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A Goal Programming Model for Joint Decision Making of Order Allocation, Supplier Selection, and Carrier Selection Considering Corporate Social Responsibility

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Abstract: Every company aims to maximize its profit to survive and maintain business growth. However, it has to allocate some of the profit to the community development in the form of corporate social responsibility. Along with the importance of the development of Corporate Social Responsibility (CSR), many companies consider the social effects of their supply chain activities. In this paper, we address a problem determining the optimal order allocation, carrier selection, and the amount of CSR in a single product, multi-suppliers, and multiple periods environment. A goal programming model was developed to solve the problem by considering all-unit quantity discounts, the lateness of deliveries, and rejections. LINGO 18.0 was used to solve the model. The results of optimization show that all the goals are achieved. Based on the sensitivity analysis results, the proposed model is relatively insensitive to the goals of the profit and social value unless at the increases of 24% of both goals. For the goals of defect items and late delivery items, both goals affect the objective function when each goal is decreased. Hence, the decision-maker has to be careful in setting the goals.

Keywords: Goal programming, corporate social responsibility, discount, order allocation.

Introduction

Every company has to develop strategies to increase profit to survive and maintain business growth. Along with the development of globalization, the interdependency relations among supply chain parties have become more critical. In making supply chain decisions, the company has to consider some risks due to the uncertainty of an event that will affect the achievement of the company's business goals [1]. One of the strategic decisions in the supply chain is the supplier selection and order allocation (SSOA) problems, in which many companies procure raw materials from several suppliers [2]. The SSOA has become one of the critical factors in supply chain management [3]. In supplier selection, decision making for selecting sustainable supplier is crucial [4]. In addition to supplier selection, another crucial decision following the supplier selection is to determining the allocation of orders and selecting carriers for deliveries.

Besides the profit aspect, some companies consider the social effects of their supply chain activities [5]. Inappropriate Corporate Social Responsibility (CSR) may cause several adverse reactions from several parties, such as human rights groups, consumers, employees, organizations, and governments. The reactions can be in the form of a boycott of a company's product, decreasing the company's income [6]. Hence, companies have to put social investment by investing some of their profits in community development. This investment will increase the consumer's loyalty and the company's image, which eventually will increase consumer demand and increase the profit of the company [7].

Supplier selection is a crucial problem to solve because it can reduce costs and increase the company's competitive level [8]. Supplier selection is also one of the strategies to determine qualified suppliers at the right price, in the correct quantity, and at the right time [9, 10]. The supplier selection process begins with determining the candidates, followed by determining the criteria for the selection. After selecting the suitable suppliers, the company should determine the order allocation to each selected supplier. One of the essential aspects to consider in order allocation is intended to determine the raw material inventory under some circumstances to minimize the inventory costs.

Choudhary and Shankar [10] proposed a mathematical model with three-goal programming (GP) approaches: preemptive GP, non-preemptive GP, and weighted min-max fuzzy GP. The model considered the storage and production capacities. The suppliers also offer quantity discounts with certain price breaks. The model was developed based on their previous research [11]. Yaghin and Sarlak [7] developed a mathematical model using Fuzzy Multi-Choice Goal Programming (FMCGP).

