ALGORITHM DEVELOPMENT of Fuzzy AHP for IT PROJECT
TENDER EVALUATION

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ABSTRACT
Tender evaluation is a vital process towards achieving successful project outcomes. The effectiveness of tender evaluation not only solely depends on criteria selection but also determining method to support the use of criteria and ensuring the smoothness of evaluation process. To ensure the smoothness and responsiveness of multicriteria tender evaluation, two stages evaluation are adopted for this study. Fuzzy AHP is adopted to deal with multicriteria analysis in tender evaluation. Through comparative study, this study aims to identify the suitable combination of method and technique for tender evaluation method for IT project.

Keywords: Multicriteria tender evaluation method, AHP/Fuzzy AHP, IT project.

1 INTRODUCTION
Researches and discussion on competitive bidding strategy models have been conducted since early 1950’s (Ballesteros-Pérez, González-Cruz, Pastor-Ferrando, & Fernández-Diego, 2012). Existing study not only prior on construction paradigm but also include other paradigm such as in IT outsourcing.

Specific to researches of IT tender in Malaysia, Fauziah (2011) proposed a standardized multicriteria for evaluating IT tender that emphasize assessment through five assessment factors such as financial, tenderer, employee, technology and documentation. In different perspective, Aris et al. (2011), the study focus on identifying risk determinants criteria for tender evaluation process which includes stability, pricing (financial), security, support, agreement, deliverable, performance operation, reporting, supply chain. Apart from that, Aris also discovered that financial construct and security have positive high relationship with risk in tender evaluation. Even with aforementioned findings of studies, it is apparent that more researches in tender evaluation of IT projects are needed. This is due to produce more sound theories, methods, and techniques for improving the accountability and integrity of tenderer selection in outsourcing the IT projects.

Choosing eligible tenderer are vital in delivering out a quality and successful project (Darvish, Yasaei, & Saeedi, 2009; Ng, Tang, & Palaneeswaran, 2009). To begin with, tender evaluation are vulnerable to several problems such as cronism, opaqueness (Hui, Othman, Omar, Rahman, & Haron, 2011; Sambasivan, Wemyss, & Rose, 2010) and slow respond time (Sambasivan, Wemyss, & Rose, 2010). Without proper tender evaluation, these flaws not only lead to inappropriate tenderer selection but inviting other unwanted outcome such as:

- Risk of delays (Hui et al, 2011; Sambasivan, Wemyss, & Rose, 2010),
- Cost overruns (Hui et al, 2011; Sambasivan, Wemyss, & Rose, 2010),
- Substandard work (Tabish & Jha, 2011),
- Disputes (Noor, Samat, Saman, Hitam, & Man, 2007; Sambasivan, Wemyss, & Rose, 2010),
- Bankruptcy (Sambasivan, Wemyss, & Rose, 2010).

To avoid these undesirable outcomes, an effective tender evaluation is vital. The effectiveness tender evaluation is influenced by criteria (Watt, Kayis, & Willey, 2010; Zhang, 2004) and tender evaluation method (Chan, Chiu, & Hung, 2007).

Despite the crucial need of identifying both criteria and method, discussion on tender evaluation method are still in scarced compared to research on criteria. This article aims to discuss on “what are the commensurate method and technique to deliver multicriteria tender evaluation of IT project?”.

The article will include the background of study, research method, result/finding, discussion and conclusion.

II TENDER EVALUATION
To select tenderer, variety of tender evaluation method can be employed such as price based evaluation or multicriteria evaluation (Zhang, 2004). Multicriteria tender evaluation can be conducted through enveloped system, multicriteria selection or two stages evaluation (Wong, Holt, & Harris, 2001; Zhang, 2004). Two stages evaluation is selected for this study. Compared to the enveloped system, the price measure is less dominance and equally assessed during evaluation phases. Two stages evaluation consist of 3 phases:

- Criteria establishment. The criteria are prepared and weighted.
• Screening. Participated tenderer are shortlisted based on selection of qualification criteria.

• Final evaluation. The shortlisted tenderer are assessed through multicriteria evaluation. The highest scorer is potentially selected for tender award.

