Kahneman, 2002). The *availability* heuristics also forecasts the frequency of an event by evaluating how easily a similar past occurrence can be recalled or a possible future scenario can be constructed from the attributes of the event (Kahneman, 2011). The *anchor and adjustment* heuristics estimates future events by applying subjective adjustments to a preliminary given anchored data to achieve the final value (Chapman and Johnson, 2002).

In the process of instinctive thinking and decision making, the human mind scans the mental image library for evidence of previous similar records to influence the modelling of the future decision event in the pattern of the previous occurrence (Benthin *et al*, 1993). A positive previous similar record with the associated positive *affective* feeling tag will inspire a positive feeling and perception of the future decision event as a benefit. A negative previous similar record with the associated negative *affective* feeling label on the other hand, will stimulate a negative feeling and perception of the future decision event as a risk. According to Finucane *et al* (2003), decision modelling in situations of multiple divergent previous comparable records, are determined by factors including the dominant attributes of the different experiences, and the physiological state of the decision maker, being either extrovert or introvert. The reliance on heuristics for instinctive thinking and decision making also suggest that the absence of a similar past record may hinder the modelling of a future decision model (Arthur and Pryke, 2013)

DISCUSSIONS

Against the background of the above theoretical evaluations, let us now proceed to discuss the implications of mixing tools and techniques from the instinctive and rational approaches to construction risk management.

Systems Analysis of Construction Risk Management Decision Making Approaches

Drawing from the principles of systems thinking, we can model the *fast* and *slow* systems of thinking and decision making (Kahneman, 2011) applied within construction risk management (Slovic el al, 2010) as depicted in Figure 1 below.

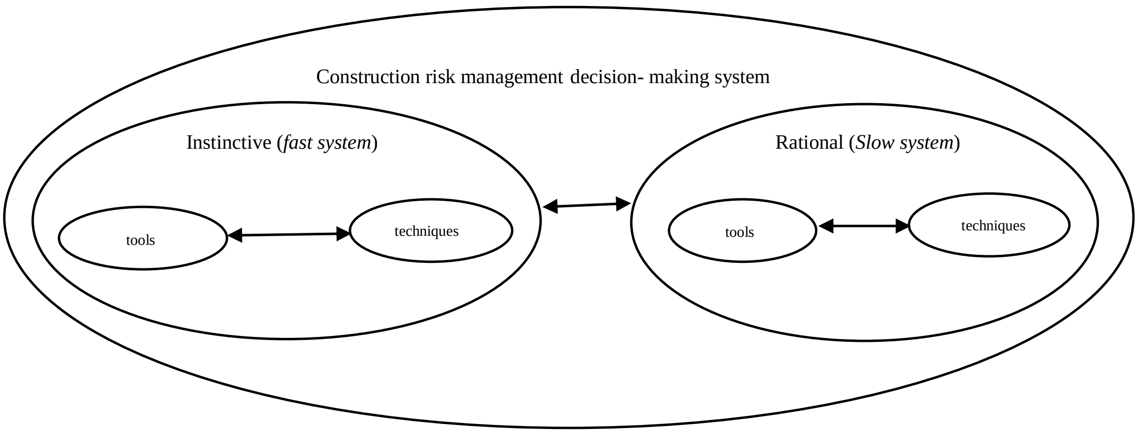

Figure 1: Construction risk management decision-making system. Derived from Walker, 2007:66- 98; Slovic et al, 2010:23- 25, Kahneman, 2011:19- 30

The principles of general systems theory suggest that the *instinctive* and *rational* construction risk management approaches will form the components of the main system. The concept of systems decomposition (Carmichael, 2006) which analyses components as subsystems with different micro objectives also suggests that the *instinctive* and *rational* approaches will comprise of parts which are identical within a group but different from those of the other group (Blanchard and Fabrycky, 1998). System transformational processes requiring collaborating working of the parts will also necessitate compatibility between the tools and techniques applied in an approach

(Walker, 2007). The implication being that, mixing an instinctive decision making approach with statistical risk data and quantitative analytical techniques may introduce conflicting objectives which may affect the collaborative processing of the risk management system, and ultimately project success (Pryke and Smyth, 2006).

Instinctive Processing of Statistics and Probability Data

According to Kahneman (2011), a major limitation of the *fast* system of thinking and decision making is its lack of understanding of logic and statistics. Tversky and Kahneman (1982a) also believe that the principles of instinctive decision making which relies on the *representative*, *availability*, and *anchor and adjustment* heuristics, are inconsistent with the principles of probability theory and may be susceptible to errors and biases. Slovic el al (2010) have also argued that, *affective feelings* involved in instinctive decision making impedes the processing of quantitative statistical data (Denes-Raj and Epstein, 1994). Other studies have however revealed instances where experts have relied on their professional experiences to achieve accurate instinctive evaluations (Kahneman, 2011).

