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Application of Linear Goal Programming (LGP) To Case Study Provider Quota Distribution

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Abstract : *Each node in a supply chain is a strategic link. The strong links make strong supply chains while the weak links hurt every member of the chain. There is an emerging need to focus on the performance of extended supply chain network in which the industry is a partner. The network gets strengthened with the legality and transparency in the quota distribution. As long as the quota distribution system remains unbiased the supply chain network achieves better results. In the present paper, application of linear goal programming has been investigated to analyze the authenticity of the quota distribution using LINDO software.*
Keywords: *linear goal programming, quota distribution, supply chain, LINDO Software.*

I. Introduction

According to Cox A. [1999] "The companies are instructed to construct efficient and responsive supply chains, because it will no longer be industry vs. industry but supply chain competing against supply chain". So there is an emerging need to focus on the performance of extended supply chain network in which the industry is a partner. There is a need to go beyond the traditional functional and trade performance measures and to develop new matrices with enough details and richness to handle the supply chain performance rather than the individual trade performance. Wind and Robinson (1968) first proposed the linear weighting method for merchant assortment decision as a way of rating different merchants on the performance criteria for their quota distributions. Cooper (1977) and many others have used the weighted linear method of multiple criteria for merchant assortment. Krause, Pagell&Curkovick (2001) Strategic decisions related to provider assortment for industries have traditionally been based on the four basic competitive priorities of cost, quality, dependability, and flexibility, with innovation added as a recent fifth priority. Other criteria are growing in importance in the literature, such as technological capabilities of the firm, as a result of the requirements placed on the buying and supply firms in the marketplace. The growing use of technology in the manufacturing, and operational settings makes the capability to understand and operate technological equipment a must for providers in manufacturing.Lambert, Adams &Emmelhainz (1997) The actual performance of the individual providers as compared against each criterion must be considered by buyers when selecting providers and by providers when seeking and gaining a competitive advantage. The type of purchasing situation in existence for an organization is indicative of the rankings of the criteria considered in the assortment process. Muralidharan, Anantharaman&Deshmukh (2002) From the standpoint of today's competitive business, most materials managers consider the assortment of providers as the most important decision or problem facing businesses .The added importance and acceptance of quality management techniques and JIT (just-in-time) methods by a large section of businesses, the provider assortment decision has become more important than ever. Moore and Fearon (1972) described the possible use of the linear programming (LP) but did not present the mathematical formulation. Anthony and Buffa (1977) formulated MAP as a LP problem with the single objective to minimize total purchasing and storage costs. Mehdi TolooandTijenErtay (2014) proposde a new cost efficiency data envelopment analysis (CE–DEA) approach with price uncertainty for findingthe most cost efficient unit. Potential uses are then illustrated with an application to automotive industry involving 73 vendors in Turkey. Hong and Hayya (1992) attempted the MAP as a non-linear programming problem. Ghodsypour and O'Brien (1998) developed decision support system by integrating approach of analytical hierarchy process (AHP) and linear programming (LP). In this approach they considered both tangible and intangible factors for choosing the best providers and their quota distribution. Feng et al. (2001) presented a stochastic integer programming model for simultaneous assortment of tolerances and providers based on the quality loss function and process capability index.Ghodsypour and O'Brien (2001) developed a mixed integer non-linear programming model to solve a multiple sourcing problem, which considers total cost of logistics including net price, storage, and transportation and ordering costs with constraints on budget, quality, service, etc. Kumar, Vrat, and Shankar (2002) analyzed the effect of information uncertainty in the provider quota distribution (PQD) with interval objective coefficients by using mathematical fuzzy programming approach. 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.

II. LGP (Linear Goal Programming)

In Linear Goal Programming Mathematical Modeling, the basic approach is to establish a specific numeric goal for each of the conflicting objectives, formulate an objective function for each goal and then seek a solution that minimizes the (weighted) sum of deviations of these objective functions from their respective goals. All the objectives and constraints are assumed to be of linear in nature. Instead of having a single objective, all the multiple conflicting goals are dealt with simultaneously to seek an optimum solution. According to the priority or importance given to the goals, GP is classified as no preemptive or preemptive. In no preemptive goal programming- all the goals are assumed to be of roughly comparable or equal importance. However in preemptive goal programming – there is a hierarchy of priority levels for goals, so that the goals of primary importance receive first priority attention, those of secondary importance receive second priority attention and so forth. The formulated linear goal programming model for the case study problem is shown in model 1.1, where the non-preemptive goal programming is used i.e. all the goals are given equal importance. Also the aspiration goal values of 3 objectives of net cost, net rejections and net late deliveries are taken from the solution of SOLP and LINDO is used to solve this model 1.1.

