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A study on formulation of provider quota distribution using additive fuzzy goal programming

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Abstract - The supply chain of a manufacturing organization consists of all the activities, which are required to deliver the products and services to the end clients. It includes receiving orders from clients through promotion division, procuring raw materials from merchants, manufacturing, and logistics in man-machine-material supervision, promotion, client relations and so on. The main problem arises due to the uneven selection of provider's quotas. To overcome the problem, the mathematical programming has been proposed. In the fuzzy programming model AFGP, an attempt is made to determine the provider's quota in a supply chain when various parameters of merchants are not known with certainty. The uncertainty of the fuzzy type is modelled using linear membership functions and the entire formulation is solved by fuzzy multi-objective programming approach.

Index Terms - FP, AGFP, SCM, QUOTA DISTRIBUTION

I. INTRODUCTION

Now a days the trade operations of manufacturing companies are changing vary rapidly due to competitive nature of the global marketplace thrown open by the internet and other IT tools. To compete successfully in the market, industries are always striving for a competitive edge. An appropriate assortment of providers is one of the many areas, which can provide a manufacturing firm with a competitive advantage in the process of effective supervision of a supply chain. Many other issues in the supply chain are directly or indirectly influenced by the effective supervision of merchants of a firm as they constitute an important starting strategic link of supply chain. All trades are either goods-producing or service-producing. Goods producing trades obtain inputs and raw materials from other trade entities and process them into products, which are then distributed to their clients. These clients include manufacturers, assemblers, warehouses, retailers, or end-users with each member becoming a merchant for the next chain except the end clients. The assortment of a proper source of material is the most important responsibility placed on the purchase department of an organization. "The role of an organization's purchase department is to buy the correct items, at the conformational specification, in the right quantity, for delivery at the right time to the right client"- (Monczka & Trecha, 1988). The purchasing function is one of the most critical activities of a firm as it is not restricted to simply buying material. The purchase department has to liaison between product design group and other planning teams for all parties involved in the procurement process. So the purchase department has shifted its focus from merely an administrative role to a strategic role in order to increase the competitive advantage for the organization. One such important strategic role is the proper assortment of providers, which is one of the most critical and most difficult also. However the ultimate goal of provider assortment is "to select the optimal providers for the organization".

II. LITERATURE REVIEW

Gao and Tang (2003) proposed a multi-objective linear programming model for decisions related to purchasing of raw materials in a large-scale steel plant in China. Kumar et al. (2004) used fuzzy mixed integer goal programming approach to deal with the effect of information uncertainty in the decisions involved in a PQD. A. Azadeh et.al (2010) proposed a decision making flowchart to choose from DEA, FDEA and CCDEA for selection of best supplier under certainty, uncertainty and probabilistic conditions. Ya-Ti Linet.al (2010) proposed a novel hybrid MCDM technique to cope with the complex and interactive vendor evaluation and selection problem which can determine the structural relationships and the interrelationships amongst all the evaluation's dimensions. Jiuping Xu and Fang Yan (2011) focused on the vendor selection problem (VSP) for material supply in large-scale water conservancy and hydropower construction projects, and establish a corresponding model to solve this problem. Yugang Yu et.al (2013) developed a hybrid algorithm for effectively and efficiently solving the developed model. The hybrid algorithm combines dynamic programming (DP), genetic algorithm (GA) and analytical methods.

III. AFGP (ADDITIVE FUZZY GOAL PROGRAMMING)

In this mathematical Programming / modeling approach the tools of fuzzy set theories are used in an additive manner to deal with the imprecision quantitatively. The formulated additive fuzzy goal programming model for the case study PQD problem is shown in model 4.3, where 11% fuzziness was created above and below of all 3 goal objectives. By now it is known that the goals of 3 objectives are Rs 429.9 millions, 478.5 tons and 576.75 tons. Their 11% variation values are 47.3 millions of cost, 52.635 tons of rejections and 63.44 tons late delivered items respectively. This variation causes an upper bound of 477.3 millions and lower bound of 382.7 millions on cost objective. Similar upper and lower bound values on allowable rejections for 11% variation are

