SUPPLY CHAIN RISK ANALYSIS IN SPORTS RELATED MANUFACTURING SECTOR USING FUZZY ANALYTIC HIERARCHY PROCESS AND TOPSIS

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Abstract: Outsourcing from third world countries is comprehensively used by Euro-American based sports companies to reduce cost in response to changing socio-economic pressure. Multi-national firms are recognizing the importance of considering risk attributes in evaluating and selecting outsourced suppliers for strategic partnerships to cope with steep competitive environment. Selection of the suppliers in upstream supply chain for manufacturing products requires an extensive evaluation process. In this paper, we propose a fuzzy multi-criteria decision model to evaluate the risk factors in supply chain of sports equipments manufacturing company. Fuzzy Analytical Hierarchy process (F-AHP) is used to calculate the weights of various risk weights based on opinion of three decision making experts and finally these weights becomes the input to TOPSIS method for calculating the various rank of the alternative suppliers. The efficacy of this two phase method is tested on a multi-sized global sports company, Adidas, in selection of its outsourced equipment suppliers from third world countries. Lastly, few important suggestions are put forward for better understanding the situation.

Keywords: Analytic hierarchy process (AHP), TOPSIS, Supply chain risk, Outsourcing

INTRODUCTION

The supply chain is conceptualized as a network of companies from suppliers to end-users, which have the intention of integrating supply and demand management. Within supply chain, the network encompasses sourcing and procurement as a strategic function by ensuring goods required is received on time with specified quantity and quality [7]. However, there is just particularly limited research done on outsourcing risk management in the field of supply chain. in sports sector. Problem of ranking alternatives is no easy matter. It involves a multiplicity of complex considerations. And yet, particularly with regard to linguistic terms are difficult to evaluate. The fuzzy set theory is ideal for sorting through the maze of vague and at times conflicting information. Multi-criteria decision making refers to find the best opinion from all of the feasible alternatives in the presence of multiple, usually conflicting, decision criteria. AHP technique investigated in the present study is a multi-criteria decision making technique developed by Saaty (1980) [2]. Although, traditional AHP technique may display expert knowledge, it cannot reflect human thinking. Therefore, FAHP technique was developed. TOPSIS method was firstly proposed by Hwang and Yoon (1981) [3-4]. According to this technique, the best alternative would be the one that is earnest to the positive ideal solution and farthest from the negative ideal solution. FAHP and TOPSIS methods can be used together for complex decision problems. Tolga et al. [6] dealt with the problems of selecting target market by using fuzzy replacement analysis and AHP. In the present study, on the other hand, for the selection of target market, FAHP and TOPSIS method is examined by using attributes of target market.

$G = \{g_1, g_2, \ldots\ldots, g_n\}$ g_i

Two Phase algorithmic approach

The first study of fuzzy AHP is proposed by Van Laarhoven and Pedrycz [1] which compared fuzzy ratios described by triangular fuzzy numbers. Chang introduced a new approach for handling fuzzy AHP, with the use of triangular fuzzy numbers for pair-wise comparison scale of fuzzy AHP, and the use of the extent analysis method for the synthetic extent values of the pair-wise comparisons.

Technique for order preference by similarity to ideal solution, TOPSIS method was firstly proposed by Hwang and Yoon [2].According to this technique, the best alternative would be the one that is nearest to the positive ideal solution and farthest from the negative ideal solution. The positive ideal solution is a solution that maximizes the benefit criteria and minimizes the cost criteria, whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria.

First Phase (Fuzzy-AHP Approach):

Let $X = \{x_1, x_2, x_3, \ldots\ldots, x_n\}$ be an object sets, and be a goal set. Each object is taken and extent analysis for each goal, , is performed, respectively. Therefore, m extent analysis values for each object can be obtained with the following signs:

$M_{gi}^1, M_{gi}^2, M_{gi}^3, ..., M_{gi}^n,\ i = 1,2,3,......n$

$M_{gi}^j,\ j = 1,2,......,m$ are triangular fuzzy numbers (TFN). The steps of Chang's extent analysis [7] can be given as in the following:

Step 1: The value of fuzzy synthetic extent with respect to the i th object is defined as

$S_i = \sum_{j=1}^{m} M_{gi}^j \otimes [\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j]^{-1}$. To obtain $\sum_{j=1}^{m} M_{gi}^j$, perform the fuzzy addition operation of m extent analysis values for a particular matrix such that,

$\sum_{j=1}^{m} M_{gi}^j = (\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j)$ .And to obtain $[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j]$ perform the fuzzy addition operation of M_{gi}^j values such that $\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j = (\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i)$ and then compute the inverse of the vector above such that

$$[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j]^{-1} = (\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i})$$

Step 2: The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_2 = (l_2, m_2, u_2)$ defined as

And expressed equivalently as follows:

Where d is the ordinate of the highest intersection point D between μ_{M_1} *and* μ_{M_2}

To compare we need both values of $V(M_2 \geq M_1)$ *and* $V(M_1 \geq M_2)$

Step 3: The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers can be defined by

Assume that

and $k = 1,2,.....n.$ Then the weight vector is given

where $A_i\ (i = 1,2,....,n)$ are n elements.

