Fuzzy-TOPSIS Analysis for Standard Alternative Selection: A Multiple Attribute Decision-Making Method and Application for Small and Medium Manufacturing Enterprises (SMEs)

FuzzyTOPSISAnalysisforStandardAlternativeSelectionAMultipleAttributesDecisionMakingMethodandApplicationforSmallandMediumMa

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1

Received: 9 December 2012 Accepted: 5 January 2013 Published: 15 January 2013

Abstract

In the era of industrialization small and medium enterprises (SMEs) play great role in world economy. The developed as well as developing countries are being benefited from SMEs which holds a strong position creating new employment and helping in the development and supporting in local production. The job creation element of SMEs enables many poor people to feel more secure, assuring that they have a stable job to survive .But the actual situation and overall working condition of SME?s is very dreadful especially due to limitation of resources, facilities and techniques. This paper compares different performance criteria on three different SME and indicates a standard benchmark SME using fuzzy-TOPSIS analysis. The proposed method states optimum SME working condition among different performance variables with different values. Qualitative variables with multiple criteria problems have been analyzed here. As human assessment is uncertain and often subjective for qualitative characteristics, the alternatives? characteristics are expressed in linguistic terms. These linguistic terms are then evaluated through integrated fuzzy-TOPSIS method to produce numerical value which is the performance rating for each characteristic of SME alternatives. According to the fuzzy rule, the alternative with the highest value is chosen as the standard and other variables of alternatives are compared with the standard. The advantage of using fuzzy- TOPSIS is that it distinguishes benefit and cost category criteria and selects solution that is closed to the positive ideal solutions and far from the negative ideal solutions. Moreover, the paper offers a new method of identifying best SME using integrated fuzzy-TOPSIS and recommends optimum performance variables.

Index terms— fuzzy, multi-criteria problem, TOPSIS.

enterprises (SMEs) play great role in world economy. The developed as well as developing countries are being benefited from SMEs which holds a strong position creating new employment and helping in the development and supporting in local production. The job creation element of SMEs enables many poor people to feel more secure, assuring that they have a stable job to survive .But the actual situation and overall working condition of SME's is very dreadful especially due to limitation of resources, facilities and techniques. This paper compares different performance criteria on three different SME and indicates a standard benchmark SME using fuzzy-TOPSIS analysis. The proposed method states optimum SME working condition among different performance

variables with different values. Qualitative variables with multiple criteria problems have been analyzed here. As human assessment is uncertain and often subjective for qualitative characteristics, the alternatives' characteristics are expressed in linguistic terms. These linguistic terms are then evaluated through integrated fuzzy-TOPSIS method to produce numerical value which is the performance rating for each characteristic of SME alternatives. According to the fuzzy rule, the alternative with the highest value is chosen as the standard and other variables of alternatives are compared with the standard. The advantage of using fuzzy-TOPSIS is that it distinguishes benefit and cost category criteria and selects solution that is closed to the positive ideal solutions and far from the negative ideal solutions. Moreover, the paper offers a new method of identifying best SME using integrated fuzzy-TOPSIS and recommends optimum performance variables.