Two stages evaluation is employed in studies conducted by Mohd Noor et al. (2007) for a systematic and organized tender evaluation of construction project. Apart from selecting the method, selecting technique to support multicriteria evaluation is also needed. Conflicting priority may occur among experts or committee during tender evaluation (Mateus, Ferreira, & Carreiro, 2010). Multiatribute analysis like multicriteria decision making (MCDM) is able to elicit consensus judgement in multicriteria decision making (Brugha, 2004). Thus, MCDM technique is adopted due to suitability to nature of consensus decision making and multicriteria analysis in tender evaluation.

A. MCDM for Tender Evaluation

MCDM employs decision matrices to select best alternatives through attractive measures, and selection based on optimal value based of human preference. MCDM is used for scoring alternatives, discovering, structuring and weighting criteria (Brugha, 2003, Watt, Kayis, & Wiley, 2010).

MCDM has been applied in various disciplines such as business, engineering, and science (Turksis & Zavadskas, 2010; Wiecek, Ehrgott, Fadel, & Figueira, 2008). In addition, there are assortment of techniques for representing MCDM (Vahdani, Iranmanesh, Mousavi, & Abdollahzade, 2012).

For example, artificial neural network (ANN) (El Sawahi, Eaton & Rustom, 2008; Noor, 2007) is capable to automate the selection process through learning, propagating, and deriving inference from past data. However, it requires tremendous past data, which may be hard to be obtained due to confidentiality.

Analytical network process, ANP (Lin & Liang, 2010; Oztays, Kaya & Kahraman, 2011) promotes extensive analysis to identify the interdependencies among criteria. Whilst, iterative techniques like technique of order preference by similarity to ideal solution (TOPSIS) and Vikor optimizes the evaluator preference thoroughly. Yet, these techniques require iterative calculation, need mathematical background and a careful tracking.

Analytical hierarchy process (AHP) and MOORA technique (Brauer, Zavadskas & Turksis, 2008) are less complex, which requires minimum decision maker involvement and easy to understand. Compared to MOORA, AHP is able to deal with quantitative and qualitative judgment.

These aforementioned techniques are different by involvement of human judgment, complexity, and responsiveness. To avoid dispute, opaqueness and slow response, the technique is easy to be tracked and responsive, AHP is chosen for this study since it is the least complex and responsive technique.

B. Analytical heirarchy process (AHP)

AHP restructure the problem into understandable hierarchy, and allowing expert to give their priority judgment upon tangible and intangible criteria (Darvish, Yasaei & Saeedi, 2008).

AHP is easy to be used and understood by expert, besides able to detect and avoid conflicting preference judgment (Mahdi et al., 2001; Topcu, 2004). AHP can be applied through extensive variation like scale value and derivation method for pairwise comparison. These variations are shown in Table 1.

<table>
<thead>
<tr>
<th>Author</th>
<th>Application domain</th>
<th>Feature</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yang &amp; Lee, 1997</td>
<td>Facility location selection</td>
<td>1) Linear scale</td>
<td>Simple calculation Rank reversal chances are reduced</td>
</tr>
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<td></td>
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<td>2) Geometric mean pairwise comparison</td>
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<tr>
<td>Tam &amp; Tunnala, 2001</td>
<td>Vender selection in telecommunication system</td>
<td>1) Saaty scale</td>
<td>Simple calculation Rank reversal chances are reduced</td>
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<td>2) Geometric mean pairwise comparison</td>
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<tr>
<td>Salmeron &amp; Hererro, 2005</td>
<td>Critical success factor in executive information system</td>
<td>1) Saaty scale</td>
<td>Simple calculation Rank reversal chances are reduced</td>
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<td>2) Geometric mean pairwise comparison</td>
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<td>Anagnostopoulos &amp; Vavatsikos, 2006</td>
<td>Construction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ramon &amp; Cristobal, 2012</td>
<td>Construction</td>
<td>1) Saaty scale</td>
<td>A simple and easy to understand.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) Additive pairwise comparison</td>
<td>Less efficient scale to deal with human judgment and rank reversal problem.</td>
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</table>

AHP is hampered with critic on AHP scale (Bana e Costa and Vansnick, 2007; Vaidya & Kumar, 2006) and aggregation phase (Stewart, 1992; Triantaphyllou, 2001). From table 1, the studies in tender selection applied Saaty scale. To point out, linear scale proposed by Saaty may be easily misinterpreted (Vaidya & Kumar, 2006) and lack of sensitivity when comparing elements (Bana e Costa and Vansnick, 2007).
Ishizaka and Labib (2009) advocates that balanced AHP scale tends to accept more variable than the conventional Saaty AHP scale. From literature, the number of research that applied balanced scale is less due to prominent use of Saaty AHP scale.