Step 4: Via normalization, weight vectors are where W is a non-fuzzy number.

Second Phase (Fuzzy TOPSIS approach)

Step 5: Decision matrix is normalized by

$r_{ij} = w_{ij} \Big/ \sqrt{\sum_{j=1}^{J} w_{ij}^2}\ ,\ j = 1,2,....J;\ i = 1,2,.....,n$ Step 6: Weighted normalized decision matrix is obtained by multiplying normalized matrix with the weights of the criteria. $v_{ij} = w_i^* r_{ij}$,

Step 7: PIS (Maximum values) and NIS (Minimum values) are determined as

$A^* = \{v_1^*, v_2^*, ..., v_n^*\}$ *and* $A^* = \{v_1^*, v_2^*, ..., v_n^*\}$

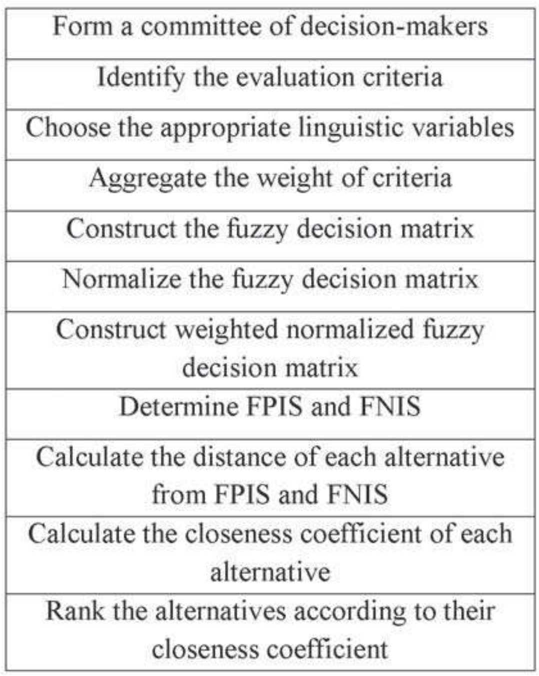
Step 8: The distance of each alternative from PIS and NIS is calculated as:

$d_i^* = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^*)^2}$ *and* $d_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2}$ $j = 1,2,.....J$

Step 9: The closeness coefficient of each alternative is calculated:

Step 10: At the end of the analysis, the ranking of alternatives is determined by comparing values.

The steps of the proposed Method.



Empirical Case Study

Adidas, world largest sports equipment manufacturer, work with more than 1,070 independent factories from around the world who manufacture our products in 67 countries. Its supply chain is global and multi-layered, with many different types of business partner, some of whom are directly contracted and others who are not. The adidas Group's Global Operations function manages product development, commercialization and distribution and also supervises the major part of manufacturing for the adidas, Reebok and Taylor Made-adidas Golf segments. In addition, Global Operations leads our Group's efforts in supply chain optimization. Due to different sourcing requirements in their respective fields of business, Rockport,Reebok-CCM Hockey, Sports Licensed Division, Taylor Made and specific business segments are not serviced through Global Operations but instead use their own purchasing organizations that are used to sourcing products through intermediaries such as agents. In order to quickly seize short-term opportunities in their local market or react to certain trade regulations, Group subsidiaries may also source from local suppliers that are not overseen by Global Operations. Local purchases, however, account only for a minor portion of the Group's total sourcing volume.

A numerical example is illustrated and trial data is used for selecting best target market according to decision maker or expert preference. Assume that twenty (20) target outsourced different third world countries producing sports equipment to be evaluated under a fuzzy environment. For selecting target market, main criteria C1-C5 are used in application, are explained in fuzzy sets and fuzzy numbers. The risk criteria are mainly Environmental risk (C1), piracy of product risk (C2), Logistics and cargo damage risk (C3), Market volatility risk (C4), Terrorism risk (C5).

Following Step 1-4, the priority weights are calculated by using MATLAB , $W^c = (1, 0.706, 0.642, 0.602, 0.791)$ .After the normalization of these values priority weights respect to main goal are calculated as (0.267, 0.188, 0.171, 0.161, 0.211).. Then, weighted normalized matrix is formed by multiplying each value with their weights. All weighted values that form criterion are aggregated. Positive and negative ideal solutions are determined by taking the maximum and minimum values for each criterion.