Keywords: fuzzy, multi-criteria problem, TOPSIS. a) Purposes of SMEs he small and medium manufacturing enterprises (SMEs) manufactures a great number of metal products every day. Manufacturing SME has a big contribution from repairing metal parts to manufacturing complex parts. There is wide range of activities behind the manufacturing system, from raw material to finished product until the product is used by customer or recycled. One of the most important roles of SMEs is poverty alleviation through job creation. The developed as well as developing countries are taking extreme benefits from SMEs and that are capable to accelerate the economy of any country. In developing countries, SMEs are major source of income. The following **??**arkis (2006) found that early adoption and increased investment in environment risk management did not increase performance for small firms in the metal finishing industry. Paying particular attention to the needs of small and medium sized enterprises (SMEs), Project Acorn by Gascoigne j. provides a framework for the systematic management of environmental issues within individual organizations and the supply chains to which they belong **??**1]. **??**oyli et al. (2008) analyzed the relationship between logistics performance and financial performance in Finnish small and medium-sized enterprises (SMEs). Several studies in South Africa **??**Mutezo, 2006; **??**aas and Herrington, 2006; **??**ngela and Motsa, 2006; **??**errington et al., 2008; **??**usara and Fatoki, 2011) have alluded to lack of access to financing as one of the major challenges impeding the survival and growth in the SME sector. **??**agner, B. A. et al. (2003) worked on E-business and Esupply chain strategy in small and medium sized businesses (SMEs). In a study in India's machine tools SMEs, Pillai (2010) found that proper inventory management practices results in lower inventory costs. In another study, **??**ee (2006) revealed that many Chinese small manufacturing firms face size-related difficulties in implementing JIT. Lee suggested that Chinese small firms can achieve their goals by implementing only feasible elements of JIT without too much capital investment. **??**ayraktar, E. et al. (2009) made a causal analysis of the impact of information systems and supply chain management practices on operational performance having evidence from manufacturing SMEs in Turkey. **??**hagwat, R., & Sharma, M. K. (2006) worked on Management and practice of information system in Indian SMEs. While it is acknowledged that large firms have an advantage for adopting sustainable practices more than SMEs and that SMEs adoption is necessary in the long run, studies found that the rate of return on early adoption is not encouraging. Banomyong, R., & Supatn, N. (2011) developed supply chain performance tool for SMEs in Thailand. There is also a vast literature on business success of small and medium enterprises (SMEs). **??**udretsch (2005) showed the relationship between ownership, decision making and employee deployment and the performances of the SMEs. In a research study on SME's in Indonesia **??**Robert, 2007) founded that SMEs operate on traditional lines in marketing. Strict reaction on account of competition should be responded proactively by SMEs by doing business development and research Information access it stands for the availability of business information is also important to initiate new enterprises and to run the existing enterprise profitably. Technology also plays an important role in this respect. Technology has a close relationship with improvement of production process. Different studies have also revealed the similar results that lack of new technology and equipment are hindrances of SME development **??**Swierczek & Ha, 2007). In Indonesian study it was revealed that business has no sufficient relation with the success of an SME **??**Huggins, 2007).

1 d) Contribution of This Paper

Works on SME were seen frequent formerly. While it is acknowledge that large firms have an advantage for adopting change discussed above where SMEs have no option but SMEs adoption is necessary. More research is thus needed on how SMEs should approach to a standard performance. In this paper standard alternative has been selected incorporation with TOPSIS and fuzzy analysis.

It is a common problem found in many cases of quantitative decision making the human assessments is uncertain and it is often difficult for decision makers to supply exact numerical values for specific criteria. In this regard most of the selection parameters can't be given precisely and the evaluation data of alternatives' characteristics is expressed in linguistic term by the decision makers. Moreover human judgment on qualitative attributes is always subjective and thus imprecise. For the sake of modeling this type of characteristics in case of human approach, fuzzy logic could be the best means.

There are many more operational tools for this type of analysis. Among those TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is applied to solve this type of multi-criteria problem. TOPSIS method is developed by **??**wang and Yoon (1981) based on the concept that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest from the negative ideal solution for solving a multi-criteria decision making problem. Briefly the positive ideal solution is made up of all the best values attainable of criteria, whereas the negative is composed of all worst values attainable of criteria.

The rest of the paper is organized as follows: Section 2 consists of briefly discussion on SME and G fuzzy-TOPSIS. Methodology is discussed in section 3. Rest of the paper is comprised of calculation, result& discussion and conclusion. There is also reference and appendix annexed at the last portion.

