

Risk Identifier of Electronic Procurement Process based on Fuzzy AHP and AHP Method

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Abstract

Risk identifier is a vital function for electronic procurement system. To avoid risk potentialities, a knowledge base is developed which provides risk messages to users to mitigate the risk in the corresponding area of risk attributes defined and an acceptable vulnerability is provided to users through algorithm execution. Multiple Criteria Decision Making (MCDM) and risk mitigation algorithm is the key strength for the newly developed system model of risk removal. Both Fuzzy and AHP based MCDM approach has been executed and the results have been compared.

Keywords: Fuzzy Pair wise decision matrix, Risk Identifier, Risk Mitigation Algorithm, Multi Criteria Decision Making (MCDM), AHP

1. Introduction

All procurement processes go through an uncertainty until it reaches at the final success of receiving procuring item or services and after that post procurement functions end. The aim of this research was to develop a fuzzy based model that allows evaluators to assess any particular case of procurement and risk level is identified with the help of a risk scale and also to mitigate the risk providing messages to users of this system from a knowledge base. The objective is to formulate the mathematical foundation and algorithm to incorporate proposed model of risk identifier and to illustrate the newly designed model with mathematical illustration to demonstrate the implementation and compare the fuzzy MCDM results with AHP MCDM results.

2. Background

In the practice of procurement, an unbiased consensus decision is a mandatory requirement for efficient ~~procurement reducing unacceptability and uncertainty. A software based risk mitigation system has~~ been presented by Raymond J. Madacy (1995) that generates decision from a knowledge base getting weightage factors and ratings given by Decision Makers using his software. The model was developed based on COCOMO which is known as software cost estimation model. Though the technique is quite preferable for automated procurement decisions and its risk mitigation, its determinants are needed to be revised for application in all general procurement cases and build mathematical model with MCDM approach.

3. e-Procurement Risk Identifier Model

Risk assessor and cost estimator, the primary tool to predict the chance of success and failure of any project, to minimize the failure chance mitigating the problem factors to maximize success potentiality, a new approach of fuzzy MCDM based risk derivation through proper quantification and mathematical foundation is introduced in this section. The generalized procurement Risk attributes are identified in Table 1. Risk assessors assess in the 5 major risk areas using 15 risk attributes in any procurement case using the grading scale mentioned in Table 2. The calculated risk is described by Risk Value (Rv) is determined by using equation 1, 2 and 3 and risk level is nomenclature using risk description of Table 3. At the time of rating by the Decision Makers, their assessments are quantified in two dimensional fuzzy matrix which form 210 knowledge predictors which are to be used for messaging the risk location and purpose to mitigate the respective area going towards risk free condition for procurement execution according to Algorithm 1. Following formula mentioned in George J. Klir[3] will do first normalization of fuzzy variable input as weight values for generalized risk attributes of procurement.

$$f(x_i, x_j) = \frac{f(x_i, x_j)}{\max[f(x_i, x_j), f(x_j, x_i)]} \quad (1)$$

$$f^{/}(x_k) = \min(X_i) \quad (2)$$

where k = 1 to 15 and X=generalized risk/maturity attributes

The total risk value of risk indicator will be calculated using following formula,

$$\mathrm{Rv} = \sum_{k=1}^{15} f^{/}(x)_k \quad (3$$

Algorithm 1: Algorithm for e-Procurement risk mitigation

Step 1: if $f^{/}(X_k)$ has more than zero rows then Select: Attribute (max[$f^{/}(X_k)$]) else goto Step5

Step 2: if (max[$f^{/}(X_k)$]) > 0.1 then goto Step 3 else goto Step 5

Step 3: Risk Message ← Description (Knowledge Base): Attribute - X_j Where X_j = All other attributes except the selected attribute

