Fuzzy optimization technique for the selection of reclaimer

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Abstract:

Economic growth and environmental protection are mutually conflicting in nature. Both issues are to be addressed simultaneously to keep up green supply chain management. Reclaimers and customers have to focus these aspects in maintaining their business relationship. An effort is made here to deploy one of the multi criteria decision making technique i.e, fuzzy analytical hierarchy process used for selection of idel reclaimer. Case study is conducted. Results are impressive.
Keywords: Green Supply Chain, Fuzzy analytical hierarchy process.

1. **Introduction**

The goal of the study is to choose the Reclaimer and quantity which is ordered in Green supply chain using Fuzzy data. As there is increase in depletion of environmental resources, the scholars of supply chain management has given greater observation towards the dispute between environmental protection and economic growth. In the context of sustainable development which is the part of creative management of supply chain, with the particular goal of minimizing the environmental impact that reclaimers have on end users, is referred to as Green Supply Chain Management (GSCM).

The word "garbage and waste" casually emphasizes aspects of the world that need to be reused, reduced, or disposed of when possible. Large amounts of waste, such as manufacturing scrap, electronic / electrical items, everyday polymers, waste construction materials, and contaminated oil, are generated every day, while the processing process is slow. The term Zero Waste (ZW) encourages both producers and consumers to continually reduce costs and adopt a sustainable approach to create a better world. Zero Waste Manufacturing (ZWM) is considered to be the roadmap for the future of manufacturing, which addresses the hot topic of "waste". However, ZWM may assist in recycling and reusing waste from different manufacturing processes, using optimization tools and sustainable manufacturing theory, and developing precision manufacturing systems.
According to the 2008 Rules on Hazardous Wastes (management, treatment and movement across borders) (HW Rules) “hazardous waste” is any waste that, due to any of its physical, chemical, reactive, toxic, flammable, explosive or corrosive properties may be hazardous or may be hazardous to health or the environment, either separately or in contact with other wastes or substances in accordance with Appendix IV of the 2008 Rules on Hazardous Wastes, both used oil and used oil layer were classified as a hazardous waste, as listed in Appendix I on the rules of [6]. Motor oil is used to lubricate various internal combustion engines to reduce friction, protect against wear and help in the distribution of heat. Under normal use, many impurities, such as soot, water, acids, dirt, metal scrapers and chemicals, can mix in oil and become ineffective for further use [1,2]. The current practice of disposing of simply dumping used oil into drains, rivers and lagoons poses a serious threat to the environment and human health. Thus, it is imperative to find more environmentally sustainable ways to recycle used lubricants through processing. Recycling of used lubricating oil is currently considered the most viable option for eliminating environmental hazards associated with indiscriminate disposal

of used engine oil. In addition, recycling is also considered an effective means of preserving depleted global oil reserves and creating jobs through the construction and operation of refineries [3,4]. Several methods for processing used lubricating oil have evolved over time, starting from the period when the processing of used oil began in the late 1930s. These methods include; acid method, distillation / clay method, acid / clay method, activated carbon / clay method and others. From the very beginning of the disposal of used lubricating oil, clay has been one of the most important and widely used adsorbent materials for oil renewal [5]. The engine oil processing chain includes used oil suppliers, distributors, utilizers, customer warehouse agents, etc., each section of the supply chain seeks to optimize its resources so that the entire system can be optimized. As shown elsewhere in the article, the ultimate goal is the absence of waste.

Supplier selection plays an important role in supporting the green program for oil recycling. The nature of the supplier is that selection is a multi-condition decision (MCDM) problem which is affected by many conflicting factors. Therefore, the purchasing manager must analyze the exchanges between various criteria. Multilevel decision techniques help support decision makers in evaluating options. The criteria are important and vary depending on the purchasing situation.