$A^+ = \{0.212, 0.01, 0.194, 0.736, 0.036\}$

$A^- = \{0.005, -0.0029, 0.004, 0.0009, 0.0027\}$

Then distance of each firm from PIS and NIS with respect to each criterion is calculated with the help of Step 8. Then closeness coefficient of each target market is calculated by using Step 9. Ranking of the target market are determined according to these values in Table IV. Different rankings can be obtained by using different decision maker's preference values.

Table I. Linguistic scale and corresponding triangular fuzzy numbers (TFN).

Linguistic scale	TFN
Equal importance (EI)	(1,1,1)
Moderate importance (MI)	(1,3,5)
Strong importance (SI)	(3,5,7)
Very strong importance (VSI)	(5,7,9)
Extremely strong importance (ESI)	(7,9,11)

Table II. Fuzzy pair wise comparison matrix.

Criteria	C1	C2	C3	C4	C5
C1	(1,1,1)	(5,7,9)	(3,5,7)	(1,3,5)	(1/7,1/5,1/3)
C2	(1/9,1/7,1/5)	(1,1,1)	(1,3,5)	(1/5,1/3,1)	(3,5,7)
C3	(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)	(1/5,1/3,1)	(5,7,9)
C4	(1/5,1/3,1)	(1,3,5)	(1,3,5)	(1,1,1)	(1/7,1/5,1/3)
C5	(3,5,7)	(1/7,1/5,1/3)	(1/9,1/7,1/5)	(3,5,7)	(1,1,1)

Table III. Risk Criteria values of target market countries alternatives.

Outsourced countries	Mean product outsourced	Rate growth	Share export	Per-capita income	Distance
Thailand	4187.00	86.18	3.39	3718.00	0.04
Malaysia	3788.67	130.16	3.18	3789.00	0.03
Kenya	3257.00	59.87	2.10	3149.00	0.07
India	2789.00	82.97	2.24	3157.00	0.08
Vietnam	2001.00	-22.49	1.90	1043.00	0.25
Chile	2351.00	36.77	1.62	2689.00	0.08
Argentina	1756.00	78.23	1.89	1056.00	0.07
Bolivia	1164.00	67.10	0.84	2383.00	0.02
Sri lanka	704.00	68.50	0.93	2839.00	0.06
Bangladesh	588.33	55.30	0.48	2693.00	0.10
Libya	681.32	0.57	0.55	1781.00	0.33
Mexico	678.00	52.00	0.55	2860.00	0.07
Venezuela	270.00	4.75	0.22	3279.00	0.08
Turkey	237.00	41.85	0.19	4068.00	0.16
Egypt	1141.00	54.23	0.48	3124.00	0.07
Bahrain	80.00	67.62	0.06	2680.00	0.12
Oman	1675.00	29.86	0.64	2021.00	0.09
Zimbabwe	704.00	49.65	1.21	3210.00	0.04
Taiwan	237.14	25.94	0.64	2645.00	0.08
Italy	2451.00	44.75	0.25	3245.00	0.12

Table IV
Ranking of the target outsourced manufacturing country market according to CCi

Serial No.	Outsourced countries	rank target market CCi
1	Thailand	0.20155
2	Malaysia	0.19004
3	Kenya	0.17621
4	India	0.14595
5	Vietnam	0.15272
6	Chile	0.14567
7	Argentina	0.14172
8	Bolivia	0.10939
9	Sri lanka	0.10408
10	Bangladesh	0.10211
11	Libya	0.09930
12	Mexico	0.05608
13	Venezuela	0.12547
14	Turkey	0.16987
15	Egypt	0.01456
16	Bahrain	0.04187
17	Oman	0.17568
18	Zimbabwe	0.08541
19	Taiwan	0.10521
20	Italy	0.12461

CONCLUSION

With the selection of appropriate target outsourcing market, in third world countries, organizations may have positive results in a world of competition and globalization such as decreased in piracy goods, least economic recession and increased quality work performance. In this paper, FAHP and TOPSIS are integrated for selection of best target market. FAHP is used for determining the weights of the criteria of target market. Then TOPSIS method is used for determining the ranking of the target market. The integration of FAHP and TOPSIS approaches enables experts and users to efficiently select a more suitable target market for specific purpose and requirements. In future studies other multicriteria methods can be used to select target market, Team selection, Sports administration to handle betting, corrupt sports manager and overall to keep up the spirit of the sports.

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