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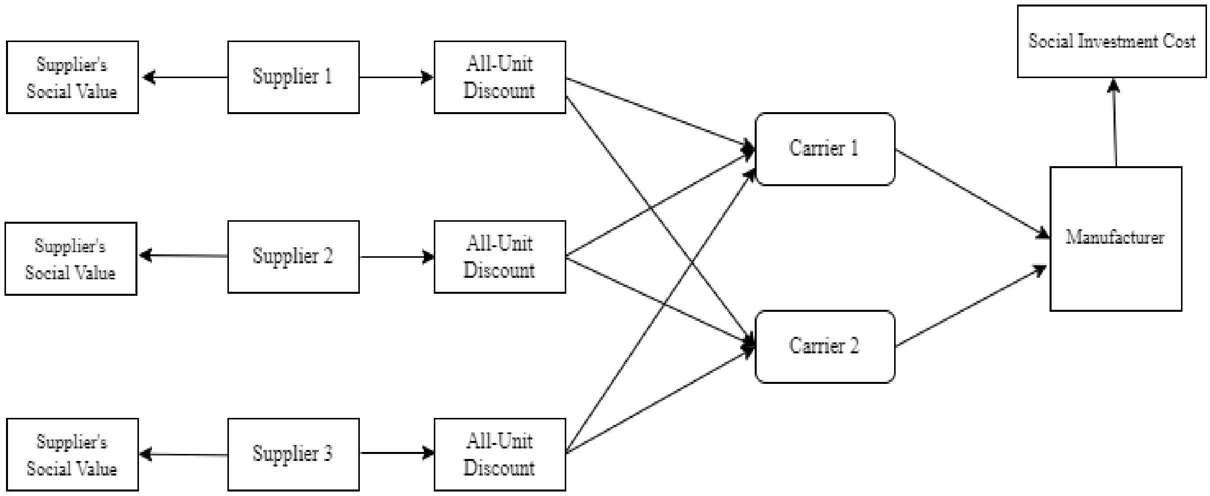

Figure 1. The system under consideration

They applied the triple-bottom-line (TBL) concept known as sustainability aspects. TBL simultaneously considers three aspects of decision-making: economics, environment, and social aspects. The model aims to solve some supplier selection, order allocation, and integrated transporttation planning problems by considering the CSR in a multi-product, multi-supplier, and multi-period environment.

In this research, a pre-emptive goal programming model is developed based on the models in [7] and [11]. The model in [7] considered the quantity discount social investment on both the supplier and manufacturer sides. One of the model objectives is to determine the number of vehicles. The model in [11] aims to determine the optimal lot size by considering the alternative carriers and quantity discounts. Hence, the novelty and contribution of this research are two-fold. First, we added the carriers selection problem in the model instead of only determining the number of vehicles as in [7]. Second, we considered lot-sizing decisions based on the quantity discounts commonly found in the actual system. The social investment for the supplier is predetermined and represents the social contribution of the supplier to its community. The supplier's social value will determine the number of orders from the manufacturer. The social investment for the manufacturer will have a direct impact on the demand. The higher the social investment, the higher the demand for products demand. Hence, the contribution of this research is the inclusion of quantity discounts and social investment on both supplier and manufacturer sides in the decision-making of SSOA. The model aims to minimize the total deviation of several goals of profits, defective products, late arrivals, and supplier social value. The model's decision variables include the supplier and the order allocation and carrier selection, social investment costs, and the inventory level.

Methods

System Description

This research addresses integrated decision-making of supplier selection, order allocation, and carrier selection in a single product, multi-supplier, and multi-period environment. Each supplier has a limited production capacity and a different product's unit price. Each supplier has a different social value which represents their social investment. In addition, each supplier offers all-unit quantity discounts to attract the manufacturer of procuring the product and has social value. The social value represents the contribution of each supplier to society. The higher the social value, the more allocation will be received by the supplier from the manufacturer. A particular size of a carrier can ship the product lot up to its full truckload (FTL) capacity. The transportation cost will be different for each carrier. The manufacturer must select one or more suppliers and carriers and determine procurement timings and lot sizes in consecutive periods. The total procurement from the selected suppliers should satisfy the demand considering rejections and late deliveries and allowing shortages with backlogging while at the same time minimizing net rejected items, net costs, and net late delivered items. Furthermore, the manufacturer tends to determine the order quantities over the multi-period planning horizon. The manufacturer invests some profit in social activities to increase customer loyalty and demand. Figure. 1 depicts the system under consideration.

Model Development

Assumptions

The following assumptions are used in this research:
1 The inventory level at the beginning of the period is assumed to be zero

2 In some certain periods, shortages and backlog are allowed
3 No shortage at the end of the period.
4 The CSR investment impact on the demand was taken from [7] through $g(\varepsilon_t) = a_t\ (1 - 1/(0{,}5\ \varepsilon_t + 1)$, which means that the higher the investment, the higher the demand.