The analytical hierarchy process (AHP) is a widely used decision-making tool (developed by saaty) in various multi-criteria decision-making problems. It takes pairwise comparisons of different alternatives with respective criteria and provides a decision support tool for multi-criteria decision problems. In a general AHP model, the objective is located at the first level, the criteria and sub-criteria are found respectively at the second and third levels. In the fuzzy analytical hierarchy (F AHP) process, pairwise comparisons of the two criteria and alternatives are performed via the linguistic variables, which are represented by triangular numbers.

2. Literature Review

Henry Mensah-Brown (2013) presented the technique for optimizing the production of lubricating oil from refined used lubricating oil, using the response surface methodology from the 90s, the optimization of the supply chain management was paid to take into account environmental issues growing attention, including the issue of the recovery of environmental investments, the internal redesign of the supply chain network, the ecological coordination between upstream and downstream enterprises and ecological initiatives (Zhu et al., 2007b [12]; Sarkis et al., 2011 [14]; Mitra et al., 2013 [15]. Recovery of environmental investments aims to encourage waste reduction and fosteran attitude of reuse and recycling through reverse logistics and regeneration (Zhuand Sarkis, 2004 [11]). (Sheu et al., 2005 [13]), proposed a multi-objective linear programming model to maximize net profit or integrated logistics and the corresponding reverse logistics of used products. Abdelkader Sbihi and Richard W. Eglese introduced the area of Green Logistics and describe some of the problems that arise in this topic that can be formulated as combinatorial optimization problems. Today, global warming and environmental issues are evident and governments are looking for alternative alternative fuels instead of fossil fuels. Among renewable fuels, biofuels are very interested because of the usable and easy direct production. Fatemeh Ezzati provided a document on optimizing the multimodal, multi-period and complex multi-objective mathematical model of the biodiesel supply chain to select suppliers and allocate orders to suppliers in conditions of uncertainty by Ali Mohtashami * and Alireza Alinezhad. In 2013, an interactive proposed solution approach for multiple objective supplier selection problems with Fuzzy AHP [16]. Their methodology comprises three objectives; minimize the total monetary cost, maximize the total quality and maximize the level of service. Thanks to the interactivity provided, the decision maker has the opportunity to incorporate his preferences during the iterations of the optimization process.

3. Brief on various techniques used

3.1 **Fuzzy AHP**

The fuzzy analytic hierarchy process (f-AHP) embodies the fuzzy analytic hierarchy process (f-AHP), which was developed by Saaty [18].

Step 1: The Comparison Builder compares criteria and / or parameters using the language terms shown in Table 1.

Table 1: Linguistic terms and the corresponding triangular fuzzy numbers

Saaty Scale	Definition	Fuzzy Triangular Scale
1	Equally Important (Eq. Imp)	(1, 1, 1)
2	The intermittent values	(1, 2, 3)
3	Weakly Important (W. Imp)	(2, 3, 4)
4	The intermittent values	(3, 4, 5)
5	Fairly Important (F. Imp)	(4, 5, 6)
6	The intermittent values	(5, 6, 7)
7	Strongly Important (S. Imp)	(6, 7, 8)
8	The intermittent values	(7, 8, 9)
9	Absolutely Important (A. Imp)	(9, 9,9)

According to the corresponding triangular fuzzy numbers in these linguistic terms, for example if criterion 1 "Criterion 1 (C1) is weakly important than Criterion 2 (C2)", then take the fuzzy triangular scale as (2, 3, 4). On the contrary, in the wise contribution matrix of the pair of the comparison of criteria from C2 to C1, the fuzzy triangular scale will be taken as (1/1, 1/3, 1/2). The pair wise contribution matrix is shown in Eq1. Where $\tilde{d}^{k}_{ij}$ indicates the kth preference of the criterion that the decision maker ith criterion over the criterion jth, through fuzzy triangular numbers.

$$\tilde{A}^{K} = \begin{bmatrix} \tilde{d}^{k}_{11} & \tilde{d}^{k}_{12} \cdots & \tilde{d}^{k}_{1n} \\ \tilde{d}^{k}_{21} & \tilde{d}^{k}_{2n} \cdots & \tilde{d}^{k}_{2n} \\ \tilde{d}^{k}_{n1} & \tilde{d}^{k}_{n2} \cdots & \tilde{d}^{k}_{nn} \end{bmatrix} \quad (1)$$

