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FORMATIVE EVALUATION OF ANALYTIC HIERARCHY PROCESS AS A RISK PRIORITISATION TOOL FOR RISK MANAGEMENT

(Penilaian Formatif Terhadap Proses Hierarki Analisis sebagai alat Pengutamaan Risiko untuk Pengurusan Risiko)

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ABSTRACT

The aim of this study is to discover strengths and limitations of Analytic Hierarchy Process (AHP) as a risk prioritisation tool for risk management. The study developed a risk management problem and used AHP to organise and structure risks and sub-risks of the problem. It used formative evaluation method with open-ended questionnaires to obtain feedbacks from risk managers on AHP. The study documented the following strengths of AHP: it is easy to use and understand, improves understanding of a problem and improve risk assessment. AHP improves risk assessment in the following ways: it provides a systematic risk assessment process, a clear and transparent risk assessment, facilitates debate and discussion of the risk ranking, and assists risk managers to make explicit trade-off between the risks and sub-risks. AHP is useful for problems with intangible elements, scarce data or requiring subjective judgements. AHP limitations are: too many pairwise comparisons decreasing risk managers concentration and the repetitiveness of the pairwise comparisons resulting in decision fatigue. The consequence, risk managers did not answer all questions or just answer the questions randomly.

Keywords: analytic hierarchy process; risk prioritisation; formative evaluation

ABSTRAK

Tujuan kajian ini adalah untuk mengetahui kekuatan dan batasan Proses Hierarki Analisis (PHA) sebagai alat pengutamaan risiko untuk pengurusan risiko. Kajian ini membangunkan satu masalah pengurusan risiko dan menggunakan PHA untuk mengatur dan menstruktur risiko dan sub-risiko masalah tersebut. Ia menggunakan kaedah penilaian formatif dengan soal selidik terbuka untuk mendapatkan maklum balas daripada pengurus risiko terhadap PHA. Kajian ini mendapati kelebihan PHA adalah seperti berikut: mudah untuk digunakan dan difahami, meningkatkan pemahaman masalah dan memperbaiki penilaian risiko. PHA memperbaiki penilaian risiko seperti berikut: penilaian risiko sistematik, penilaian risiko yang jelas dan telus, memudahkan perdebatan dan perbincangan mengenai tahap kepentingan risiko, dan membantu pengurus risiko untuk membuat penilaian jelas dan seimbang terhadap risiko dan sub-risiko. PHA berguna untuk masalah yang mempunyai unsur tak ketara, data berkurangan atau memerlukan pertimbangan subjektif. Batasan PHA adalah perbandingan yang terlalu banyak mengurangkan tumpuan pengurus risiko dan perbandingan yang berulang-ulang menyebabkan keletihan pembuatan keputusan. Akibatnya, pengurus risiko tidak menjawab semua soalan atau hanya menjawab soalan secara rawak.

Kata kunci: proses hierarki analisis; pengutamaan risiko; penilaian formatif

1. Introduction

The primary aim of this study is to investigate whether Analytic Hierarchy Process (AHP) (Saaty 1977) can be a risk prioritisation tool for risk management. Saaty (1987a) defined AHP as a theory of measurement to derive a ratio scale from both discrete and continuous paired comparisons. The comparisons can be actual measurements or fundamental scales reflecting

relative strengths of preferences or feelings. AHP is a framework to execute both deductive and inductive thinking. The framework requires considering several factors simultaneously and making numerical trade-off between the factors to arrive at a synthesis or conclusion. AHP uses a hierarchy to organise a complex and unstructured problem. A problem is deconstructed into parts or variables, and structured into a hierarchy. The hierarchy establishes relations between parts or variables. AHP uses pairwise comparisons to elicit decision makers' judgements on the relative importance of the variables. The pairwise comparisons facilitate a trade-off between the variables. The judgements are translated into values and developed into a decision matrix. The values in the decision matrix are then converted into ratio scales. AHP uses eigenvector to derive the weights of the variables. Decisions are based on the variable with the largest weight. AHP can be used as a decision making tool for six types of decision making: choosing the best alternative, prioritizing or ranking alternatives, allocating resources, benchmarking an alternative against a standard and managing quality (Bushan & Rai 2004).

