Modeling Multi-Objective, Multi-Product and Multi-Period Supplier Selection Problem Considering Stochastic Demand

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Abstract: In this paper, a multi-objective, multi-period and multi-product mixed integer programming model for the supplier selection and quota allocation problem under an all-unit quantity discount policy, constrained storage space and stochastic demand is considered. Also, due to the stochastic status of the demand, we use the Chance Constrained Programming (CCP) in order to transform the inventory balance equation to a stochastic position. Since the discount policy encourages the buyer to buy more while the storage capacity restricts, we require to consider both in the supplier selection and quota allocation problem; furthermore, different priorities for the objectives should be considered. We use the LP-metric method, goal programming and the novel solution technique called multi-choice goal programming in order to model the multi-objective problem. Furthermore, a numerical example using three modeling approaches, considering the different scenarios are solved. The differences in the scenarios are the importance of the objective function in terms of the decision maker. Results show if an objective function is prioritized, that objective will be closer to its optimal value.

Keywords: Supply Chain, Supplier Selection, All-unit Discount, Stochastic Demand, Multi-choice Goal Programming

Introduction: The evaluation and selection of suppliers is one of the interesting topics for many researchers. Esfandiari and Seifbarghy (2013) classified the research in the field of evaluation and supplier selection as follows:

- The first class: mathematical programming models considering the cost objective function
- The second class: mathematical programming programming considering two objective functions including minimizing cost and maximizing utility function.
- The third class: mathematical programming considering at least three objective functions including minimizing cost, return items and delay in delivering products.
- The forth class: phase models that deal with phase and vague data input such as demand and capacity.
- The fifth class: models that consider different types of discount
- The sixth class: models that considering the uncertainties of demand, capacity and ... .

The contributions of this paper are as follows:

- Considering multi-period and multi-objective programming model for supplier selection and quota allocation problem under an all-unit quantity discount policy, constrained storage space and stochastic demand
- Considering different multi-objective modeling techniques in the field of supplier selection

Using the Chance Constrained Programming (CCP) in order to transform the inventory balance equation to a stochastic position.

Materials and Methods: In this paper, a multi-objective, multi-period and multi-product mixed integer programming model for the supplier selection and quota allocation problem under an all-unit quantity discount policy, constrained storage space and stochastic demand is proposed. The Chance Constrained Programming (CCP) in order to transform the inventory balance equation to a stochastic position is used. The assumptions of this paper are as follows: the demand for each product has a normal distribution with specific mean and variance. Inventory holding and shortage costs of each

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unit product are independent of the price. The number of planning periods is distinct and limited. Suppliers offer all-unit quantity discount policy. The initial inventory level is zero. The remaining inventory of each period is transferable to subsequent periods. The load unit of each product is considered to be 1. The mathematical model of this paper is as follows:

$$MinZ_1 = \sum_{t=1}^{T}\sum_{j=1}^{P}\sum_{i=1}^{n}\sum_{k=1}^{A_{jit}} C_{ijkt} \times q_{ijkt} + \sum_{t=1}^{T}\sum_{j=1}^{P}\sum_{i=1}^{n}\sum_{k=1}^{A_{jit}} O_{jt} \times Y_{ijkt} + \sum_{t=1}^{T}\sum_{j=1}^{P} h_{jt} \times I_{jt} + \sum_{t=1}^{T}\sum_{j=1}^{P} \pi_{jt} \times S_{jt} \tag{1}$$

$$MinZ_2 = \sum_{t=1}^{T}\sum_{j=1}^{P}\sum_{i=1}^{n}\sum_{k=1}^{A_{jit}} d_{ji} \times q_{ijkt} \tag{2}$$

$$MinZ_3 = \sum_{t=1}^{T}\sum_{j=1}^{P}\sum_{i=1}^{n}\sum_{k=1}^{A_{jit}} H_{ji} \times q_{ijkt} \tag{3}$$

$$\sum_{j=1}^{P} I_{j(t-1)} + \sum_{j=1}^{P}\sum_{i=1}^{n}\sum_{k=1}^{A_{jit}} q_{ijkt}) \le CAP \quad \forall t \tag{4}$$

$$q_{ijkt} \le U^{*}_{ijkt} \times Y_{ijkt} \qquad \forall j,i,k,t \tag{5}$$

$$q_{ijkt} \ge U_{ij(k-1)t} \times Y_{ij(k-1)t} \quad \forall j,i,k,t \tag{6}$$

$$\sum_{k=1}^{A_{jit}} Y_{ijkt} \le 1 \qquad \forall j,i,t \tag{7}$$

$$P\left(\frac{\underline{I} - I_{j(t-1)} + S_{j(t-1)} - \sum_{k=1}^{A_{jit}}\sum_{i=1}^{n} q_{ijkt} - \mu_{it}}{\sigma_{jt}} \le \frac{D_{jt} - \mu_{it}}{\sigma_{jt}} \le \frac{\bar{I} - I_{j(t-1)} + S_{j(t-1)} - \sum_{k=1}^{A_{jit}}\sum_{i=1}^{n} q_{ijkt} - \mu_{it}}{\sigma_{jt}}\right) \ge \alpha \tag{8}$$

$$Y_{ijkt} \in \{0,1\} \qquad \forall j,i,k,t \tag{9}$$

$$I_{jt}, S_{jt}, q_{ijkt} \ge 0 \qquad \forall i,j,k,t \tag{10}$$

The objective function (1) minimizes costs. The first sentence is buying cost, the second sentence is ordering cost, the third sentence is holding cost and the forth sentence is shortage cost. The objective function (2) minimizes the average amount of returned products. The objective function (3) minimizes the average late delivery of products. Constraint (4) shows the warehouse capacity. Constraint (5), (6) and (7) are related to all-unit discount. Constraint (8) shows inventory balance equilibrium and constraint (9) and (10) show the variables of the model.
In this paper, three techniques including LP- metric, goal programming and multi-choice goal programming for modeling are used.

Results and Discussion: To solve numerical example using LP- metric, goal programming and multi-choice goal programming, different scenarios are considered. The difference in scenarios was determined in the importance of objective functions from decision makers' point of view. The results showed that the LP-metric method is not an appropriate method for solving multi-objective problems. Also, the results showed that if the importance of an objective function is increased from decision maker point of view, that objective function is improved and other function get worse.

Conclusion: In this paper, a multi-objective, multi-period and multi-product mixed integer programming model for the supplier selection and quota allocation problem under an all-unit quantity discount policy, constrained storage space and stochastic demand were considered. The objective of this model is to minimize the costs, the returns and the delays. Also, due to the stochastic status of the demand, the Chance Constrained Programming (CCP) was used in order to transform the inventory balance equation to a stochastic position. Also, the three methods of LP-metric, goal programming and multi-choice goal programming were used. The results showed that if the importance of an objective function is increased from the decision maker's point of view, that objective function improves and other functions get worse.

References

Seifbarghy, M., & Esfandiari, N. (2011). "Modeling and solving a multi-objective supplier quota allocation problem considering transaction costs". *Journal of Intelligent Manufacturing*, 24(1), 201-209.

Esfandiari, N., & Seifbarghy, M. (2013). "Modeling a stochastic multi-objective supplier quota allocation problem with price dependent ordering". *Applied Mathematical Modelling*, 37(8), 5790-580.

Razmi, J., & Maghool, E. (2009). "Multi-item supplier selection and lot-sizing planning under multiple price discounts using augmented ε-constrained and Tchebycheff method". *International Journal of Advanced Manufacturing Technology*, 49(1-4), 379-392.