Step2: if there is more than one decision maker. Preferences of each decision maker ($\tilde{d}^{k}_{ij}$) are averaged and ($\tilde{d}_{ij}$) is calculate as in the Eq. 2.

$$\tilde{d}_{ij} = \frac{\sum_{k=1}^{k} \tilde{d}^{k}_{ij}}{K} \quad (2)$$

Step 3: according to averaged preferences, pair wise contribution matrix is updated as show in Eq. 3

$$\tilde{A} = \begin{bmatrix} \widetilde{d_{11}} & \cdots & \widetilde{d_{1n}} \\ \vdots & \ddots & \vdots \\ \widetilde{d_{n1}} & \cdots & \widetilde{d_{nn}} \end{bmatrix} \quad (3)$$

Step 4: the geometric mean of fuzzy comparison values f each criterion is calculated as show in Eq 4. Here, $\widetilde{r_i}$ still represents triangular values.

$$\widetilde{r_i} - \left(\prod_{j=1}^{n} \widetilde{d_{ij}}\right)^{1/n}, \ i=1,2,\ldots\ldots\ldots n \quad (4)$$

Step 5: The fuzzy weights of each criterion can be found with Eq 5.by incorporating next steps.

Find the vector summation of each $\widetilde{r_i}$.Find the (-1)' power of summation vector.
Replace the fuzzy triangular number.
To make it in an increasing order. To find the fuzzy weight of criterion i ($\widetilde{w_1}$), multiply each $\widetilde{r_i}$ with this reverse vector.

$$\widetilde{w_1} = \widetilde{r_i} \times (\widetilde{r_1} \times \widetilde{r_2} \times \ldots\ldots \times \widetilde{r_n})^{-1} \quad (5)$$

$$=(lw_i,\ mw_i,\ uw_i)$$

Step 6: since $\widetilde{w_1}$ are still fuzzy triangular numbers, they need to de-fuzzified by centre of area method proposed by chou and chang[50]. Via applying the Eq.6.

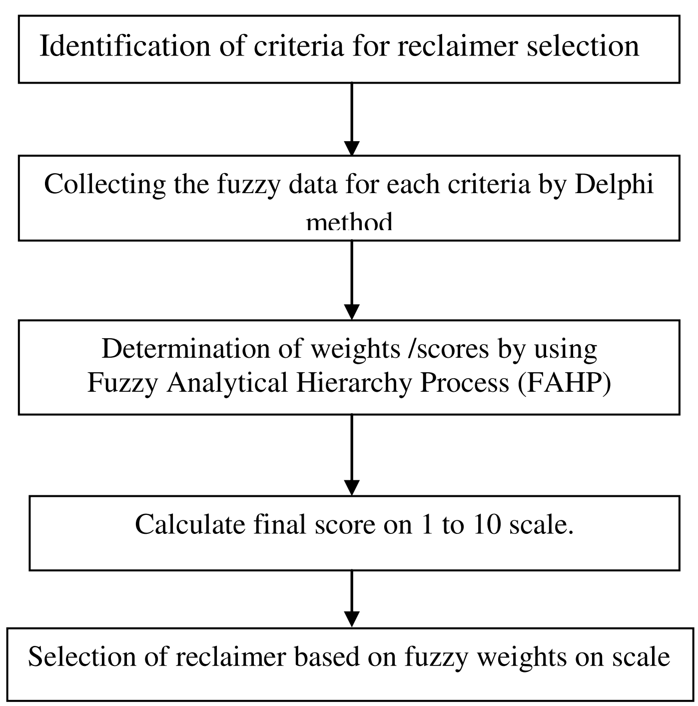
$$M_l = \frac{lw_i + mw_i + uw_i}{3} \quad (6)$$

