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Assessing the Effectiveness of Vendors through Goal Programming using Changing Goal Priorities: Case Study

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ABSTRACT

The vendor selection process has undergone significant changes during the past 20 years. These include increased quality guide lines, improved reliability, reduced product costs and increased technical capabilities. A supply chain selection of vendors is a multi-objective problem involving both quantitative and qualitative criteria. Over the years, a number of quantitative approaches have been applied to vendor selection problems. In this paper, a comprehensive application of Goal programming with software tool for a real situation case is presented along with changing goal priorities to the best supply chain of vendors with optimum cost. This model was solved on LINGO optimization software by utilizing the sequential goal programming solution method. A vendor selection problem has been formulated as a changing goal priorities integer goal programming. This selection problem includes seven primary goals: Minimizing the amount of units rejected, number of lots rejected, amount of units delivered late, amount of lots delivered late, and maximize the multiplication of the order quantity with the past landed cost index, multiplication of the order quantity with capacity utilization ratio, multiplication of order quantity with measure of past business. The proposed approach has the capability to handle realistic situation in changing goal environment using LINGO software tool and provide a better decision tool for selection of vendors.

Key words: *Vendor selection problem, Goal programming, Goal, LINGO.*

1. INTRODUCTION

One of the important areas of purchasing research that has significant practical implication is evaluation and selection of vendors. Several researches have addressed the strategic importance of the vendor evaluation process. These studies have mainly emphasized the impact of the selection decision of vendors on the various functional areas of business from procurement to production and delivery of the product to the end customer. Vendors having reliable supply chain are considered as the best intangible asset of any organization. Hence, both new and established vendors are coming for critical review of their plant capacity, financial condition, and performance, and particularly in today's dynamic situation. The materials executives have to follow a selective policy and choose only those vendors that are suitable to their needs [1,2]. A true measurement of an effective purchasing department is obtained by the quality of a reliable vendors selected for supplying goods and services. The purchaser's primary interest lies in getting for his company the best value of money from his vendors. This implies that he should be in a position to asses and rate their vendors performance against what is expected from an ideal supplier in the prevailing socio-political and economical environment. The absolute standard is difficult to define with any degree of exactness, but mathematical models are available to evaluate the performance of vendors [3,4].

Many companies purchase many of the items from many of the suppliers. Purchased materials account for 30-60% of sales and more than 50% of the cost of goods sold in most manufacturing firms. In today's competitive operating environment, it is impossible to successfully produce low-cost, high-quality products without satisfactory suppliers.

Selection decisions of vendors are complicated by the fact that various criteria must be considered in the decision-making process. Quality, delivery, cost, cost, capacity, and the past business are known as

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the most crucial criteria [2]. Frequently, the relevant criteria are in conflict. For example, the supplier with the lowest price may not have the best quality or delivery performance of the various suppliers under consideration. The firm must analyze the trade-offs among the relevant criteria when making a decision regarding selection of vendors. Consequently, it can be said that the assessing supply chain of vendors through goal programming, is often an inherently multiobjective one. In this paper, an integrated goal programming model is presented to solve supply chain selection of a vendor of a manufacturing company.

2. GOAL PROGRAMMING

Goal programming is a multiobjective programming technique. It can be thought of as an extension of linear programming that allows simultaneous satisfaction of several conflicting objectives while obtaining a solution that is optimal with respect to the decision maker's specification of goal priorities.

In the typical real world situation, goals set by the decision maker are achievable only at the expense of other goals, which are often incompatible. Since it may be impossible for a decision maker to meet all of the decided goals, he/she attempts to find a solution that comes as close as possible to reaching all goals. In cardinal ranking cases, important parameters or weights are assigned to the given goals. Then, all of them are expressed in a composite objective function; the problem is solved as a single-objective problem. The most intuitive and simplest way for normalizing the goals are to express them in percentages rather than in absolute values [2]. In this approach, the most important goal which is in priority level one is satisfied using the standard linear programming, after that the second priority level is considered, then the third and so on.