Notations

Indices:

l : index for supplier ($l = 1, 2, \ldots, L$)
m : index for price break level ($m = 1, 2, \ldots, M$)
t : index for period ($t = 1, 2, \ldots, T$)
j : index for carrier ($j = 1, 2, \ldots, J$)
n : index for the goals (n=1,2, …, N)

Objective function variables:

d_1^+ : Surplus deviation as the difference between the goal achievement and target of the defect items
d_2^- : Negative deviation as the difference between the goal achievement and target of the total profit
d_3^+ : Surplus deviation as the difference between the goal achievement and target of the late delivered items
d_4^- : Negative deviation as the difference between the goal achievement and target of the total profit

Decision variables:

X_{lmtj} : Quantity of order that buyer procures from supplier l at the price break level m in period t using carrier j (unit)
ε_t : Social investment cost in period t ($)
Z_{lt} : Binary variable indicating whether supplier l gets order or not in period t
U_{lmtj} : Binary variable indicating whether carrier j is selected or not for transporting the order from supplier l at the price break level m in period t
Y_{lmtj} : Binary variable used in separating price break level m for a product in a transaction between buyer and supplier l in period t using carrier j
Ys_t : Binary variable, 1 if the shortage occurs at period t, 0 otherwise.
Yh_t : Binary variable, 1 if an item is stored in the inventory at period t, 0 otherwise

Parameters:

a_t : Positive parameter for indicating demand increase because of the social activity at period t
D_t : Buyer's demand of the product in period t.
P_n : Preemptive priority factors of the n-th goal
N_{lmt} : Cost of procuring one unit of product from supplier l at price break level m in period t
B_{lmt} : Quantity at which all-unit price break m occur at supplier l in period t
O_{lt} : Cost of ordering to supplier l in period t
T_{ltj} : Buyer's transportation cost from supplier l in period t for carrier j
Q_{lmt} : Percentage of rejected items delivered by supplier l at price break level m in period t
LD_{lmt} : Percentage of late delivered items by supplier l at price break level m in period t
C_{lt} : Capacity of supplier l in period t
Ω_{tj} : Full truck load (FTL) carrying capacity of carrier j in period t
V_{tj} : Total numbers of carrier j that are available in period t
h_t : Buyer's unit inventory holding cost of the product in period t
W_t : Buyer's storage capacity in period t
θ_t : Buyer's service-level in period t where (1 - θ_t) is the proportion of end user demand that are not met and backordered for buyer in period t
I_t^+ : Intermediate variable indicates inventory level in period t
I_t^- : Intermediate variable indicates the amount of the backorder in period t
I_b : Inventory level in the beginning of period (assumed to be 0) (unit)
I_s : Backorder level in the beginning of period (assumed to be 0) (unit)
Sp_{lt} : Social purchasing value of Supplier l in period t
M : Positive big number (assumed to be 1000000)
S : Positive small number (assumed to be 0.00001)
NR : Net rejected value goal
NP : Net profit goal
ND : Net delivery items goal
SS : Social value goal

Model Formulation

Objective Function

The objective function of the model is to minimize total deviation of the goals from the targets as formulated in Equation (1). In Equation (1), P_1, P_2, P_3, and P_4 denote preemptive priority factors of defect rate, profit, late delivered items, and supplier social value respectively. While d_1^+, d_2^-, d_3^+, d_4^4 respectively denote the deviation of the achievement from the target of defect rate, profit, late delivered items, and supplier social value.

$$Min\ Z = P_1 \times d_1^+ + P_2 \times d_2^- + P_3 \times d_3^+ + P_4 \times d_4^- \quad (1)$$

Constraints Formulation

The first set of constraints is used to determine the deviation of each goal as shown in Equations (2)-(5) respectively for defect rate, profit, late delivered items, and supplier social value. In Equation (3), IC, PC, TC, OC, and HC denote social investment cost, procurement cost, transportation cost, ordering cost, and holding cost respectively.

$$\sum_l \sum_m \sum_t \sum_j X_{lmtj} \times Q_{lmt} + d_1^- - d_1^+ = NR \quad (2)$$

$$\left(\sum_t N_t \times \left(D_t + a_t\left(1 - \frac{1}{0{,}5\varepsilon_t - 1}\right)\right)\right) - IC - PC - TC - OC - HC + d_2^- - d_2^+ = NP \quad (3)$$

$$\sum_l \sum_m \sum_t \sum_j X_{lmtjk} \times LD_{lmt} + d_3^- - d_3^+ = ND \quad (4)$$

$$\sum_l \sum_m \sum_t \sum_j X_{lmtj} \times Sp_{lt} + d_4^- - d_4^+ \geq SS \quad (5)$$