The fuzzy TOPSIS approach involves fuzzy assessments of criteria and alternatives in TOPSIS **??**Hwang and Yoon, 1981) [2]. The TOPSIS approach chooses alternative that is closest to the positive ideal solution and farthest from the negative ideal solution. A positive ideal solution is composed of the best performance values for each criterion whereas the negative ideal solution consists of the worst performance values. The various steps of fuzzy TOPSIS are presented as follows:

? Step 1: Assignment of ratings to the criteria and the alternatives Let us assume there are J possible candidates called A = {A 1 , A 2 ???. A j } which are to evaluate against n criteria, C = {C 1 , C 2 ??????.C i }. The criteria weights are denoted by w= (1, 2, 3,?????m). The performance ratings of each decision maker D=(1,2,3????k) for each alternative A j (j=1,2,3???n) with respect to criteria C i (i=1,2,3??..m) are denoted by R k =X ijk (i=1,2,3?m; J=1,2,3?n; K=1,2,3??..k) with membership function µ rk (x) ? Step 2 : Compute aggregate fuzzy ratings for the criteria and the alternatives. If the fuzzy ratings of all decision makers is described as triangular fuzzy number R k =(a k , b k , c k) K=1,2,3??.k; then the aggregated fuzzy rating is given by R=(a, b, c), K=1,2,3??k wherea=min {a k }, b= 1 ? ? ? ? ?=1 k , c=max {c k } (1)

If the fuzzy rating and importance weight of the k th decision maker are X ijk =(a ijk ,b ijk ,cijk) and Wi jk =(w jk1 ,w jk2 ,w jk3); i=1,2,3?..m; j=1,2,3??n; respectively ,then the aggregated fuzzy ratings (X ij) of alternatives with respect to each criteria are given by X ji =(a ij ,b ij ,c ij) wherea ij =min{a ijk }, b ij = 1 ? ? ? ? ?=1 ijk , ; c ij =max {c ijk } (2)

The aggregated fuzzy weights (W ij) of each criterion are calculated as w j = (w j1 ,w j2 ,w j3) where x 11 ? ? 1? ? ? ? ? ?1 ? ? ??] i=1,d * i = ? ? ? ?=1 v (v ij ,v * j) i=1,2,3??..m (9) d -i = ? ? ? ?=1 v (v ij ,v -j) i=1,2,3??..m(

2 G

In order to identify the causes behind the production quality three SMEs were observed. Then some fundamental points were selected. The points were of two types: qualitative and quantitative. Even menial errors were tried to be overcome, so before taking the data they were checked and rechecked. There were some categorizations set for quantitative data analysis. Criteria weights are calculated as the triangular fuzzy numbers and then these fuzzy criteria weights are inserted to the fuzzy TOPSIS methodology to rank the alternatives.

The data were taken on the following points: Working space(in sq. ft.), light (in lumen), salary of workers, age of machines, cutting tool quality, maintenance of machines, waste disposal system, basement space, floor quality, welding rod, safety measures, handling equipment ,working conditions, amount of work per hour, amount of scrap material, quality of material used etc.

Then using fuzzy logic the qualitative and quantitative data analysis was performed.

The Process flow diagram is described below: (1, 3, 5, 1, 3, 5, 1, 3, 5)

3 =1

It is shown for the first element. Similarly others were calculated.

According to equation no. 4 normalized fuzzy was calculated represented in table 4. For the Alternative 1; a 11 = 7/9 = 0.78 For the Alternative 2;

(For Benefit Criteria) a 21 = 3/9 = 0.33 For the Alternative 3; a 31 = 5/9 = 0.56

It is shown for the first element. Similarly others were calculated. According to equation no. 5 For Alternative 1; a 13 , 1= 1/5 =0.20 For Alternative 2;

(For Cost criteria) a 13 , 2= 1/1 =1 For Alternative 3; a 13 , 3= 1/1 =1 It is shown for the first element. Similarly others were calculated.

At the Table **??**o.5 the weighted normalized matrix was calculated from equation (**??**

4 G

The fuzzy positive ideal solution (FPIS) was Calculated by using equation (**??**).

Max (a 11) =Max (2.33, 5.00, 7.00, 1.00, 2.78, 5.44, 1.67, 3.89, 7.00) =7.00;

It is shown for the first element. Similarly others were calculated.

The distance of each alternative from FPIS and FNIS was calculated using equation following equation.d (a, b) = ? 1 3 [(? 1 ? ? 1) 2 + (? 1 ? ? 2) 2 + (? 1 ? ? 3) 2] (12)

For Alternative 1(D-), using equation 12.d (a 11) = ? 1 3 [(1 ? 2.33) 2 + (1 ? 5) 2 + (1 ? 7) 2] =?17.93 =4.23

It is shown for the first element. Similarly others were calculated.