531.1 and 425.8 tons respectively. The same for late delivery objective are 640.2 and 513.3 tons respectively. Using MATLAB 7.1, the membership function representation of these 3 goals is shown in figure 3.1. Finally LINDO 6.1 is used to solve model 3.1 and the results are shown in table 3.1

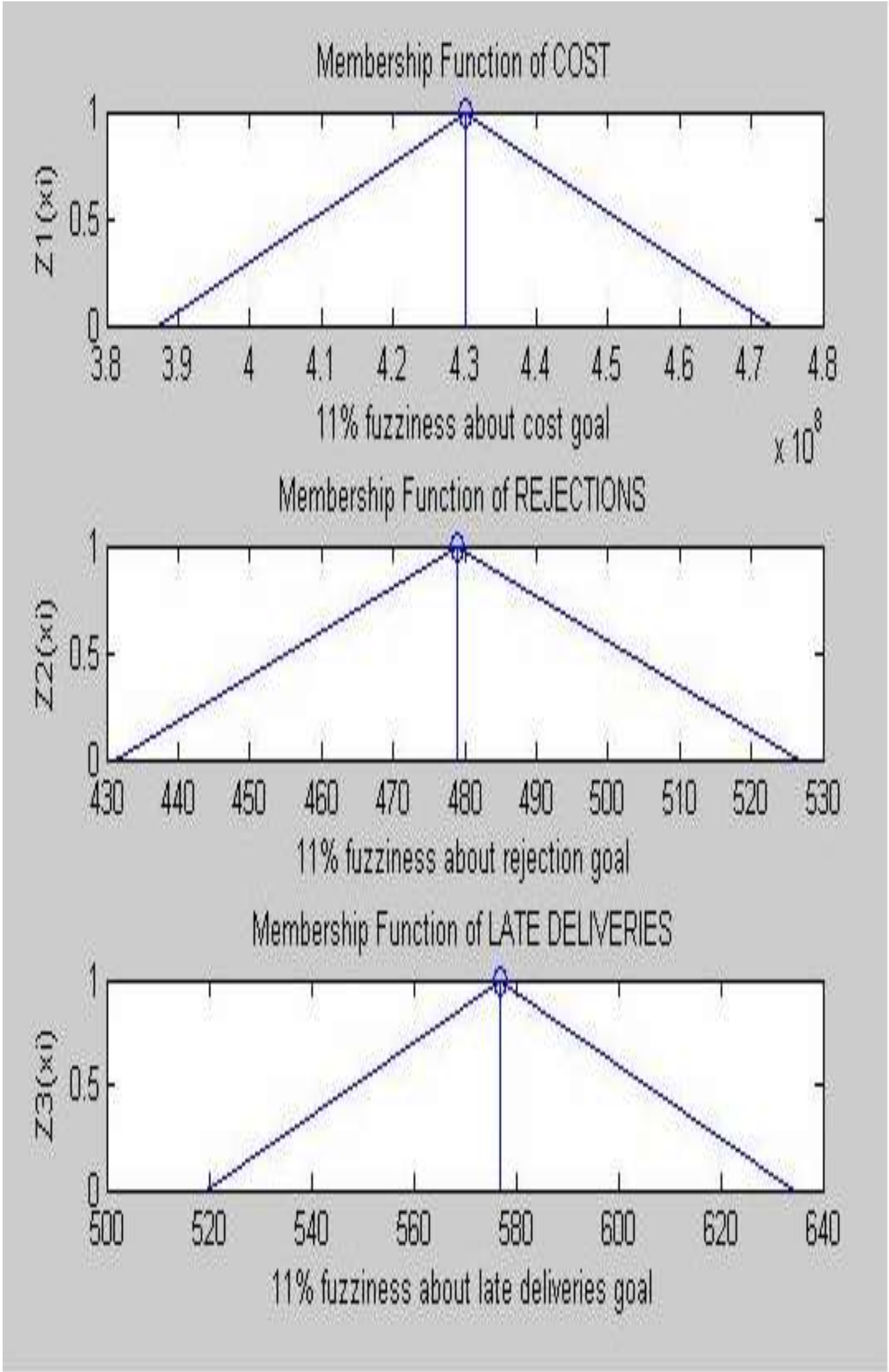

Figure 3.1

However in this AFGP model two points are worth to be noted:–

- The vagueness or fuzziness is created about three selected goals only and constraint parameters are kept fixed or deterministic, as per the requirements of the model 3.7.
- 10% or less than 10% fuzziness could not be studied because LINDO gave infeasible solutions in those cases. For feasibility the software demanded a change in fixed coefficients or parameters, which as per the theory of this model and as per the data in case study are fixed and can not be altered. However the cause of fuzziness in the parameters and their effect on upper and lower bound of objectives and hence in optimum quota distributions will be studied in

the subsequent model 4.4 dealing with Fuzzy Programming

Model 3.1: A representative AFGP formulation for case study PQD problem with 11% fuzziness about goal