III. Linear Goal Programming Equation

Model 1.1: LGP formulation for case study PQD Problem

.	**MINIMISE** Z = DP1+DP2+DQ1+DQ2+DL1+DL2		
	Subject To:		
	40000X1+33000X2+35000X3+32000X4+DP2-DP1 = 429968700		
	0.02X1+0.08X2+0.05X3+0.10X4+DQ2-DQ1	= 478.5	
	0.05X1+0.034X2+0.089X3+0.045X4+DL2-DL1	= 576.75	
	X1 + X2 + X3 + X4	= 12000	
	X1	<= 6250	
	X2	<= 3000	
	X3	<= 5000	
	X4	<= 2000	
	0.97X1+0.90X2+0.89X3+0.79X4	>= 10920	
	0.04X1+0.03X2+0.08X3+0.01X4	<= 600	
	40X1	<= 2500000	
	33X2	<= 1000000	
	35X3	<= 2000000	
	32X4	<= 600000	
	X1, X2, X3, X4	>=0	
	DP1, DP2, DQ1, DQ2, DL1, DL2	>=0	
	END		

In the above model 1.1, the new symbols used have following meaning.

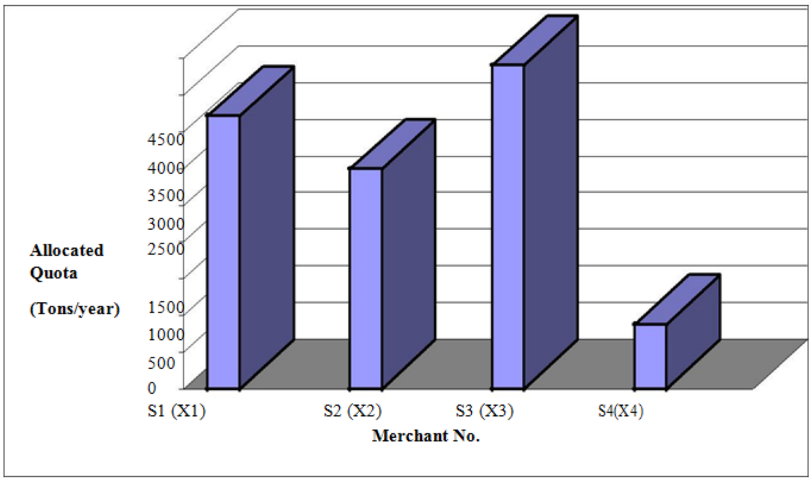
DP1 = Over-achievement of Cost objective
DP2 = Under-achievement of Cost objective
DQ1 = Over-achievement of Rejection objective
DQ2 = Under-achievement of Rejection objective
DL1 = Over-achievement of Late Delivery objective
DL2 = Under-achievement of Late Delivery objective

All the above terms represent the penalties incurred for either over or under achievement of chosen value of goal. The net objective function Z represents the summation of all these penalty points which needs to be minimized.

Table 1.1: Results of LGP for multi-objective PQD problem

GOAL	Desired Optimum		LGP Solution		Optimum provider Quota Distributions (tons)					
					S1	S2	S3	S4	Sum	
	Value		Value		(X1)	(X2)	(X3)	(X4)		
Cost Goal	429,968,700		**429,968,746**							
Rejection Goal	478.50		**622.19**		3718.75	3000	4406.25	875	12000	
Late Deliveries Goal	576.75		**719.47**							
Over /Under	**achievement of**		**Goals**							
DP1	DP2	DQ1	DQ2		DL1	DL2	Sum of	Deviations (Z)		
46.00	0.00	**143.69**	0.00		**142.72**	0.00		**332.41**		

Figure 1.1 Optimum PQD distributions with LGP



IV. Conclusion

When LINDO is applied to the model 1.1, the solution is shown in Table1.1and in figure 1.1. The deductions show that:

1. All the goals are over-achieved when they are allowed to interact simultaneously and not independently as in SOLP.
2. The cost objective is over-achieved by just Rs 46 i.e. almost achieved but the rejection objective is over-achieved by 143.69 tons and the late delivery objective is over-achieved by 142.72 tons.
3. Also the important point to note here is that, the quota distributions to 4 merchants are in almost in consistent with the present order policy by ABC LTD.. Presently the industry is ordering as (S1) = 3600 tons, (S2) = 2400 tons, (S3) = 4800tons and (S4) = 1200 tons.
4. But the decisions here are being taken under static or certain or deterministic environment in which all the parameters are fixed and known with certainty beforehand. This model does not take into account the uncertainty or fuzziness or imperfect information inherent in some of the dynamic parameters like merchant's capacities, their budget distributions etc. So the fuzziness will be discussed in next 2 models.

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