Tversky and Kahneman (1982a; 1982b) have suggested the inherent biases in instinctive decision making under the *Representative* heuristics to include, *insensitivity to prior probability predictions* which leads to the error of formulating project risk registers based on typical industry risk events without careful consideration of the specific project environment; *insensitivity to sample size* which gives a false expectation of comparable industry experience on every project; *insensitivity to external influences* which leads to the exclusion of third party impacts from risk analysis; and *insensitivity to the validity of base data* which leads to the error of applying extraneous variables in project risk analysis and decision making. In summary, these factors lead to poor assessment of, and responses to, project risks.

Instinctive judgement under the *Availability* heuristics may also exhibit biases originating from the ease of retrieving past occurrences. This may lead to the error of assigning high probability predictions to occurrences associated with issues in the media, and low probability predictions to occurrences associated with obscure past events (Tversky and Kahneman, 1982a; 1982c). A typical example is the recent media publications on the effects of Japanese knotweed on the structural integrity of residential buildings; this may have accounted for the high attention given to the plant in most project risk management registers, compared to the other less known but equally invasive plants such as aphalara itadoin, giant hogweed, Himalayan balsam, mares tail, buddleia, rhododendron (Hodgson, 2014).

The inherent errors of instinctive decision making under the A*nchor and Adjustment* heuristics have been attributed to the inadequacies of adjustments (Epley and Gilovich, 2002), which leads to errors in the final estimations. Inadequacies of adjustment results from the premature termination of the adjustment process, or when a base anchored value is perceived as a *case of suggestion* which should reflect the final estimate (Kahneman, 2011). According to Cohen *et al*, (1972), cited in Tversky and Kahneman (1982a) the impact of *anchor and adjustment* may account for overestimation of probability predictions involving compound conjunctive events, and underestimation of probability predictions of compound disjunctive events. This may be due to the fact that the sum of probability predictions of compound conjunctive events is less than the values of each of the individual events, whereas the sum of probability predictions for compound disjunctive events is more than the probability predictions of each of the individual events. In the context of construction risk analysis, the errors from *anchor and adjustment* heuristics may result in unrealistic project programming anchored on optimistic critical path activities, and under estimation of project risk impact anchored on the individual risk events, without careful consideration of the consequential impact from third party events.

Denes-Raj and Epstein (1994) have stated that, most people undertaking instinctive evaluation of statistical data will perceive higher probability values for prospects offering *"more options"* compared to prospects of *"less options"*. An investigation involving undergraduate psychology students who were asked to draw red jelly beans from different sized transparent containers holding different sample sizes, revealed a preference for the container with bigger sample size in spite of the fact that the container with the smaller sample size offered the best probability of chance (Denes-Raj and Epstein, 1994). The implication being that, instinctive construction risk analysis of statistical data may produce variations in the risk quantification and classification depending on the probability scales applied in the base data. The cumulative effect may include erroneous risk analysis and responses.

Slovic *et al* (2010) have argued that, instinctive evaluation of events which evoke strong *affective* memories such as addiction, faith, affection, anger and resentment may be indifferent to quantitative statistical analysis. A research by Loewenstein *et al* (2001) also identified comparable evidence in the form of similar *affective* feelings towards winning the lottery irrespective of the value of probability prediction. In the context of construction risk management, people with sentimental project experiences associated with an innovative construction solution, asbestos contamination deaths, and fire destructions on timber frame construction sites, may form block opinions which may affect the processing of probability prediction of similar future event. Such individuals may become indifferent in their future risk analysis and response of a similar event irrespective of the probability prediction.

The theoretical evidence on the problems associated with mixing tools and techniques from the *fast* and *slow* systems of thinking and decision making probably explains why instinctive construction risk analysis utilising statistical and probability data usually produces projections that are different from the actuals (National Audit Office, 2000; CBI, 2010; Flyvbjerg *et al*, 2003).

CONCLUSIONS

The above discussions have centred on the variances in micro objectives between the different construction risk management subsystems (Walker, 2007, Carmichael, 2006, Slovic *et al*, 2010, Kahneman, 2011, Blanchard and Fabrycky, 1998), the intrinsic biases and errors in instinctive decision making under the *Representative*, *Availability*, and *Anchor and Adjustment* heuristics (Kahneman, 2011; Epley and Gilovich, 2002), the insensitivity of strong *affective stimuli* to quantitative statistical analysis (Slovic, 2010), and the discrepancies between the principles of instinctive decision making, and statistics (Tversky and Kahneman, 1982a; Denes-Raj and Epstein, 1994). Collectively, they provide evidence on the systematic errors inherent in the existing construction risk management practices of applying statistical and probability data within an instinctive decision making approach.