Step 4: Resolve the discrepancies, remove row from $f^{/}(X_k)$, goto Step 1

Step 5: Risk mitigated/Insufficient Risk

4. Illustrative Example

15 generalized risk attributes in 5 categories are defined in Table 1. These risk attributes have been rated in fuzzy pair wise comparison matrix in Table 5 which is further normalized in Table 6 by using eq (1) and later values of 15 different risk attributes have been determined with their respective risk levels by using eq (2) which are then added together to determine the value of *Rv*. The values of risk levels of each attribute aggregated and value of Rv are summarized in Table 4 for fuzzy ratings in Table 5. Through the implementation of fuzzy pair wise comparison matrix, a fuzzy based knowledge base is generated by nomenclature of risk attributes pair e.g. RELY-DURN (Reliability with limited duration of supply or service), CPLX-SCED (Optimization of product or job complexity for delivering product or service within tight schedule), UMTG-RVOL (Bidder's usage of modern technology is required to be cope able with any kind of requirement volatility) etc. 210 knowledge atoms have been identified all of which are to be used as risk messages focusing the location where risk exist which is subject to be mitigated. In the execution of risk mitigation algorithm mentioned in Algorithm 1, 16 times of iterations has been found to remove all major risks in this case. In the first iteration, the algorithm generated risk messages are UMTG-RELY, UMTG-DURN, UMTG–CPLX, UMTG–CPIS, UMTG–CADP, UMTG–SCAP, UMTG–WSZE, UMTG–WSKL, UMTG –SEXP**,** UMTG– SCED, UMTG– PMEX, UMTG–PDTH, UMTG–RISK, UMTG–RVOL as highest risk level existence has been noticed for UMTG (Use of modern technologies) is 0.6. After execution of Step 1, Step 2, Step 3 and Step 4 in first iteration, the algorithm is again iterated to loop back at Step 1. Meeting the criteria at Step 1, second iteration goes to Step 2, Step 3 and Step 4 again. The risk messages generated in this iteration are DURN-RELY, DURN-CPLX, DURN-CPIS, DURN-CADP, DURN-SCAP, DURN-WSZE, DURN-WSKL, DURN-SEXP, DURN-UMTG, DURN-SCED, DURN-PMEX, DURN-PDTH, DURN RISK, DURN-RVOL concentrating on Project Duration main attribute with risk value 0.429. After resolution of risk showed, the algorithm is iterated further for third loop back and so on. The process is iterated for 15 times and then at the sixteenth iteration, the loop is terminated meeting the terminating condition at Step 1. Thus, the procurement risk is mitigated completely and procuring agency can proceed toward bidder selection and other procuring process.

5. Conclusions

The major disadvantage of Algorithm 1 is that algorithmic approach for procurement risk mitigation is to remove all risk issues completely from procurement process is given mandatory which may become problematic in a real case where procurement process is needed to be executed with existence of some level of risk at least. In such case this model will stuck the whole process until risk is totally removed as it is in the loop of the algorithm. The remedy to this problem is nothing but it is to insert another conditional statement whether to leave the risk value to exist in the procurement process or it is really needed to remove risks and make the process totally risk free before the selection process starts. Moreover, we have devised 210 rules for knowledge base or rule base where all the rules have been used as message for risk definition and its risk potentiality. There could be more accurate knowledge base if attribute pairs are paired further and new knowledge description is determined. Raymond J. Madachy (1995) also derived about 210 rules and he separated some of them as suggestions, some as rules and few as useless but we have considered all 210 rules as message to users and risk factor to be mitigated. Beside the application of Fuzzy based method discussed above, AHP method has also been executed and risk level has been noted and compared with Fuzzy based result. Assessment of risk ratings summarized in Table 5 using the linguistics in Table 2 which is normalized using equation eq (1) and determined risk values for each attribute of risk areas which is later used to determine the optimized risk value of the procurement project. After that AHP normalization processed has been exercised over the same dataset of Table 5 by dividing each element of the matrix by the column sum of respective column then summing up the averages of new values each rows. The result of $f'(x)$ of Fuzzy normalization and the result of AHP normalization have been summarized in Table 7 and tried to observe the differences. Here we have found a significant difference between AHP and Fuzzy MCDM method results (Figure 2). We have found that Fuzzy MCDM showed higher values in attributes of risk associated in test result where AHP produces lower values. The question is which results are to be considered as more acceptable. AHP determines the selection by selecting highest value from the matrix of the row sums of AHP normalized matrix. AHP method has produced selected risk area CPLX (Product or Service Complexity). According to Fuzzy MCDM we have the selected risk area is UMTG (Usage of Modern Technology Area) which is determined by selecting the maximum value from the minimum values of each attribute pairs' normalized. This is actually an optimized solution determined by Fuzzy MCDM method. AHP result will provide less opportunity to concentrate for risk mitigation for each area as both CPLX and UMTG have higher risk value generated by Fuzzy method than AHP results. If we execute the risk mitigation algorithm with AHP values, it would be iterated less times and mitigate less risk found by the system as AHP method has produced lower risk values in the results than Fuzzy MCDM which could lower the system efficiency. Hence, Fuzzy MCDM has been found better suited method than AHP in this risk area selection and risk mitigation.

6. Recommendations

Reliability measure of proposed e-Procurement risk identifier model is badly necessary before implementation of the proposed model. We encourage assessing the decisions taken in many tendering and procurement cases, samples collected from public and private sectors and feed into this new model, to analyze the deviations including the thorough studies of the risk attributes. Moreover, in the illustrative example, fuzzy rating is shown by one decision maker whereas many decision makers' rating will make the decision result more appropriate. To achieve this fuzzy MCDM with fuzzy TOPSIS with the help of some mathematical techniques could be applied obtaining more sophisticated model. Development of neuro-fuzzy and fuzzy-genetic approach will be an effective way of implication of such a model for better efficiency.