3. CASE STUDY DESCRIPTION

The study has been conducted in an electronic company, which produces more than 20 varieties of products. The company manages all of the business operations using SAP R/3, which is an enterprise resource planning system. The company requires many kinds of material and finished components at large amounts. There are lots of suppliers that they are willing to supply such an organization. That is to say for a specific item, many different suppliers being alternative to each other are available from abroad, and domestic markets. From this point of view, it can be pointed out that management and evaluation of all these suppliers is a very hard, complex, and comprehensive duty. This study considers one final product which requires four items such as raw materials or finished products and each item being supplied by four different vendors. This study focuses on the evaluation of vendors.

The company wants to purchase 100,000 units of each of five different items to make a final product. The capacity limitations of different vendors are as follows.
Vendor-3 can supply item no 4 <45,000 units
Vendor-4 can supply item no 2 <30,000 units
Vendor-4 can supply item no 1 >600,000 units
Vendor-2, Vendor-3, Vendor-4 together can supply item no 4 of 1,00,000 units.

Each of the vendor can supply a total of 1,00,000 units of all four variety of parts put together.

To have an effective vendor evaluation and selection system. Company's most important goal is to establish a vendor evaluation system based on tangible criteria, and thus, they want to use the outputs of this system for supplier selection and order allocation decisions. The company desires to determine the best suppliers for each material and allocate orders among them in the present requirements and constraints.

4. THE PROPOSED APPROACH

This study shows an application of the goal programming to solve a multiitem multiple sourcing vendor selection problems. Such a model can be useful for future order allocation decisions while benefiting from the past performance data. The integrated model includes two basic objectives in a preemptive structure to address these considerations: Quality, delivery, cost, capacity, and the amount of the past business. The methodology used in this study comprises modeling and solution phases, sequentially. Therefore, the steps of the methodology are summarized as follows:

4.1. Define Vendor Selection Criteria

To determine the preferences of the company about the supplier selection criteria, three meetings were organized with the participation of the purchasing specialists. According to these meetings, seven important criteria were defined to address quality, delivery, cost, capacity, and the past business considerations. The main and subcriteria are shown in Table 1.

Table 1: Company's vendor supply chain supplier selection criteria.

Main criteria	Sub criteria
Quality	Percentage of units rejected (POUR)
	Percentage of lots rejected (POLR)
Delivery	Percentage of units delivered late (POUDL)
	Percentage of lots delivered late (POLDL)
Cost	Past landed cost index (PLCI)
Capacity	Capacity utilization ratio (CUR)
Past business	Measure past business (MOPB)

4.2. Data Collection

To collect necessary data, "ABC" analysis was performed to determine the materials that are going to be included in the model. The reason for use this analysis is that these selected materials, which generate a large majority of the material costs, make the largest impact on the company's overall purchasing performance. After doing this analysis, the class "A" materials was chosen to be focused in the model. The data required to construct the model has been collected from all the four vendors and are shown in Tables 2-5, respectively.

The data collected earlier are used to calculate the performance measures as per the following formulas are shown in Table 6.

4.3. Performance Measures

$$\text{POUR} = \frac{\text{Units rejected}}{\text{Units received}}$$

$$\text{POLR} = \frac{\text{Lots rejected}}{\text{Lots received}}$$

Table 2: Vendor-1.

Details	Item-1	Item-2	Item-3	Item-4
Number of units received	10800	21950	10920	21890
Number of lots received	20	25	23	26
Number of units delivered late	302	507	253	652
Number of lots delivered late	0	1	0	0
Number of units rejected	210	360	184	168
Number of lots rejected	0	0	0	0
Minimum past landed cost (Rs)	113	171	146	205
Average past landed cost	117	175	148	221
Yearly capacity	15000	30000	15000	30000

Table 3: Vendor-2.