The theoretical evidence on the transformational processes of the different systems of thinking and decision making (Kahneman, 2011), and the need for coordination among system components (Walker, 2007) also suggest that addressing the systematic errors may require careful revision of the existing construction risk management practices to ensure compatibility between the decision making vehicle, and the data presentation and analytical techniques. This calls for either adopting rational decision making approaches to complement the statistical and probability tools, or on the other hand, applying qualitative risk data formats and subjective techniques which are compatible with instinctive decision making. The existing empirical evidence of low level competency in rational techniques among construction professionals (Akintoye and Macleod, 1996; Lyon and Skitmore, 2003) indicates that adopting the latter option may be more feasible in the present context. There is however the need for further investigations to confirm this. We therefore propose further studies into the level of knowledge and application of statistics and probability within the construction industry, the qualitative data formats and subjective techniques that will be compatible with the existing instinctive practices, and a comparative analysis of the decision making effectiveness of instinctive construction risk analysis which utilises qualitative data, versus the continual use of statistical and probability data.

REFERENCES

Adams, F. K. (2008). Risk Perception and Bayesian analysis of international construction contract risks: The case of payment delays in a developing economy. *International Journal of Project Management.* **26** (2008), 138- 148.

Akintoye, A. S. and Macleod, M. J. (1996) Risk analysis and management in construction. *International Journal of Project Management*, **15** (1), pp. 31- 38.

Arthur, A. C. and Pryke, S. D. (2013). Instinctive Thinking; Analysis of Construction Risk Management Systems. In: *Proceedings of the Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors, New Delhi, September 2013*. London: RICS.

Bateman, I. Dent, S. Peters, E. Slovis, P. and Starmer, C. (2010) *"The Affect Heuristic and the Attractiveness of Simple Gambles"* In P Slovic (ed). *The Feeling of Risk, new perspective on risk*. Earthscan Ltd, London, 3-19.

Benthin, A., Slovic, P., Severson, H. (1993). A Psychometric study of adolescent risk perception. *Journal of Adolescence*, 1993 (16), 153- 168.

Bertalanffy, L. V. (1968). *General System Theory, Foundations Development Applications*. Fletcher and Son Ltd. Norwich.

Blanchard, B. S. and Fabrycky, W. J. (1998). *Systems Engineering and Analysis*. 3ed. Prentice Hall Inc, London.

Bowden, A. R., Lane, M. R., and Martin, J. H. (2001). *Triple Bottom Line Risk Management*. John Wiley and Sons, New York.

Byrne, P. (1995). A Vague Way of Dealing with Uncertainty in Real Estate Analysis? *Journal of Property Valuation & Investment*, **13** (3), 22- 41.

Carmichael, D. G. (2006). *Project Planning, and Control*. Taylor & Francis, Oxon.

Chapman, G. B., and Johnson, E. J. (2002) *"Incorporating the Irrelevant: Anchors in Judgments of Belief and Value"* In T. Gilovich, D. Griffin, D. Kahneman *Heuristics and Biases, The Psychology of Intuitive Judgment.* Cambridge University Press, Cambridge 120- 138.

Checkland, P. (1999). *Systems Thinking, Systems Practice*. John Wiley and Sons Ltd. Chichester.

Dane, E., Rockmann, K. W., and Pratt, M. G., (2012). When should I trust my gut? Linking domain expertise to intuitive decision-making effectiveness. *Organizational Behaviour and Human Decision Processes*. **119** (2012), 187- 194.

Denes-Raj, V., and Epstein, S., (1994). Conflict Between Intuitive and Rational Processing: When People Behave Against Their Better Judgment. *Journal of Personality and Social Psychology*, **66** (5), 819- 829.

Edwards, P. J., and Bowen, P. A (1998). Risk and Risk Management in Construction: A Review and Future Directions for Research. *Engineering, Construction and Architectural Management*, **5** (4), 339- 349.

Epley, N., and Gilovich, T. (2002). *"Putting Adjustment Back in the Anchoring and Adjustment Heuristic"* In T. Gilovich, D. Griffin, D. Kahneman *Heuristics and Biases, The Psychology of Intuitive Judgment.* Cambridge University Press, Cambridge 139- 149.

Khazaeni, G., Khanzadi, M., Afshar, A. (2012a). Fuzzy adaptive decision making model for selection balanced risk allocation. *International Journal of Project Management*, **30** (2012), 511- 522.

Khazaeni, G., Khanzadi, M., Afshar, A. (2012b). Optimum risk allocation model for construction contracts: fuzzy TOPSIS approach. *Can. J. Civ. Eng*. **39**, 789- 800.

Flyvbjerg, B. Bruzelius, N. and Rothengatter, W. (2003). *Megaprojects and Risk, an anatomy of ambition*. Cambridge University Press, Cambridge.