Equation (6) is needed to determine the product demand which depends on the manufacturer social investment. This Equation is derived from [12].

$$g(\varepsilon_t) = a_t\,(1 - 1/(0{,}5\,\varepsilon_t + 1) \quad (6)$$

Equations (7)-(11) are required to calculate all the cost in Equation (3) which comprises of social investment cost, procuring cost, transportation cost, ordering cost, and holding cost respectively. The first three costs depend on the decision variable of the number of purchased item, while the rest two equations depend on the decision variable of selected supplier and inventory level.

$$IC = \sum_l \sum_m \sum_t \sum_j \varepsilon_t \times X_{lmtj} \quad (7)$$

$$PC = \sum_l \sum_m \sum_t \sum_j N_{lmt} \times X_{lmtj} \quad (8)$$

$$TC = \sum_l \sum_m \sum_t \sum_j T_{ltj} \times X_{lmtj} \quad (9)$$

$$OC = \sum_l \sum_t Z_{lt} \times O_{lt} \quad (10)$$

$$HC = \sum_t h_t \times I_t^+ , \forall t \quad (11)$$

Equation (12) expresses the inventory balance between inventory level of the previous period and the current period which takes into account the quantity order, late delivered items from the previous period and the current period, defective items, shortage level at the previous and current period, and demand. Equation (13) expresses the allowable shortage and ensure that the total demand for the entire planning horizon should be met. Equation (14) ensures the order quantity does not exceed the total demand.

$$I^+_{t-1} + I^-_{t-1} + \sum_l \sum_m \sum_j X_{lmtj} + \sum_l \sum_m \sum_j l_{lm(t-1)} \times X_{lm(t-1)j} - \sum_l \sum_m \sum_j l_{lmt} \times X_{lmtj} - \sum_l \sum_m \sum_j q_{imt} \times X_{lmtj} - I^+_t - I^-_t = D_t + a_t\left(1 - 1/(0.5\varepsilon_t + 1)\right), \forall t \quad (12)$$

$$I_b + I_s + + \sum_l \sum_m \sum_t \sum_j X_{lmtj} - \sum_l \sum_m \sum_t \sum_j l_{lmt} \times X_{lmtj} - \sum_l \sum_m \sum_t \sum_j q_{lmt} \times X_{lmtj} = \sum_t D_t + a_t\,(1 - 1/(0{,}5\,\varepsilon t + 1)) \quad (13)$$

$$X_{imtj} \leq \left(\sum_{k=t}^{T} D_k\right) \times Z_{lt} \quad (14)$$

Equation (15) indicates the specific price break in the discount interval.

$$b_{l(m-1)t} \times y_{lmtj} \leq X_{lmtj} \leq b_{lmt} \times y_{lmtj} \quad (15)$$

Equations (16)-(17) deal with the capacity of each supplier and carrier, while Equation (18) restricts the availability of the carrier in the period t.

$$X_{lMtj} \leq C_{ltk} \times y_{lMtj}, \forall l, m, t, j \quad (16)$$

$$X_{lmtj} \leq \Omega_{tj} \times u_{lmtj} \forall l, m, t, j \quad (17)$$

$$\sum_l \sum_m u_{lmtj} \leq V_{tj}, \forall t, j \quad (18)$$

Equation (19) expresses the maximum storage capacity and guarantee that the inventory level at the end of period t cannot be more than available storage space. Equation (20) ensures that the amount of stock-outs cannot exceed than the manufacturer service-level.

$$I_t^+ \leq W_t, \forall t \quad (19)$$

$$I_t^- \leq (1 - \theta_t) D_t, \forall t \quad (20)$$

Equations (21-23) ensure respectively that only one carrier is selected and also one price break level is selected. Equations (24-25) express the restriction of the amount of inventory and shortage.