Details	Item-1	Item-2	Item-3	Item-4
Number of units received	10905	20916	10870	21930
Number of lots received	29	28	24	25
Number of units delivered late	500	700	207	456
Number of lots delivered late	0	0	0	1
Number of units rejected	135	198	129	213
Number of lots rejected	0	1	0	0
Minimum past landed cost (Rs)	113	169	146	205
Average past landed cost	119	182	149	228
Yearly capacity	15000	30000	15000	30000

Table 4: Vendor-3.

Details	Item-1	Item-2	Item-3	Item-4
Number of units received	10900	21807	10876	21790
Number of lots received	24	24	24	25
Number of units delivered late	505	832	360	418
Number of lots delivered late	1	1	0	1
Number of units rejected	164	217	345	377
Number of lots rejected	0	1	1	1
Minimum past landed cost (Rs)	112	171	146	205
Average past landed cost	115	180	152	221
Yearly capacity	15000	30000	15000	30000

Table 5: Vendor-4.

Details	Item-1	Item-2	Item-3	Item-4
Number of units received	10704	21904	10732	21594
Number of lots received	24	24	25	24
Number of units delivered late	206	1010	169	351
Number of lots delivered late	0	0	1	1
Number of units rejected	135	485	164	156
Number of lots rejected	0	1	1	0
Minimum past landed cost (Rs)	115	171	146	205
Average past landed cost	121	183	155	224
Yearly capacity	15000	30000	15000	30000
Total received from all Suppliers	43309	86577	43398	87204

Table 6: Calculated performance measures of vendors.

Vendor	POUR	POLR	POUDL	POLDL	PLCI	CUR	MOPB
Vendor-1							
Item-1	0.0194	0.0000	0.0280	0.0000	0.9658	0.7200	0.2494
Item-2	0.0164	0.0000	0.0231	0.0400	0.9771	0.7317	0.2535
Item-3	0.0168	0.0000	0.0232	0.0000	0.9865	0.7280	0.2516
Item-4	0.0077	0.0000	0.0298	0.0000	1.0000	0.7297	0.2510
Vendor-2							
Item-1	0.0124	0.0000	0.0459	0.0000	0.9496	0.7270	0.2518
Item-2	0.0095	0.0357	0.0335	0.0000	0.9286	0.6972	0.2416
Item-3	0.0119	0.0000	0.0190	0.0000	0.9799	0.7247	0.2505
Item-4	0.0097	0.0000	0.0208	0.0400	0.8991	0.7310	0.2515
Vendor-3							
Item-1	0.0150	0.0000	0.0463	0.0417	0.9739	0.7267	0.2517
Item-2	0.0100	0.0417	0.0382	0.0417	0.9500	0.7269	0.2519
Item-3	0.0317	0.0417	0.0331	0.0000	0.9605	0.7251	0.2506
Item-4	0.0173	0.0400	0.0192	0.0400	0.9276	0.7263	0.2499
Vendor-4							
Item-1	0.013	0.000	0.019	0.000	0.950	0.714	0.247
Item-2	0.022	0.042	0.046	0.000	0.934	0.730	0.253
Item-3	0.015	0.040	0.016	0.040	0.942	0.715	0.247
Item-4	0.007	0.000	0.016	0.042	1.323	0.720	0.248

POUR=Percentage of units rejected, POLR=Percentage of lots rejected, POUDL=Percentage of units delivered late, POLDL=Percentage of lots delivered late, PLCI=Past landed cost index, CUR=Capacity utilization ratio, MOPB=Measure past business

$$\text{POUDL}=\frac{\text{Units delivered late}}{\text{Units received}}$$

$$\text{POLDL}=\frac{\text{Lots delivered late}}{\text{Lots received}}$$

$$\text{PLCI}=\frac{\text{Min. past landed cost}}{\text{Avg. past landed cost}}$$

$$\text{CUR}=\frac{\text{Units received}}{\text{Yearly capacity of the supplier}}$$

$$\text{MOPB}=\frac{\text{Units received from the relevant supplier}}{\text{Total quantity received from all suppliers}}$$

4.4. Assumptions

The assumptions made in mathematical modeling of the problem are as follows:

- The planning period is 3-month.
- The material requirements and average monthly capacities of the suppliers are constant during the planning period.
- It is assumed that the early deliveries do not affect the landed costs.
- There is no budget constraint to obtain the orders.

qo_{ij} = j^{th} item will be supplied by i^{th} vendor.