Finucane, M.L., Peters, E., and Slovic, P., (2003). *"Judgement and Decision Making: The Dance of Affect and Reason"* In S. L. Schneider and J. Shanteau (eds). *Emerging Perspectives on Judgement and Decision Research*. Cambridge University Press, Cambridge. 327- 346.

Hodgson, S. (2014). *Knotweed and Invasive Weeds.* CPD Foundation. Accessed on 9 June 2014. Available from https://feusd-cpdfoundation.s3.amazonaws.com/uploads/asset/file/951/140609_-_Japanese_Knotweed.pdf

Inbar, Y., Cone, J., and Gilovich, T. (2010). People's Intuitions About Intuitive Insight and Intuitive Choice. *Journal of Personality and Social Psychology*. **99** (2), 232- 247.

Jain, L. C., and Martin, N. M (1998). *Fusion of Neural Networks, Fuzzy Sets and Genetic Algorithms- Industrial Application.* CRC Press, London

Kahneman, D., (2011). *Thinking fast and slow*. Penguin Books Ltd, London

Kululanga, G., and Kuotcha, W., (2010). Measuring project risk management process for construction contractors with statement indicators linked to numerical scores. *Engineering, Construction and Architectural Management.* **17** (4), 336- 351.

Lock, D. (2003). *Project Management*, 8ed. Gower Publishing Limited, Hampshire.

Loewenstein, G. F., Weber, E. U., Hsee, C. K., Welch, N., (2001). Risk as Feelings. *Psychology Bulletin*, **127** (2), 267- 286.

Loosemore, M. Raftery, J. Reilly, C. and Higgon, D., (2006). *Risk Management in Projects*. Taylor & Francis, Oxon.

Kuo, Y., and Lu, S. (2013). Using fuzzy multiple criteria decision making approach to enhance risk assessment for metropolitan construction projects. *Internal Journal of Project Management*. **31** (2013), 602- 614.

Lyons, T., and Skitmore, M. (2003). Project risk management in the Queensland engineering construction industry: a survey. *International Journal of Project Management*. **22** (2004), 51- 61.

March, J. G. and Shapira, Z. (1987). Managerial Perspectives on Risk and Risk Taking. *Management Science*, **33** (11), 1404- 1418.

National Audit Office (2000). *The Millennium Dome; Report by the Comptroller and Auditor General.* HC 936 Session 1999- 2000. The stationery office, London.

Pryke, S, and Smyth, H. (2006). *The Management of Complex Projects, a relationship approach*. Blackwell Publishing Ltd, Oxford.

Slovic, P., Finucane, M., Peters, E., and MacGregor, D. G. (2002) *"The Affect Heuristic"* In T. Gilovich, D. Griffin, D. Kahneman. *Heuristics and Biases, The Psychology of Intuitive Judgment.* Cambridge University Press, Cambridge 397- 420.

Slovic, P., and Peters, E. (2006). Risk Perception and Affect. *Currrent Directions in Psychological Science*, **15** (6), 322- 325.

Slovic, P., Finucane, M. L. Peters, E. and MacGregor, D. G. (2010) *"Risk as Analysis and Risk as Feelings: Some Thoughts about Affect, Reason, Risk and Rationality"* In P. Slovic *The Feeling of Risk, new perspective on risk*. Earthscan Ltd, London 21-36.

Tversky, A. and Kahneman D., (1982a) *"Judgement under uncertainty: Heuristics and biases"* In D. Kahneman, P. Slovic, A. Tversky *Judgement under uncertainty: Heuristics and biases.* Cambridge University Press, Cambridge 3- 20.

Tversky, A. and Kahneman D., (1982b) *"Belief in the law of small numbers"* In D. Kahneman, P. Slovic, A. Tversky *Judgement under uncertainty: Heuristics and biases.* Cambridge University Press, Cambridge 23- 31.

Tversky, A. and Kahneman D., (1982c) *"Availability: A heuristic for judging frequency and probability"* In D. Kahneman, P. Slovic, A. Tversky *Judgement under uncertainty: Heuristics and biases.* Cambridge University Press, Cambridge 163- 178.

Tversky, A. and Kahneman, D., (2002). *"Extensional versus Intuitive Reasoning: The Conjunction Fallacy in Probability Judgment"* In T. Gilovich, D. Griffin, D. Kahneman *Heuristics and Biases, The Psychology of Intuitive Judgment.* Cambridge University Press, Cambridge 19- 48.

Walker, A. (2007). *Project Management in Construction*. Blackwell Publishing Ltd, Oxford.

Winch, G. M. (2010). *Managing Construction Projects*, 2ed. Blackwell Publishing Ltd. Chichester.

Zeng, J., An, M., and Smith, N, J. (2007). *Application of a fuzzy based decision making methodology to construction project risk assessment.* International Journal of Project Management, **25** (2007), 589- 600.