Mi is non fuzzy number. But it needs to be normalized by following Eq.7

$$N_i = \frac{M_i}{\sum_{i=1}^{n} M_i} \quad (7)$$

4 .Methodology

The following steps are followed
Step 1: Framing the relevant criteria for reclaimer selection
Step 2: Collecting the fuzzy data for each criteria by field study.
Step 3: Comparison of data by fuzzy analytical hierarchy process method and determination of weights /scores.
Step 4: Calculate final score on 1 to 10 scale.
Step 5: Selection of reclaimer based on fuzzy weights on scale



5.Case Study

This study focuses mainly on the problem of selecting green suppliers of an oil company in Vijayawada. Four possible winners have been determined by the expert. Due to an increasing awareness of environmental issues and under pressure from customer demand, the company tends to include environmental criteria in the reclaimer selection process. Therefore, the criteria in the table have been determined based on green terms based on the observations and findings of the literature researcher.

5.1 Fuzzy AHP Method

Regarding the cost criterion, if other conditions are the same, the purchaser becomes interested in buying from those reclaimers who propose cheaper prices. In general, quality level has a reverse relation with defective items' ratio. Therefore, high quality level is equal to the low ratio of defective items. Regarding the criterion of delivery time, customers are interested in having the item when they need it (not sooner or later than this time). Delivering the item sooner results in maintenance cost and delivering the item later will be accompanied by shortage cost. Evaluating the criterion of environmental competencies includes effect of pollution generated and control techniques which consumes money and time ; but they are vital for a supplier's success. environmental competencies include pollution control techniques. Source capacity is the ability of suppliers capacity to meet the demand.

Table :1 :comparison values of criteria terms of waste oil reclaimer

	Quality	Source Capacity	Cost Charged	Delivery Terms	Environmental Competence
Quality	(1,1,1,)	(1,1,1)	(4,5,6)	(6,7,8)	4,5,6)
Source Capacity	1,1,1,	(1,1,1,)	4,5,6)	(6,7,8)	(6,7,8)
Cost	1/6,1/5,1/4	1/6,1/5,1/4	(1,1,1,)	¼,1/3,1/2	2,3,4
Delivery Terms	1/8,1/7,1/6	1/8,1/7,1/6	2,3,4	(1,1,1,)	1/6,1/5,1/4
Environmental Competence	1/6,1/5,1/4	1/8,1/7,1/6	¼,1/3,1/2	4,5,6	(1,1,1,)

After the first three steps of the methodology, in the fourth step the geometric mean of the fuzzy comparison values of each criterion is calculated. For example, $\widetilde{r_i}$ the geometric mean of the fuzzy comparison values of the "Quality" criterion is calculated.

$$\widetilde{r_i} = \left(\left[\prod_{j=1}^{n} \widetilde{d_{ij}}\right]\right)^{1/n} = [(1x1x4x6x4)^{1/5} ; (1x1x5x7x5)^{1/5} ; (1x1x6x8x6)^{1/5}]$$

$$=[2.49; 2.81; 3.10] \qquad (12)$$

.Table2 : relative fuzzy values of quality weights

Quality(fuzzy values)	2.49	2.81	3.1
Source capacity	2.7	3	3.29
Cost	0.43	0.53	0.66
Delivery Terms	0.35	0.41	0.49
Environmental Competence	0.46	0.54	0.66
Total	6.43	7.3	8.2
Inverse(1/Col Value)	0.16	0.14	0.12
Ascending Order	0.12	0.14	0.16

$$\widetilde{w_1} = [(2.49 * 0.12); (2.81 * 0.14); (3.10 * 0.16);] = [0.304; 0.385; 0.483] \qquad (13)$$

Hence the relative fuzzy weights of each criterion are given Table 5;

Table:3:fuzzy weights of all the criteria

Quality(fuzzy values)	0.304	0.385	0.483
Source capacity (fuzzy values)	0.330	0.412	0.511
Cost(fuzzy values)	0.052	00.072	0.103
Delivery Terms(fuzzy values))	0.043	0.057	0.076
Environmental Competence(fuzzy values)	0.056	0.075	0.103

the relative non fuzzy weight of each criterion (M_i) is calculated by taking the average of fuzzy numbers for each criterion.
Ex: for environmental competence m1 = (.056+.075+.103)/3 = .078
By using non fuzzy M_i ‘s, the normalize weights(N_i)of each criterion are calculated and tabulated in Table 4.
Table 4.normalised values of criteria of reclaimer