5 At table no.7

For Alternative 1(D+), using equation 12. For Alternative 1 calculation of (cc); cc = 63.25/ (63.25+78.57) = 0.446 =44.60%.

It is shown for the first element. Similarly others were calculated.

Table **??**o. 8 shows the final result. There are three values for three alternatives. The alternative having highest value is the best, hereby standard among all. The analysis shows "alternative 1" as the standard manufacturing SME (small and medium enterprise).So the best possible alternative is "alternative 1. It is said in previous section that, on qualitative characteristics human assessment is uncertain and often subjective so the alternative characteristics are expressed in linguistic terms. There were some characters tics which were qualitative, but due to simplicity they were also transferred to quantitative. And for the purpose of confidentiality the real name of the manufacturing SMEs were not disclosed.

For the selection of the best alternative the proposed method is a unique one. As the best is selected by the analysis then is can be said as standard. So changing the others comparing to it can make them well efficient in production. So drastically change is not needed for SMEs. The proposed method will help the SMEs to cope with the competition in the era of industrialization. To our knowledge no previous work investigated such a solution with TOPSIS and fuzzy analysis. As the proposed method is novel, it might be applied to other MADM problem.

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Level of material performance.

Material that are useless after working.

An action process of waste disposing.

Available voltage from the power supply.

Category of wire according to performance.

The process of maintaining of Machine.

7 Distinctive attribute of gas welding

Available space for the machine holding in basement

The standard of cutting fluid against similar kind Amount of production hourly(kg)

8 Quantity of worker appointed in working

The degree or intensity of heat present in working condition

9 Skill of worker

Conditions in which a worker operates machines Lower surface of the working room Distinctive attribute of welding rod Equipment that ensure safety like Googols, apron, Hand gloves, cades.

The equipment used for lifting, holding.

Distinguishing performance level of lubricant used.

10 Payment of worker

Length of time machine has been worked

Categorization of belt basis of performance [1] [2] [3] [4]

Figure 1:

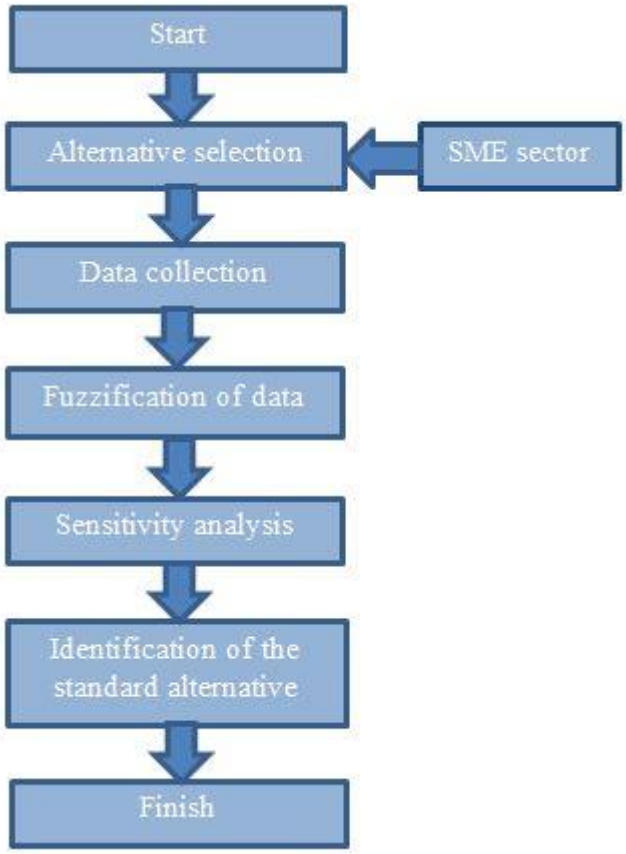
Start
Alternative selection
SME sector
Data collection
Fuzzification of data
Sensitivity analysis
Identification of the standard alternative
Finish

Figure 2: ?

important and necessary research, how the SMEs can be made enable without changing infrastructure, equipment, environment, budget, capacity and environment.
c) Previous Work
SMEs have received noticeable attention in the literature.