Generally, risk management uses risk matrix to prioritise risks. It is a tool to determine important risks. Risks are plotted on a graph, with the vertical axis representing impact or magnitude, and the horizontal axis representing likelihood or probability. The matrix is divided into four quadrants: (i) low impact, low likelihood; (ii) low impact, high likelihood; (iii) high impact, low likelihood; and (iv) high impact, high likelihood. Likelihood and impact are evaluated using a scale of 1 to 9. Figure 1 presents an example of a risk matrix for six risks R1, R2, R3, R4, R5 and R6.

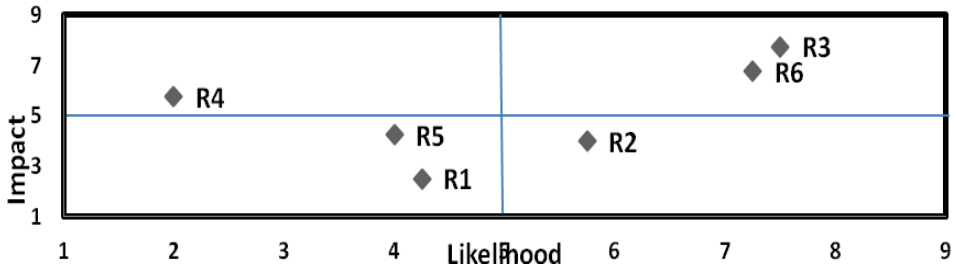

Figure 1: An example of a risk matrix

The following discusses risk matrix limitations. Shenkir and Walker (2007) argued the likelihood-magnitude approach does not consider the preferences and value judgements of decision makers. Decision maker's preferences and judgements are important in determining significant risks and planning actions to mitigate the risks. According to Emblemsvag and Kjolstad (2006), the logic of the likelihood and impact risk assessment is unclear. Further analysis to improve the assessment is not possible. The final act is to place the risks in a likelihood and impact matrix without any inconsistency check or sensitivity analysis. Cox (2008) stated the following risk matrix limitations: (i) risk matrix makes an accurate comparison on only a small number (less than 10 percent) of randomly selected hazards; (ii) it can mistakenly assign higher qualitative ratings to quantitatively smaller risks; (iii) the matrix is ineffective in allocating resources to mitigate risks; (iv) ratings in risk matrix depends on subjective judgements of decision makers. Different decision makers may have opposite ratings on the same risk. Shortreed (2010) argued the mathematical background of risk matrix. It uses simple arithmetic to produce level of risk. The level of risk is determined by multiplying likelihood and impact. The method of calculation is not mathematically sound. Level of risk is not a product of likelihood and impact, but it is some combination of

likelihood and impact. Moeller (2007) argued the low-medium-high risk mapping is suitable for a small number of risks. For a large number of risks, probability estimation is more appropriate for ranking the risks. Saaty (1987b) argued a complex problem such as risk analysis is better presented through priority rather than probability alone. Some elements in risk analysis cannot be described with probabilities but are better represented with importance. Saaty (1987b) claimed one of the flaws in risk analysis is the practice of representing all elements in probability. Priority of the elements need to be measured using both importance and likelihood of occurrence. Risk analysis has two types of uncertainties: uncertainty on the occurrence of events and uncertainty on the measurement of judgements to convey preferences. Decision makers cannot control the first uncertainty. The second uncertainty can be overcome by using pairwise comparison judgement.

2. Overview of Evaluation

Evaluation is an activity to judge the value, merit or worth of something (Clarke & Dawson 1999). Patton (1997) defined evaluation as a systematic collection of information about the activities, characteristics, and outcomes of programs to make judgements about the program, improve program effectiveness, and/or inform decisions about future programming.
Clarke and Dawson (1999) defined evaluation as a form of disciplines inquiry using scientific procedures to collect and analyse information about content, structure and outcomes of programmes, projects or interventions.