$$y_{lmtj} \leq X_{lmtj}, \forall l, m, t, j \quad (21)$$

$$\sum_m \sum_j y_{lmtj} = Z_{lt}, \forall t \quad (22)$$

$$\sum_m \sum_j u_{lmtj} = Z_{lt}, \forall t \quad (23)$$

$$-M \times Ys_t \leq I_t^- \leq -S \times Ys_t, \forall t \quad (24)$$

$$S \times Yh_t \leq I_t^+ \leq M \times Yh_t, \forall t \quad (25)$$

Eq (26) ensures that shortage and inventory cannot occur at the same time. Equation (27) defines the binary variables that are used in the model. Equations (28-30) ensure the non-negativity variables, respectively, for the deviation variables, shortage level, inventory level, and the quantity of order. Equation (30) ensures that the order quantity should be integer.

$$Ys_t + Yh_t \leq 1, \forall t \quad (26)$$

$$y_{lmtj}, u_{lmtj}, Z_{lt}, Ys_t, Yh_t \in \{0,1\} \quad (27)$$

$$d_n^-, d_n^+ \geq 0 \;\; \forall n \in \{1, \ldots, 4\} \quad (28)$$

$$I_t^-, I_t^+ \geq 0 \;\forall t \quad (29)$$

$$X_{lmtjk} \geq 0 \;\&\; Integer \quad (30)$$

Results and Discussions

Numerical Example

This section gives a numerical example to show the model's applicability. The input parameters for the model are extracted from the research of [7,11]. The target for each goal is assumed to be set at 900, 94000, 1100, and 2700 respectively, for a net rejected product, net profit, net late delivery, and supplier social value. Table 1 shows the demand, storage capacity, service level, inventory holding cost, selling price, and demand function parameter. The social value, ordering cost, capacity, rate of late delivery items, and defect rate for each supplier are shown in Table 2. In Table 2, social value determines the level of the supplier in terms of its social contribution to society.

Table 1. Demand, Storage, Service Level, Inventory Holding Cost, Selling Price, and Increase Demand Parameter

Parameter	Period			
	1	2	3	4
Demand (D_t)	2700	2300	2000	2500
Storage (W_t)	1800	1800	1800	1800
Service Level (θ_t)	0.8	0.8	0.8	0.8
Inventory holding cost (h_t)	0.1	0.1	0.1	0.1
Selling price (s_t)	31	31	32	32
Increase demand parameter (a_t) (a_t respectively are 16%, 4%, 8%, and 12% of (D_t)	432	92	160	300

Table 2. Social value for every supplier

Parameter	Supplier		
	1	2	3
Social value (C_{ci})	0.476	0.505	0.501
Ordering cost	1000	1500	1400
Capacity	900	1000	1300
Rate of late delivery items	0.14	0.06	0.12
Defect rate	0.10	0.08	0.06

Table 3. Purchasing cost

Supplier	Price break level	Period			
		1	2	3	4
	1	14	14	14	14
	2	12	12	12	12
1	3	10	10	10	10
	1	17	17	17	17
	2	15	15	15	15
2	3	15	15	15	15
	1	20	20	20	20
	2	16	16	16	16
3	3	12	12	12	12

Table 4. Break point

Supplier	Price break level	Period			
		1	2	3	4
	1	1000	1000	1000	1000
1	2	1500	1500	1500	1500
	3	2000	2000	2000	2000
	1	1500	1500	1500	1500
2	2	1700	1700	1700	1700
	3	2500	2500	2500	2500
	1	1700	1700	1700	1700
3	2	2000	2000	2000	2000
	3	3000	3000	3000	3000

Table 5. Carrier data

Parameter	Supplier					
	1		2		3	
	Carrier		Carrier		Carrier	
	1	2	1	2	1	2
Transportation cost	190	200	210	250	200	260
Capacity	1500	2000	1500	2000	1500	2000

Table 6. Optimization result

Goal constraint	RHS	Result	Description
Minimize the net rejected items	900	$d_1^+=0$ $d_1^-=20.46$	**Achieved** with a value of 879.54
Maximize total profit	94000	$d_2^+=59.49$ $d_2^-=0$	**Achieved** with a value of 94,059.49
Minimize the net late delivered items	1100	$d_3^+=0$ $d_3^-=64.4$	**Achieved** with a value of 1,035.6
Maximize the supplier's social value	2700	$d_4^+=0$ $d_4^-=0$	**Achieved** with a value of 2,700

Tables 3 and 4 listed each supplier's purchasing cost data in terms of price break level and break pint, respectively. Table 5 contains the transportation cost and its respective capacity for each carrier.