Importance of SMEs on Economy of Asian Countries country SMEs as %

	all enterprises	employees as % of total employees population
Japan	98.9	69.2
Singapore Hong-Kong Thailand	99.7	57.0 60.0
Taiwan Philippines	98.0	58.0 68.8
Malaysia	99.7	70.0 45.0
	97.7	
	99.6	
	96.1	

T

Figure 3:

3

	Weightage			Alternative 1	
	3	5	7	7	9
	7	9	9	3	5
	5	7	9	7	9
	5	7	9	7	9
	3	5	7	5	7
	5	7	9	5	7
Year	3 3 5 5	5 5 7	7 7 9 9	1	3 3 3 5
2013	7	7 9	9	1	1
				1	
				3	
				1	
	3	5	7	3	5
	5	7	9	1	3
XIII	3 3 5 3	5 5 7	7 7 9 7	1	3 3 5 7
Is-	3 7 5 3	5 5 9	7 9 9 7	1	5 1 1 7
sue	7	7 5 9	9	3	1
v v				5	
V				3	
Ver-				1	
sion				1	
I				5	
				1	
Volume	5 3	7 5	9 7	3	5 5
				3	

D D
D D
)
(

Table 4 : Fuzzy normalized matrix for alternatives

Global Journal of Researches in Engineering	Max/Min	∅78	Alternative 1 1.00 0.56 1.00 1.00 0.78 0.78 0.60 0.33 0.33 0.56 0.14 0.71	1.00
	9	0.33		0.78
	9	0.78		1.00
	9	0.78		1.00
	9	0.56		1.00
	9	0.56		1.00
	9	0.20		1.00
	5	0.11		0.56
	9	0.11		0.56
	9	0.33		0.78
	9	0.14		0.43
	7	0.43		1.00
	7			
	1	1.00	0.33	0.20
	1	1.00	0.33	0.20
	1	1.00	0.33	0.20
	3	1.00	0.60	0.43
	3	0.60	0.43	0.33
	3	1.00	0.60	0.43
	1	1.00	1.00	0.33
	1	1.00	1.00	0.33

[Note: G]

Figure 4: Table 3 :

5

5	1.00	0.71											0.56	1.0
1	1.00	1.00											0.33	1.0
1	0.33	0.20											0.14	0.3
1	0.33	0.20											0.14	0.2
														We
Alternative 1														Al
2.33	5.00										7.00	7.00	9.00	1.0
2.33	5.00										9.00			5.4
3.89	7.00													1.6
3.89	7.00													3.8
1.67	3.89										7.00	9.00		1.0
2.78	5.44													2.7
0.60	3.00										7.00	3.89	5.00	0.6
0.33	1.67										7.00	3.86	7.00	1.6
0.56	2.33										1.80	1.40	1.40	1.6
1.67	3.89										3.86			0.5
1.00	1.29													3.0
1.29	3.57													1.2
5.00	2.33													5.0
3.00	1.67													3.0
3.00	1.67													3.0
5.00	4.20													3.0
1.80	2.14										2.33	3.00	3.00	1.2
3.00	3.00													3.0
7.00	9.00													7.0
5.00	7.00	3.57	9.00	1.40	1.00	FPIS MAX	7.00	9.00	9.00	9.00	7.00	9.00	7.00	Table 6 : Negative distanc
3.00														
7.00														
1.67														
1.00														
FNIS														
MIN														
1.00														
2.33														
1.67														
3.89														
1.00														
2.78														
0.60														
0.33	7.00													4.81 2.1
0.56	9.00													7.64 2.7
0.56	9.00													17.96 4.2
1.00	9.00													2.75 1.6
1.29	7.00													12.63 3.5
1.80	5.00													3.51 1.8
1.00	3.00													1.53 1.2
1.40	3.00													0.88 0.9

Figure 5: Table 5 :

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