MAXIMISE $\mu Z1+\mu Z2+\mu Z3$

Subject To:

$47300\mu Z1 + 40X1 + 33X2+35X3+32X4 \quad <= 477300$

$47300\mu Z1 - 40X1-33X2-35X3-32X4 \quad <= - 382700$

$52.635\mu Z2 + 0.02X1+0.08X2+0.05X3+0.10X4 \quad <= 531.135$

$52.635\mu Z2 - 0.02X1-0.08X2-0.05X3-0.10X4 \quad <= - 425.8$

$63.4425\mu Z3 + 0.050X1+0.034X2+0.089X3+0.045X4 <= 640.2$

$63.4425\mu Z3 - 0.050X1-0.034X2-0.089X3-0.045X4 \quad <= - 513.3$

$X1+X2+X3+X4 \quad = 12000$

$X1 \quad <= 6250$

$X2 \quad <= 3000$

$X3 \quad <= 5000$

$X4 \quad <= 2000$

$0.97X1+0.90X2+0.89X3+0.79X4 \quad >= 10920$

$0.04X1+0.03X2+0.08X3+0.01X4 \quad <= 600$

$40X1 \quad <= 2500000$

$33X2 \quad <= 1000000$

$35X3 \quad <= 2000000$

$32X4 \quad <= 600000$

$X1, X2, X3, X4 \quad >= 0$

$0 <= \mu Zl <= 1 \quad l = 1,2,3$

END

Table 3.1: Results of AFGP for multi-objective PQD problem

Objective	Optimum Value	11% var. Value	Solution Value	uzl	Optimum Provider Quota Distributions in tons				Sum
					S1 (X1)	S2 (X2)	S3 (X3)	S4 (X4)	
Cost Goal (Rs. Millions)	430.0	4.30	**443.95**	**0.705**					
Rejection	478.5	52.69	**524.16**	**0.133**	6250	3000	2316.89	433.11	12000

Goal									
Late Deliveries Goal	576.75	63.47	**640.19**	**0.00**					
			Overall Uz	**0.838**					

IV. RESULTS AND ANALYSIS

After the application of LINDO to model 3.1, the solution set is shown in Table3.1. The analysis of the result shows that:

- At optimal level the degree of satisfaction (uZl) for all goals is 1.0 each, which gives a total possible overall satisfaction of 3.0. However when 11% uncertainty about all the goals is created and are allowed to interact simultaneously through model 3.1, all of the objectives become over-achieved with total degree of satisfaction of 0.838 only.
- The cost objective is over-achieved by Rs 13.95 millions with 0.705 satisfaction level, the rejection objective is over-achieved by 45.66 tons with 0.133 satisfaction level and the late delivery objective is over-achieved by 63.44 tons with zero satisfaction level because it is at upper bound level of late delivery goal.
- At 11% fuzziness the optimum quota distributions are: TNPL (S1) = 6250 tons, MPI (S2) = 3000 tons, SI (S3) = 2316.89 tons and KPM (S4) = 433.11 tons. Here TNPL, the high price merchant, is getting the quota equal to his entire capacity and is responsible for increase in cost. Also MPI, the merchant poor in late delivery, is getting the quota equal to his entire capacity which led to zero satisfaction level of delivery objective. Thus the uncertainty about goal objectives causes considerable swing in quota distributions.
- In this model the decisions are being taken in an environment in which the coefficients of constraints are fixed and known with certainty beforehand, but the uncertainty or fuzziness is created in 3 goals. To study this model in detail, more fuzziness is created about three selected goals and the corresponding swing in level of satisfaction and PQDs is analyzed graphically in next step.

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