Optimization results

The pre-emptive GP model is used to solve the multi-objective order allocation, supplier selection, and carrier selection problem. The developed model is a multi-objective model in the form of linear programming with integer variables. Tables 6-8 show the results of the goal programming optimization for each goal by optimizing each objective separately in the proposed model. Table 6 shows the deviation that is minimized for every goal. From Table 6, we can see that the model's objective function is zero, which means that all the goals are achieved. Table 7 shows the optimal solution for every decision variable in the proposed model, while Table 8 shows the optimal order quantity for every supplier, price break level, and period.

Table 7. Order allocation in every supplier

Supplier	Price break level	Period 1		Period 2		Period 3		Period 4	
		J1	J2	J1	J2	J1	J2	J1	J2
	1	0	250	0	0	0	0	0	0
1	2	0	0	1486	0	0	0	0	0
	3	0	0	0	0	0	0	0	0
	1	1499	0	0	0	0	1500	0	0
2	2	0	0	1500	0	0	0	0	1695
	3	0	0	0	0	0	0	0	0
	1	0	1505	0	0	0	1392	610	0
3	2	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0

Table 8. Result of decision variables for every period

Decision variable	Planning period			
	1	2	3	4
Inventory level	0.0001	417	1146	860
Social investment cost	0.063	0.18	0	0.0064

Table 9. Scenario of right-hand side changes

Goal	Right-hand side changes				
$Z1$	-24%	-12%	0%	12%	24%
$Z2$	-24%	-12%	0%	12%	24%
$Z3$	-24%	-12%	0%	12%	24%
$Z4$	-24%	-12%	0%	12%	24%

Table 10. Results of the objective function for every goal changes

Goal	Scenario				
	-24%	-12%	0%	12%	24%
Defect items	206	217	0	0	0
Total profit	0	0	0	0	2840
Late delivery items	84	76	0	0	0
Social value	0	0	0	0	84

Sensitivity Analysis

Sensitivity analysis is conducted to study effect of some parameters value to the decision variables and outputs of the model [13]. The analysis was done by changing the value of some parameters of the model. Sensitivity analysis can be performed by changing the weight of the goals as in [14, 15]. In this research, the sensitivity analysis is done by changing the target value or right-hand side for each goal as other way to perform sensitivity analysis [16]. The changes in the right-hand side value of the target in this analysis have a different meaning from duality analysis. The interpretation of duality analysis in goal programming is different from linear programming. The analysis in goal programming takes on multi-dimensional characteristics. Hence, the interpretation is quite different from the one in single objective linear programming.

Table 9 shows the scenarios of the right-hand side changes for each goal. Table 10 shows the results of the objective function for each scenario. Based on the table, the goal of defect items affects the objective function when the goal is decreased. When increased, the goal of defect items has no effect on the objective function. Hence, it does not mean that the defect goal can be set at any value since the company should minimize the defect at the zero level if possible. The goal of total profit has no impact on the objective function unless the increased goal is at 24%. Hence the company should carefully set its profit goal by looking at several factors such as the market sale. The late delivery items impact the objective function when the goal is decreased. This result does not mean the company gives high tolerance on the late delivery items; instead, it should be kept at zero level as in the defect rate case. The goal of social value impacts the objective function when the goal increases by 24%. It could be happened due to the effect of social value on the demand increased. This result may differ from one industry to another depending on the sensitivity of the social investment to the increased demand. The sensitivity analysis also clearly shows the trade-off between the objective functions, especially between defects and late delivery items. Both objective functions have to be minimized; the lower the goal results in, the lower defect items but higher late delivery items.