Evaluation is divided into two types: formative and summative (Scriven 1967). Formative evaluation is an evaluation to provide feedbacks to people trying to improve something. The evaluation is conducted to identify strengths and weaknesses of a program or an intervention to support the process of improvements. The aim is to ascertain if any changes are needed to improve the program. A formative evaluation does not attempt to generalise findings beyond the setting in which the evaluation takes place. Summative evaluation is an activity to determine the overall effectiveness of a program or project. The aim is to recommend whether or not to continue a program or a project. Formative evaluation is action-oriented and summative evaluation is conclusion-oriented (Patton 1986). Data collection for formative evaluations rely heavily and even primarily on qualitative methods (Patton 2002). Summative evaluations relatively require larger samples with statistical pre, post, and follow up results.

Patton (1986) developed utilisation-focused evaluation (UFE) approach. The primary criterion by which a program or product is judged is the intended use of the program by the intended users (Patton 1997). Ramrez and Brodhead (2013) stated UFE is a guiding framework, as opposed to methodology, and people and context dependent. UFE can be used for a formative or summative evaluation; qualitative, quantitative or mixed data; naturalistic or experimental research design; and processes, outcomes, effects or cost-benefit evaluation focus (Patton 1997). To conduct UFE, four items need to be clarified (Ramrez & Brodhead 2013): (i) the purpose of evaluation. The purpose could be to improve a program, terminate a program or, find strengths and limitations of a program; (ii) the evaluation criteria. The criteria to judge the program; (iii) the evaluation method. The methodology used in the evaluation. The method can be quantitative such as historical data of sales or customers' complaints, or qualitative such as interviews or questionnaires; (iv) the evaluation time line. The time line is determined by when the decision makers or product developers need the evaluation output.

3. The Design of AHP Evaluation

This study used formative UFE approach. AHP evaluation design is outlined below.

3.1. *Evaluation Purpose*

The purpose is to investigate whether AHP can be used as a risk prioritisation tool for risk management. Feedbacks from the evaluation are used to understand AHP from risk managers' perspectives, learn and understand AHP in a new way and add knowledge to the application of AHP to risk management. Specifically, the purpose is to enhance knowledge on AHP on its application to risk management.

3.2. *Evaluation Criteria*

The core components of AHP represent the evaluation criteria. The following outlines the criteria:

- The hierarchy. The evaluation aims to find out whether a hierarchy is a useful technique for structuring risk management problems. Figure 2 presents how AHP structures risks of an insurance company in a hierarchy.