4.5. Formulation of the Goals

The first objective function aims to minimize sub goal-1. The subgoals were formulated as soft constraints in the model as shown below were percentages; there is no need for normalization of the goals. The subgoals were formulated as soft constraints in the model as shown below:

Subgoal-1: Minimize the amount of units rejected.
Subgoal-2: Minimize the number of lots rejected.
Subgoal-3: Minimize the amount of units delivered late.
Subgoal-4: Minimize the amount of lots delivered late.
Subgoal-5: Maximize the multiplication of the order quantity and the past landed cost index.
Subgoal-6: Maximize the multiplication of the order quantity and the capacity utilization ratio.
Subgoal-7: Maximize the multiplication of the order quantity and the measure of past business.

4.6. Formulation of the Constraints

The sum of the assigned order quantities to the selected suppliers should not be less than the required quantity by the company.

$$qo11 + qo21 + qo41 = 100000 \quad (1)$$

$$qo12 + qo22 + qo32 + qo42 = 100000 \quad (2)$$

$$qo13 + qo23 + qo33 + qo43 = 100000 \quad (3)$$

$$qo14 + qo24 + qo34 + qo44 = 100000 \quad (4)$$

$$qo24 + qo34 + qo44 = 100000 \quad (5)$$

$$qo42 \leq 30000 \quad (6)$$

$$qo34 \leq 45000 \quad (7)$$

$$qo41 \leq 60000 \quad (8)$$

4.7. Solution of the Model

In this paper, the Industrial LINGO software was used to solve model. LINGO is known as a mathematical programming language and allows users to solve linear and also nonlinear models. The sequential goal programming solution method was utilized in this software to get the optimum results for different priority sets of goals.

Initially in multiobjective goal programming to find solution for priority set-1. Consider goal-1 and given set of constraints, objective value is found using LINGO software.

Then, consider goal-2 as next objective function with given set of constraint and goal-1 objective function is also incorporated as additional constraint and objective function value is found. Like this considering the final

Table 7: Results of goal programming.

Vendor	Quantity ordered	Goal priority-1	Goal priority-2	Goal priority-3	Goal priority-4
1	QO11	0	40000	40000	0
	QO12	0	100000	100000	0
	QO13	0	0	0	0
	QP14	0	0	0	0
2	QO21	100000	0	0	100000
	QO22	100000	0	0	100000
	QO23	100000	0	0	100000
	QO24	0	0	0	100000
3	QO31	0	0	0	
	QO32	0	0	0	
	QO33	0	0	0	
	QO34		0	0	
4	QO41	0	60000	60000	0
	QO42	0	00	0	0
	QO43	0	100000	100000	0
	QO44	0	100000	100000	

goal as objective function and including all earlier goals as additional constraint with the initial set of constraints, we compute final objective value which becomes the solution for the priority set-1. Similarly, we compute the solution for different goal priority sets and solutions is given in Table 7.

4.8. Result

For each of the priority set of goals, the resulting optimum order quantities assigned to each vendor are calculated using the method of goal programming (Table 8).

5. CONCLUSIONS

A goal programming method was developed for vendor selection of a manufacturing company. The described model determines the best vendor for each material and also simultaneously allocates purchase orders among them with consideration of conflicting objectives. It is observed that when company follows goal Priority-1, order has to be placed only on Vendor-2. When the company implements either goal Priority-2 or goal Priority-3, order has to be placed both on Vendor-1 and Vendor-4. Finally, when the company adopts goal Priority-4, order has to be placed on Vendor-2. Hence, the management of company can choose appropriate vendors. The performance measures or criteria used to evaluate vendor's supply chain are tangible, and calculated according to the proper formulations developed in the modeling phase.

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***Bibliographical Sketch**

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