Conclusion

This paper developed a pre-emptive goal programming to select the optimal supplier, order allocation, and carrier by considering corporate social responsibility and the all-unit discount. The optimization result using LINGO 18.0 shows that all goals are achieved. The sensitivity analysis results show that defect items and late delivery items goals impact the objective function when the goals are decreased and have no impact on the objective function when increased. The total profit and social value goals have no impact on the objective function except in changing the goal value of 24%. It is interesting to consider the disruption both on the demand and supply sides and explore evolutionary algorithms such as a genetic algorithm to solve more significant size problems using the proposed formulation

References

1. Pinto, L. M. V. G., Dias, B., Szczupak, J., Maia, R., and Tsunechiro, L., A Novel Risk Management Model Based on the Real Options Concept. *Proceedings of 2007 IEEE Lausanne Power Technology, Lausanne, Switzerland,* 1-5 July 2007, pp. 2144-2149.
2. Lee, H. L.,The Triple-A Supply Chain. *Harvard Business Review*, 82(10), 2004, pp. 102-113.
3. Burke, G. J., Carrillo, J. E., and Vakharia, A. J., Single Versus Multiple Supplier Sourcing Strategies. *European Journal of Operational Research*, 182(1), 2007, pp. 95-112.
4. Lin, K-P., Tseng, M-L., and Pai, P-F, Sustainable Supply Chain management Using Approximate Fuzzy DEMATEL Method, Resources, Conservation and Recycling 128, 2018, pp.134-142.
5. Winter, S., and Lasch, R., Environmental and Social Criteria in Supplier Evaluation–Lessons from the Fashion and Apparel Industry, *Journal of Cleaner Production*, 139, 2016, pp. 175-190.

6. Maignan, I., Hillebrand, B., and McAlister, D., Managing Socially-Responsible Buying: How to Integrate Non-Economic Criteria into the Purchasing Process, *European Management Journal*, 20(6), 2002, pp. 641-648.
7. Yaghin, R. G., and Sarlak, P., Joint Order Allocation and Transportation Planning Under Uncertainty within A Socially Responsible Supply Chain, *Journal of Modelling in Management*, 15(2), 2019.
8. Amid, A., Ghodsypour, S. H., and O'Brien, C., A Weighted Additive Fuzzy Multiobjective Model for the Supplier Selection Problem under Price Breaks in a Supply Chain, *International Journal of Production Economics*, 121(2), 2019, pp. 323-332.
9. Özkan, B., Başligil, H., and Şahin, N., Supplier Selection Using Analytic Hierarchy Process: An Application from Turkey, *Proceedings of the World Congress on Engineering, London, UK., July 6-8, 2011.* Ofori, G.:Greening the Construction Supply Chain in Singapore, *European Journal of Purchasing & Supply Management*, 6(3-4), 2000, pp. 195-206.
10. Choudhary, D., and Shankar, R., A Goal Programming Model for Joint Decision Making of Inventory Lot-Size, Supplier Selection and Carrier Selection, *Computers & Industrial Engineering*, 71, 2014, pp. 1-9.
11. Choudhary, D., and Shankar, R., Joint Decision of Procurement Lot-Size, Supplier Selection, and Carrier Selection, *Journal of Purchasing and Supply Management*, 19(1), 2013, pp. 16-26.
12. Nematollahi, M., Hosseini-Motlagh, S. M., and Heydari, J., Coordination of Social Responsibility and Order Quantity in a Two-Echelon Supply Chain: A Collaborative Decision-Making Perspective, *International Journal of Production Economics*, 184, 2017, pp. 107-121.
13. Saltelli, A., Jakeman, A., Razavi, S., and Wu, Q., ensitivity Analysis: A Discipline Coming of Age. *Environmental Modelling & Software*, 146, 2021, 105226.
14. Wankhade, M. O. and Lunge, H. S. Effect of The Chages in The Weights on The Solution of The Preemptive Weighted Linear Goal Programming Problems, *International Journal of Scientific & Technology Research*, 3(2), 2014.
15. Gosling, E., Reith, E., Knoke, T., and paul, C., A Goa Programming Approach to Evaluate Agroforestry Systems in Eastern Panama, *Journal of Environment Managemen*, 261, 2020.
16. Ignizio, J. P., *Linear Programming in Single- and Multiple-Objective Systems*, Prentice Hall, 1982.