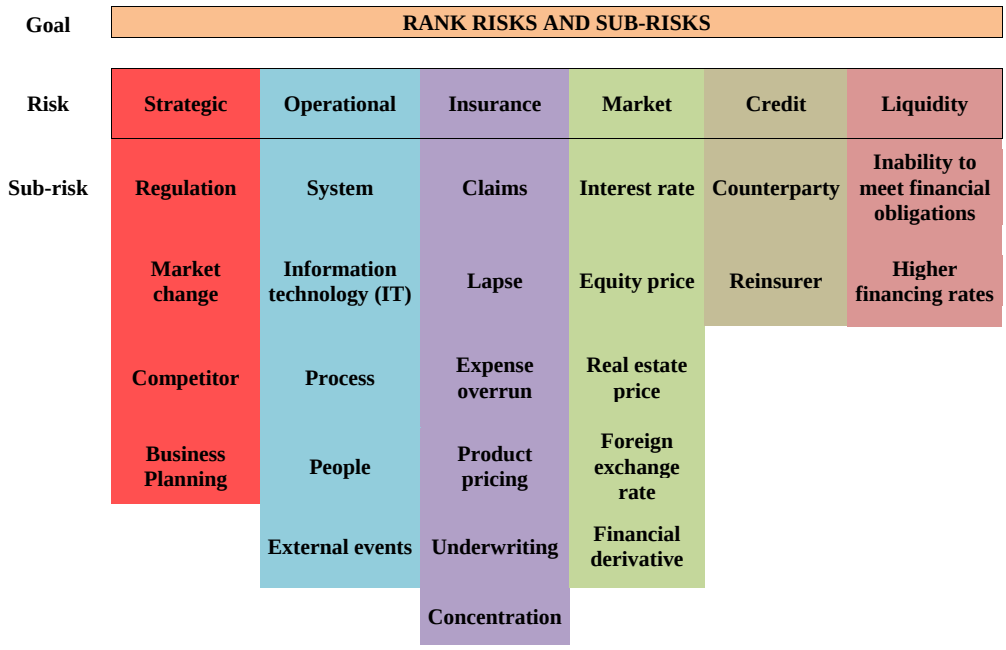

Figure 2: Risk hierarchy of an insurance company

- Pairwise comparisons, decision consistency and priority weights. The evaluation aims to find out whether the pairwise comparison is a useful technique to make risk trade-off, the decision consistency enables participants to make consistent judgements and the priority weights of the sub-risks or risks represents the rankings. Figure 3 presents the pairwise comparisons, decision consistency and priority weights of the risks. Participants input their judgement and the priority weight are automatically calculated. The rankings are immediately produced after a set of pairwise comparisons. They are presented in bar charts. The bar in the charts changes as participants changes their judgements in the

pairwise comparison. Decision consistency is automatically calculated and immediately produced after each set of pairwise comparisons. Participants can immediately check the consistency of their decisions and review inconsistent decisions. The decision consistency has three levels: excellent (consistency ratio (CR) is less than 5 per cent) , good (CR is less than 10 per cent) and poor (CR is more than 10 per cent)

- AHP decision-making steps. The evaluation aims to find out whether the steps guide participants to achieve the decision goal. Figure 4 presents the decision-making steps.
- Results produced by AHP. The evaluation aims to find out whether the results are useful and meaningful. The global priority weight of sub-risks is automatically produced after completion of all pairwise comparisons. Figure 5 presents the priority weights of risks and sub-risks. It represents the overall risk prioritisation results.

Instruction: For each risk compare sub-risks in pairs. Determine which sub- risk you worry about more and the intensity of worry.

Strategic risk

Sub-risks	Worry	Intensity	Compared to	Decision Consistency
Regulation	more	moderate	Market change	Good
	more	moderate	Competitor	
	more	moderate	Business Planning	
Market change	less	moderate	Competitor	
	equal		Business Planning	
Competitor	equal		Business Planning	

Figure 3: Pairwise comparisons, decision consistency and priority weights

3.2. *Evaluation Method*

The study used open-ended questionnaire to obtain feedbacks from participants. The questionnaire consisted of the following questions:

- The hierarchy. Participants evaluate the hierarchy as follows: does the hierarchy improve understanding of the problem?; does the hierarchy make the problem more structured and organised?; is disagreement constructively managed by presenting the problem in a hierarchy?; can overlook or missing risk be easily detected?; does the hierarchy make communication about the problem more focused?; do structuring and organising the problem in a hierarchy promote creative thinking?
- Pairwise comparison and decision consistency. Participants evaluate the pairwise comparisons and decision consistency as follows: paired comparison is a natural way to make trade-off between risks; the pairwise comparison question is easy to follow and understand; the scales equal, moderate, strong, very strong and extreme are easily understood; decision consistency assists in making consistent judgement.

- Decision making steps. Participants evaluate the usefulness of each step as follows: whether AHP is easy to use and the decision-making steps are easy to follow; whether the steps are useful; suggest the most useful steps; suggest new steps to be added to AHP; suggest a new AHP decision making steps or framework with the new step.
- The results. Participants evaluate the results produced by AHP as follows: is the result produced by AHP useful; suggest other results AHP should produce.