Above that, human preference cannot solely be compared to a crisp scale value. Thus, the crisp value of AHP scale has been enhanced with fuzzy number. Fuzzy AHP is significant to deal with uncertainty in judgment (Ding, Yuan & Li, 2008). Further discussion on Fuzzy AHP is presented in next section.

In other cases, AHP aggregation phases usually associated with rank reversal problem. This event occurs when a copy or a near copy of an alternative is introduce or removed (Triantaphyllou, 2001; Stewart, 1992). According to Cui and Yong (2008), rank reversal can be lessen by adopting multiplicative pairwise comparison. There are varieties of multiplicative pairwise comparison such as logarithm least square, eigenvector or geometric mean (Ishizaka & Labib, 2009).

Therefore, this study will employ balanced AHP scale and multiplicative pairwise comparison for weighting the criteria. However, this adopted approach is less adequate to deal with ambiguity of decision making in MCDM. Thus, this study will apply the benefit of fuzzy AHP.

C. Fuzzy extended AHP (Fuzzy AHP)

The complexity and vagueness of MCDM attribute mostly occurred during response evaluation, uncertainty management, leveraging domain knowledge, and decision maker preference (Bennison, Subbu & Lizzi, 2009).

Zadeh (1965) stated the key elements in human thinking are not numbers but labels of fuzzy sets. Fuzzy Set Theory (FST) is a tool to handle vague data and fuzzy expressions (Mikhailov, 2003) that are more natural for humans than to be understand trough crisp measurement.

The Fuzzy AHP firstly proposed by van Larhooven (1983) to apprehend the inadequacy of crisp AHP scale, with replacement of triangular fuzzy number. Later, Buckley (1985) proposed enhancement of fuzzy trapezoidal number into Fuzzy AHP scale to produce unique solution under linear equation. The extensive variation of Fuzzy AHP and its application domain are shown in table 2.

Table 2 shows the disposition of studies to use fuzzy triangular AHP. Although, to fuzzy trapezoidal AHP are adequate compare to fuzzy triangular AHP. For reason, less studies adopt fuzzy trapezoidal AHP since it required meticulous and tremendous calculation (Tan, 2013; Tüysüz & Kahraman, 2006).

<table>
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<tr>
<th>Author</th>
<th>Application domain</th>
<th>Feature</th>
<th>Comment</th>
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<tbody>
<tr>
<td>Kahraman, Cebeci &amp; Ulukan, 2003</td>
<td>Supplier selection</td>
<td>1) Balanced scale value</td>
<td>Ease the decision maker to provide judgement and scoring upon tangible and vague criteria</td>
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<td></td>
<td></td>
<td>2) Triangular fuzzy number</td>
<td>Balanced scaled cover more variable</td>
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<td></td>
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<td>3) Additive pairwise comparison</td>
<td>However, a careful track need to be employed during defuzzification since in compromise more option compare to triangular fuzzy number.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>The method are vulnerable to rank reversal problem</td>
</tr>
<tr>
<td>Duran &amp; Aguilo, 2008</td>
<td>Machine-tool selection</td>
<td>1) Saaty scale</td>
<td>Adaptable to linear and non linear equation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) Triangular fuzzy number</td>
<td>However, a careful track need to be employed during defuzzification since in compromise more option compared to triangular fuzzy number.</td>
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<tr>
<td></td>
<td></td>
<td>3) Geometric mean</td>
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<tr>
<td>Jaskowski, Biruk &amp; Bacon, 2010</td>
<td>Construct ion</td>
<td>1) Saaty scale</td>
<td>Less response time without requiring trackback as in geometric mean</td>
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<tr>
<td></td>
<td></td>
<td>2) Triangular fuzzy scale</td>
<td>However, a careful track need to be employed during defuzzification.</td>
</tr>
<tr>
<td>Alias et al., 2011</td>
<td>Construct ion</td>
<td>3) Integral based ranking</td>
<td>By using integral value, this method hard to be employed further in network process</td>
</tr>
<tr>
<td>Tan et al., 2013</td>
<td>Environment</td>
<td>1) Saaty scale</td>
<td>The linguistic subjective scale ease the decision maker to provide judgement and scoring upon tangible and vague criteria.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) Trapezoidal fuzzy number</td>
<td>Trapezoidal are adaptable to linear and non linear equation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3) Logarithm least square pairwise comparison</td>
<td>Less response time without requiring trackback as in geometric mean</td>
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</tbody>
</table>