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Table 1: Generalized e-Procurement Risk Attributes

Category	**Description of Attributes**
Product or Service Attributes	Required product or service reliability (RELY)
	Required product volume or service duration (DURN)
	Product complexity or service (CPLX)
Customer Attributes	Product complementary infrastructure (CPIS)
	Customer skills, knowhow and adaptability (CADP)
Personnel Attributes	Service Providers or consultants or bidders capability (SCAP)
	Workforce size (WSZE)
	Workforce skills (WSKL)
	Service experience (SEXP)
Project Attributes	Use of modern technologies (UMTG)
	Required supply or service schedule (SCED)
Process Attributes	Process experience (PMEX)
	Process documentation thoroughness (PDTH)
	Risk eliminated by rules and regulations (RISK)
	Requirements volatility (RVOL)

Table 2: Suggested numbers for risk rating

$f(x_i, x_j)$	Risk/Maturity weight of x_i with respect to x_j
1	Low Risk
3	Moderate Risk
5	High Risk
7	Very High Risk
9	Extra High Risk
2,4,6,8	Intermediate values between above levels

Table 3: Risk Scale

Risk Value *(Rv)*	**Risk Description**
00.000~03.000	Very Low Risk
03.001~06.000	Low Risk
06.001~09.000	Moderate Risk
09.001~12.000	High Risk
12.001~15.000	Very High Risk

Table 4: Calculation of Risk Value

Product or Service			Customer		Personnel				Project		Process			
RELY	DURN	CPLX	CPIS	CADP	SCAP	WSZE	WSKL	SEXP	UMTG	SCED	PMEX	PDTH	RISK	RVOL
0.33	0.429	0.33	0.33	0.11	0.11	0.11	0.11	0.2	0.6	0.33	0.143	0.2	0.429	0.11
Rv = 3.87 (Low Risk)														

Table 5: Fuzzy rating of risk attributes by decision maker

$f(x_i, x_j)$	RELY	DURN	CPLX	CPIS	CADP	SCAP	WSZE	WSKL	SEXP	UMTG	SCED	PMEX	PDTH	RISK	RVOL
RELY	1	3	7	9	7	9	3	5	5	5	3	1	3	9	5
DURN	5	1	3	5	5	3	7	5	3	5	9	3	3	3	9
CPLX	9	5	1	9	9	9	7	9	5	7	5	7	3	9	5
CPIS	3	3	5	1	1	3	3	5	3	1	3	5	3	7	1
CADP	9	1	1	1	1	1	3	3	5	5	3	3	1	7	1
SCAP	5	7	5	3	1	1	7	7	3	1	5	7	1	9	1
WSZE	1	9	7	1	1	3	1	9	3	3	5	1	1	3	1
WSKL	7	7	5	5	1	5	3	1	5	3	7	1	1	9	3
SEXP	1	1	3	1	1	5	3	7	1	1	1	3	1	3	1
UMTG	7	5	5	3	3	9	3	7	3	1	3	5	3	9	7
SCED	1	5	7	1	1	5	9	9	3	5	1	1	5	7	3
PMEX	3	1	1	3	1	7	3	5	7	5	3	1	7	1	1
PDTH	1	1	7	3	1	5	3	5	1	1	1	3	1	1	1
RISK	5	7	9	7	3	7	3	9	5	9	3	3	3	1	5
RVOL	5	1	3	1	7	3	1	1	5	1	5	3	5	7	1