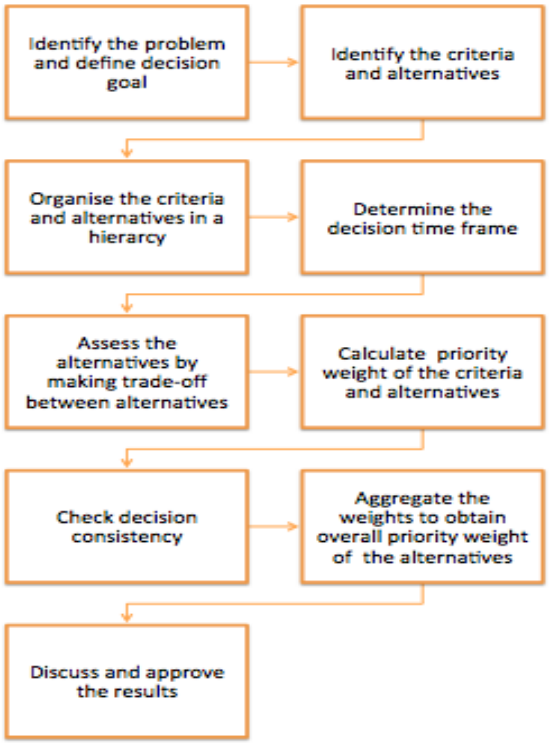

Figure 4: AHP decision-making steps

4. CONDUCTING THE AHP EVALUATION

This section discusses how the study conducted the AHP evaluation. It explains the research participants, the evaluation sessions, and the feedbacks collected from the participants.

4.1. *The Participants*

This study defined the research participant or evaluator as a person whose professional activity involves managing risks or making decisions under conditions of risks and uncertainties. It used focus group approach to collect the feedbacks. The focus group is risk managers practising in Kuala Lumpur, Malaysia. Ten evaluators or research participants took part in the evaluation. The evaluators had a minimum of three years and a maximum of 15 years' work experience in risk management. Seven evaluators were members of Malaysia Association of Risk and Insurance Managers (MARIM). The other three evaluators were staff members of a risk management department in a government agency. The government agency handles business registration for companies or individuals conducting business in Malaysia.

4.2. *The Evaluation Session*

The evaluation session was conducted in two group meetings in June 2014 in Kuala Lumpur, Malaysia. The first group consisted of the seven MARIM members, and the second group consisted of the three risk managers from the government agency. The duration of the meeting was four hours for the first group and seven hours for the second group. The seven-hour meeting with the second group took place in two meetings. The first meeting lasted for four hours and second meeting was three hours. The evaluation sessions were audio recorded.