In conjunction to this, Tan (2013) stated that the tremendous calculation in fuzzy trapezoidal AHP can be reduced by adopting logarithm least square for deriving vector values. On other hand, Alias (2011) proposed implementation of integral based fuzzy ranking approach as derivation method to reduce the calculation steps in fuzzy AHP. However, integral based derivation only suits to independent variable (Liou & Wang, 1992). In a nutshell, improvements on responsiveness of Fuzzy trapezoidal AHP are
proposed through variation of pairwise comparison of the fuzzy derivation method.

Despite that, finding in table 2 shown that study in tender evaluation mostly use geometric mean which require tremendous calculation and tracking. Thus, this has intrigue the need of application of logarithm least square.

III METHODOLOGY
The paper aims to propose algorithm of AHP (Fuzzy AHP) for tender evaluation. The methodology is constructed based on application of Fuzzy AHP in two stages multicriteria evaluation. The structure are adapted from Alias et al. (2013), Mohd Noor et al.(2007).The activities are portrayed through following the steps:

Step 1: Theoretical study.
To develop understanding on method for tender evaluation, document review and literature review is conducted. The sources are obtained from different journal library such as Science direct, Springer, and Taylor and Francis. The outcome of this study is to specify the possible methods and AHP combination for conducting multicriteria tender evaluation .The selection are also made by taking consideration on harnessing responsiveness of the tender evaluation process.

Step 3: Preparing the nomenclature (Tan et al, 2013)
The nomenclature relevant to selected combination of Fuzzy AHP and criteria are prepared as follow:

a) Set for analysis:
   \( i \), Criteria (\( i = 1,2,\ldots, N \))

b) Variables:
   \( \lambda \), Fuzzy consistency
   \( W_{c} \), Weight of criterion, \( n \) ,

c) Parameter:
   \( a = (a_{1}, a_{2}, a_{3}, a_{4}) \) fuzzy number for pairwise comparison

Step 3: Constructing the algorithm
The nomenclature and relevant calculation steps are placed according to the phases in the algorithm. As a result, the algorithm of proposed method is prepared.

IV RESULT
The algorithm only covers criteria establishment phases with application of Fuzzy AHP. The flow chart is prepared to visualize the algorithm.

A. Flow chart
From the proposed method, the flowchart for representing the rule of multicriteria tender evaluation is prepared as shown in Figure 1.
Thus, logarithm least square pairwise comparison is selected for harnessing the responsiveness of analysis process. Together with balanced AHP scale, it enables the decision analysis to cover more variable during aggregation phases.

The drawback of the adapted Fuzzy AHP combination requires more calculation steps and mathematical background. To point out, one of limitation pertain is to gather appropriate data for tender evaluation in IT project, since the discussion on technique and data for evaluating IT project is in scarce. Though the data can be adapted from established field such like construction industry, yet there may be dissimilarities among the criteria and preference.

VI CONCLUSION

To support the effectiveness of tender evaluation, it requires proper selection of criteria and method. This study proposed tender evaluation method for IT project by employing two stages of evaluation and Fuzzy AHP technique. The selection takes consideration on the adequacy and ensuring the responsiveness of the evaluation process. Thus the proposed method not only sought for handling multicriteria evaluation but also ensuring the feedback and track back that can be done in fast manner.

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REFERENCES


Cui, D. & Yong, R. (2009) “Fuzzy-Multi-Attribute Decision Making Based on Degree of Grey Incidence. 2009 International Conference on Artificial Intelligence and Computational Intelligence”.


Triantaphyllou, E. (2001). Two new cases of rank reversals when the AHP and some of its additive variants are used that do not occur with the multiplicative AHP. *Journal of Multi-Criteria Decision Analysis, 10*(1), 11-25.