	M_i	(N_i)
Quality	0.3901	0.383
Source Capacity	0.418	0.409
Cost	0.075	00.074
Delivery Terms	0.058	0.057
Environmental Competence	0.078	0.076

Table5 :Comparison matrix of reclaimers with respect to quality criteria

	reclaimer A	reclaimer B	reclaimer C
reclaimer A	(1,1,1,)	1/6,1/5,1/4	1/9,1/9,1/9
reclaimer B	4,5,6)	(1,1,1,)	¼,1/3,1/4
reclaimer C	9,9,9	2,3,4	(1,1,1,)

Table6:fuzzy weights of reclaimers with respect to quality

	reclaimer A	reclaimer B	reclaimer C
reclaimer A	0.265	0.281	0.303
reclaimer B	1	1.186	1.442
reclaimer C	2.621	3	3.302
Total	3.885	4.47	5.047
Inverse(1/Col Value)	0.25	0. 22	0.19
Ascending Order	0.19	0.22	0.25

Table 7 : Average and normalized weights of reclaimers with respect to quality

	M	N
reclaimer A	0.064	0.063

reclaimer B	0.27	0.272
reclaimer C	0.68	0.665

Table 8. Normalized weights of reclaimers with respect to various criteria

	Quality	Source Capacity	Cost charged	Delivery terms	Environmental Competence
reclaimer A	0.063	0. 425	.629	.149	0.62
reclaimer B	0.27	0.425	.107	.784	.107
reclaimer C	0.66	0.151	.26	0.06	.263

Table 9 reclaimer wise ranks are calculated .Each reclaimer is given weight with respect to each factor. On a scale of 1 ---10.

	Reclaimer 1 (1)	Weights (2)	Product (1*2)	Reclaimer 2 (3)	Weights (4)	Product (3*4)	Reclaimer 3 (5)	Weights (6)	Product (5*6)
Quality	8	0.063	0.504	5	0.425	2.125	7	0.66	4.62
Source Capacity	5	0.425	2.125	8	0.629	5.032	6	0.151	0.96
Cost	7	0.629	4.403	6	0.107	0.642	6	0.26	1.56
Delivery Terms	7	0.149	1.043	7	0.784	5.488	5	0.06	0.3
Environmental Competence	5	0.62	3.1	6	0.107	0.642	6	0.263	1.578
Total			11.175			13.929			9.018
Normalized Weights			0.3275			0.408			0.2642

From the above table reclaimer 2 is given highest ranking

6.Conclusion ;

Many scholars and researchers have shown the advantages of green supply chain management for environment sustainability . creating a nearer and long term relation between the reclaimer and purchaser is one of the main elements of supply chain creation success to obtain competitive advantage.. Therefore, the issue of reclaimer selection is the most important issue in effectively implementing supply chain.

On the other hand, the issue of reclaimer selection in general faces imprecise and ambiguous data and using the theory of fuzzy sets in considering this kind of uncertainty seems logical.

To this end, decision making approaches such as Fuzzy Analytical Hierarchy Process were used in this research; which employed a fuzzy approach which can be considered close to real data. optimizing reclaimer parameters such as quality ,cost ,delivery etc. Sensitivity analysis demonstrates the possible variations of the priority level of the most important three criteria regarding criteria weights which can be carried out by changing weights. Further research might be investigating the integrity of other Multi Criteria Decision Making.

Another research direction might be to develop a decision support system where appropriate reclaimers and order sizes can be determined in succession.

The provider who gets the best positioning will be chosen to perform with most elevated weight with respect to each factor. On a scale of 1 ---10.

	Elevated weight	**Rank**
Reclaimer-1	0.3275	**2**
Reclaimer-2	0.408	**1**
Reclaimer-3	0.2642	**3**

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