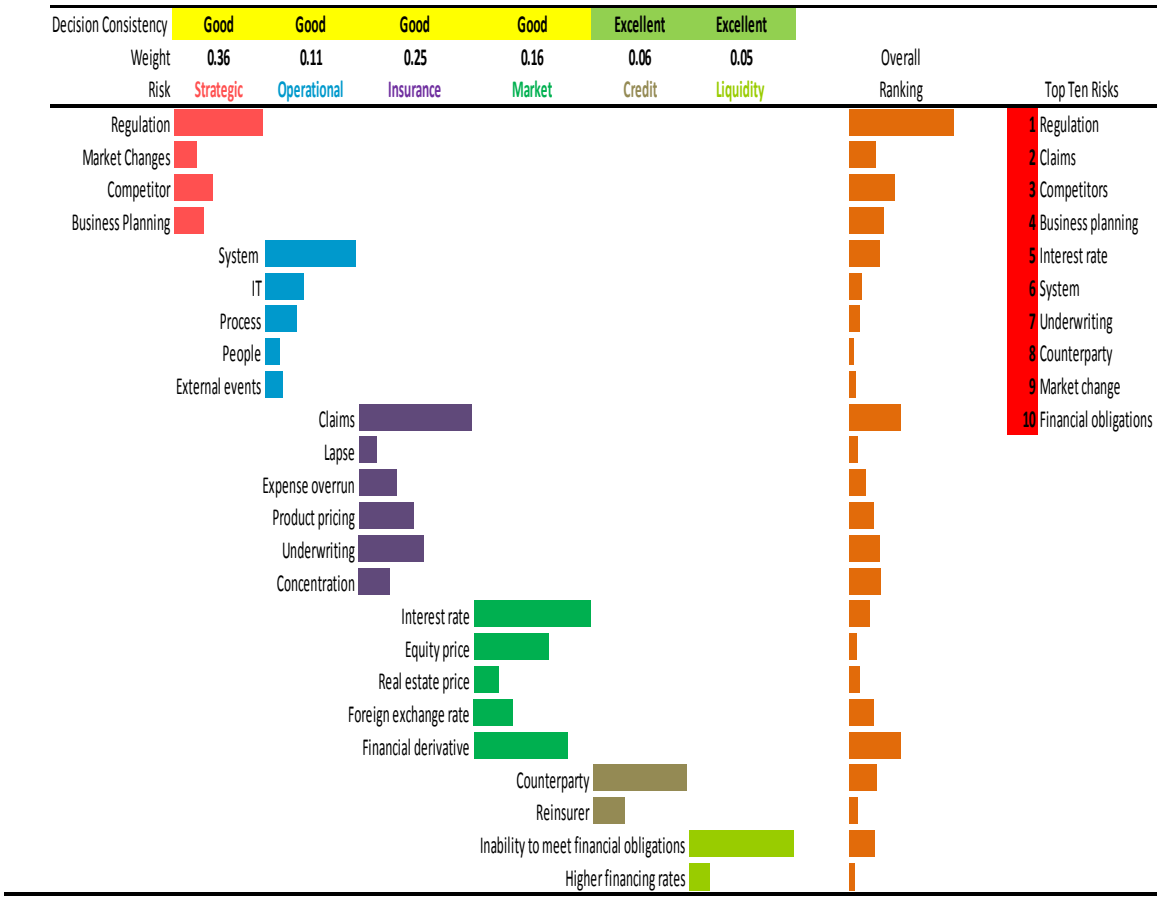

Figure 5: AHP risk prioritisation results

The participants were required to speak their thoughts during the sessions. They were encouraged to give their own opinions based on their knowledge and experience, discuss and debate the structure of the problem, and to effectively comment on how they are interacting with the risk management problem, what they are attempting to do and how does AHP assists them to achieve it, how they feel about AHP and what problems they encounter.

4.3. *Feedbacks Collected and Analysis*

The recorded audios of participants' feedbacks were transcribed verbatim. The feedbacks were divided into five themes: hierarchy, pairwise comparison questions, decision consistency, decision making steps and results. The feedbacks were then analysed to identify how and in what way AHP was useful for risk prioritisation. They represented AHP strengths.

The feedbacks were also analysed to identify how and in what way participants faced difficulties in using AHP for risk prioritisation. They represented AHP limitations. The following section discusses the evaluation results.

5. Evaluation Results

Strengths and limitations of AHP as a risk prioritisation tool for risk management.

5.1. *AHP Strengths*

- Easy to use and understand. AHP is easy to use and understand, and its decision-making process is simple and logical. The participants understood how each step is a guide to achieving the decision goal. Risk matrix did not provide clear explanation on how a risk assessor arrives at judging the importance of risks. AHP, on the other hand, provided a systematic decision-making process. Therefore, producing understandable, reliable and defensible risk ranking.
- Improved understanding of a problem. Organising risks and sub-risks in a hierarchy enabled the participants to see all risks relevant to a problem. It provided a holistic view of risks faced by a company. The participants already had an underlying understanding of the flow of influences and connections of risks and sub-risks. However, risk matrix did not have a platform to display the influences and connections. In contrast, the hierarchy systematically structured and displayed their understanding of the influences, connections and interactions. Therefore, provided a clear and transparent risk assessment and facilitated communication between risk assessors, risk managers and top management.
- Improved risk assessment. AHP improved risk assessment as follows:
  - It converted subjective judgement into objective decision. AHP translated participants' subjective judgement into numerical values. The values were used to obtain the priority weights of the risks. Using risk matrix, the participants faced difficulties to explain to top management how risks are judged as low likelihood and high impact, or high likelihood and low impact. The priority weight provided ranking of the risks based on the participants' knowledge, perspectives and feelings.
  - The pairwise comparisons assisted participants to make explicit trade-off between the risks. The participants were aware that they had to make trade-off to determine more important risks. Deciding which risk is important is easy, as they did it frequently in their professional activity. However, using pairwise comparisons to determine the importance of risks is new. The pairwise comparisons forced them to make careful and thoughtful risk trade-off compared to direct ranking.
  - It recorded and documented risk rankings of every risk assessor. According to the participants, each person has a different judgement on the importance of risks and AHP enabled them to document each risk assessor's ranking. Therefore, facilitated communication between risk assessors, and with other stakeholders not directly involved in the risk assessment process.
  - It monitored subjective judgements. Similar to risk matrix, AHP used subjective judgement to assess risks. However, subjective risk assessments lack consistency. A same person may give a different assessment of the same risks in a different situation or at different time. AHP used CR to monitor the consistency of the subjective judgements.
- AHP is useful for problems with intangibles elements, limited or no data or requiring subjective judgements. The problems require risk managers to use value judgements to