Table 6: Normalized matrix of fuzzy ratings of Table 5

$f(x_i, x_j)$	RELY	DURN	CPLX	CPIS	CADP	SCAP	WSZE	WSKL	SEXP	UMTG	SCED	PMEX	PDTH	RISK	RVOL
RELY	**1**	**0.6**	**0.78**	**1**	**0.78**	**1**	**1**	**0.714**	**1**	**0.714**	**1**	**0.33**	**1**	**1**	**1**
DURN	**1**	**1**	**0.6**	**1**	**1**	**0.429**	**0.78**	**0.714**	**1**	**1**	**0.6**	**1**	**1**	**0.429**	**1**
CPLX	**0.33**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0.429**	**1**	**1**
CPIS	**1**	**0.6**	**0.56**	**1**	**1**	**1**	**1**	**1**	**1**	**0.33**	**1**	**1**	**1**	**1**	**1**
CADP	**1**	**0.2**	**0.11**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0.143**
SCAP	**0.56**	**1**	**0.56**	**1**	**1**	**1**	**1**	**1**	**0.6**	**0.11**	**1**	**1**	**0.2**	**1**	**0.33**
WSZE	**0.33**	**1**	**1**	**0.33**	**0.33**	**0.429**	**1**	**1**	**1**	**1**	**0.11**	**0.33**	**0.33**	**1**	**1**
WSKL	**1**	**1**	**0.56**	**1**	**0.33**	**0.714**	**0.33**	**1**	**0.714**	**0.429**	**0.11**	**0.2**	**0.2**	**1**	**1**
SEXP	**0.2**	**0.33**	**0.6**	**0.33**	**0.2**	**1**	**1**	**1**	**1**	**0.33**	**1**	**0.429**	**1**	**0.6**	**0.2**
UMTG	**1**	**1**	**0.714**	**1**	**0.6**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
SCED	**0.33**	**0.55**	**1**	**0.33**	**0.33**	**1**	**1**	**1**	**1**	**1**	**1**	**0.33**	**1**	**1**	**0.6**
PMEX	**1**	**0.33**	**0.143**	**0.6**	**0.33**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0.33**	**0.33**
PDTH	**0.33**	**0.33**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0.33**	**0.6**	**0.429**	**1**	**0.33**	**0.2**
RISK	**0.56**	**1**	**1**	**1**	**0.429**	**0.78**	**1**	**1**	**1**	**1**	**0.429**	**1**	**1**	**1**	**0.714**
RVOL	**0.2**	**0.11**	**0.6**	**1**	**1**	**1**	**1**	**1**	**1**	**0.143**	**1**	**1**	**1**	**1**	**1**

Table 7: Risk attributes' values generated by Fuzzy MCDM and AHP method

	RELY	DURN	CPLX	CPIS	CADP	SCAP	WSZE	WSKL	SEXP	UMTG	SCED	PMEX	PDTH	RISK	RVOL
AHP data	0.085	0.083	0.114	0.051	0.05	0.069	0.052	0.069	0.034	0.081	0.068	0.057	0.038	0.09	0.058
Fuzzy data	0.33	0.429	0.33	0.33	0.11	0.11	0.11	0.11	0.2	0.6	0.33	0.143	0.2	0.429	0.11

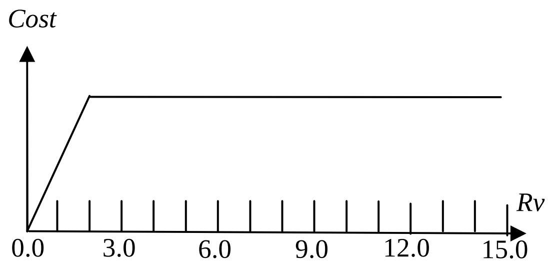

Figure 1: Efficiency of Risk mitigation algorithm

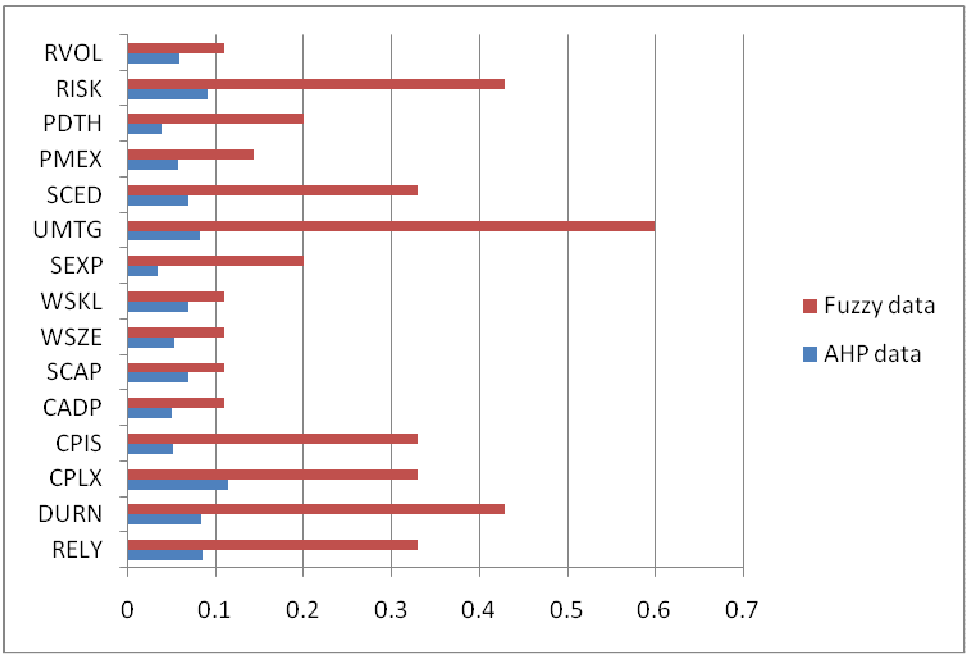

Figure 2: Comparison of risk values for Fuzzy MCDM and AHP results