assess the risks. Both AHP and risk matrix used subjective judgement. However, AHP provided a systematic value judgement to assess and prioritise risks.

5.2. *AHP Limitations*

- Number of pairwise comparisons. The number of risk and sub-risks determines the number of pairwise comparisons. A problem consisting of m risks has $m(m\text{-}1)/2$ numbers of pairwise comparisons. Strategic risk has four sub-risks. Participants had to answer six pairwise comparison questions. In total, participants had to answer fifty eight pairwise comparison questions. Too many pairwise comparisons decreased participants' concentration. They did not make careful and deliberate judgements. Therefore, increased decisions inconsistency. Inconsistent pairwise comparisons produced invalid risk ranking.
- Decision fatigue. Pairwise comparison questions are repetitive. As a result, participants experienced decision fatigue. They did not answer all questions or randomly answered the questions. Randomly or not answering all the questions created missing values. As a result, AHP did not produce the risk ranking.

References

Bushan N. & Rai K. 2004. The Analytic Hierarchy Process. In R. Roy (Ed.) *Strategic Decision Making: Applying the Analytic Hierarchy Process*, pp. 11-21. London: Springer-Verlag.

Clarke A. & Dawson R. 1999. *Evaluation research*. London: SAGE Publications Ltd.

Cox L. A. 2008. What is wrong with risk matrices? *Risk Analysis* **28**(2): 497–512.

Emblemsvag J. & Kjolstad L. E. 2006. Qualitative risk analysis: some problems and remedies. *Management Decision* **44**(3): 395-408.

Moeller R. R. 2007. *COSO Enterprise Risk Management: Understanding the New Integrated ERM Framework*. New Jersey: John Wiley & Sons.

Patton M. 1986. *Utilization-Focused Evaluation*. Newbury Park, CA: Sage.

Patton M. 1997. *Utilization-Focused Evaluation: The New Century Text*. Thousand Oaks, CA: Sage.

Patton M. Q. 2002. *Qualitative Research and Evaluation Method.* Thousand Oaks, CA: Sage.

Ramrez R. & Brodhead D. 2013. *Utilization Focused Evaluation: A Primer for Evaluators*. Penang: South Bound.

Saaty T. L. 1977. A scaling method for priorities in hierarchical structure. *Journal of Mathematical Psychology* **15**: 234-281.

Saaty T. L. 1987a. The Analytic Hierarchy Process: What it is and how it is used. *Mathematical Modelling* **9**(3-5): 161-176.

Saaty T. L. 1987b. Risk- its priority and probability: The Analytic Hierarchy Process. *Risk Analysis* **7**(2): 159-171.

Scriven M. 1967. The Methodology of Evaluation. In R. W. Tyler, R. M. Gagn´e, M. Scriven, et al. (Eds.), *Perspectives of Curriculum Evaluation*, pp. 39-83. Chicago: Rand McNally.

Shenkir W. G. & Walker P. L. 2007. Enterprise risk management: tools and techniques for effective implementation. In *Statement of Management Accountant*, pp. 1-31. Montvale NJ.: Institute of Management Accountant.

Shortreed J. 2010. ERM frameworks. In J. Fraser & B. J. Simkin (Eds.) *Enterprise Risk Management: Today's Leading Research and Best Practices for Tomorrow's Executives*, pp. 97-123. Hoboken: John Wiley & Sons.

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