A Supplier Selection Model for Social Responsible Supply Chain

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Received 10 December, 2010; Revised 6 Januvary, 2011; Accepted 11 February, 2011

Abstract

Due to the importance of supplier selection issue in supply chain management (SCM) and ,also, the increasing tendency of organizations to their social responsibilities, In this paper, we survey the supplier selection issue as a multi objective problem while considering the factor of corporate social responsibility (CSR) as a mathematical parameter. The purpose of this paper is to design a model so that suppliers are selected and quota is allocated to them while raising their social responsibility to the maximum expected extent. Supplier selection objectives such as cost minimization, quality maximization and on-time delivery maximization have already been surveyed. In this paper, we add objectives such as CSR maximization, maximization of advantages of domestic supplier selection and minimization of sum total distance to suppliers, to the prior objective functions while considering the quality and on time delivery constraints. Observance of CSR is lineally related to quality and on-time delivery and will lead to their increase. The model is presented in linear and integer programming in two states, single product and multi product, then it is solved by Multi Objective Decision Making (MODM) methods (Utility Function, STEM and Goal Programming) and answers are obtained and compared.

Keywords: Suppler selection; Corporate social responsibility; Supply chain management; Multi objective decision making.

1. Introduction

In recent years, the concept of CSR has been given a significant attention and the issue of for whom or what organizations are responsible has become very important. CSR has various dimensions, some more important ones being : responsibility of the organization for stakeholders (staff, investors, customers, suppliers, etc.), environmental issues, social issues (child labor, racism, right to have union congregation), organization's legal responsibilities (paying tax, paying custom, observance of local and global rules about staff, etc.), organization's economical responsibility (i.e. one of the important and strategic responsibilities of the organization), and organization's charitable responsibility that is taken voluntarily and leads to a positive image of the organization in local and global societies. Supply chain management is a fundamental basis for constitution of business in the world. In the global competition, various products should be available to customers according to their requirements. In today's competitive world, customer's demand is, to be of high quality, to serve quickly, to have on time delivery, to have fair pricing, to observe environmental issues, to be respectful to social issues that result in additional pressure to the organization, that didn't exist before or it was very Slight. As a result, due to the fact that organizations can not comply with all these demands in the society, they require surveillance and management on external resources and external partner's production in addition to their own production and internal resources. In fact, this issue has emerged to help organizations reach competitive advantage in the market. As the supply chains emerge in the society and their efforts for gaining profit consumes social resources, observing all or at least a part of their social responsibilities, can support the strategic and functional interrelationship between supply chain figures. Observance of CSR will become more important when organizations are evaluated before being chosen. After being evaluated and chosen for cooperation, an amount of required merchandise (quota) is allocated to each supplier according to buying organization's goals and criteria. Although great efforts have been made to develop a perspicuous and thorough definition for CSR, there is not still a standard definition for this concept, and global organizations gave different definitions. Alexander Dahlsrud [11] gathered and presented different definitions of CSR in his research. In the last decade, CSR has become an important issue for organizations from

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business point of view and the field of CSR has increasingly developed. There are so very organizations, that decidedly tried to employ the concept of CSR in all aspects of their business. World Business Council for Sustainable Development (WBCSD) defines CSR as "Business' commitment to contribute to sustainable economic development, working with employees, their families, the local community, and larger associations of the society in order to improve the quality of life." Business for Social Responsibility (BSR) defines CSR as "Achieving commercial success in ways that honor ethical values and respect people, communities, and the natural environment." The International Chamber of Commerce (ICC) maintains that CSR is the voluntary commitment by business to manage its activities in a responsible way. The American Society for Quality (ASQ) defines social responsibility as "people and organizations behaving and conducting business ethically and with sensitivity toward social, cultural, economic, and environmental issues. Striving for social responsibility helps individuals, organizations and governments have a positive impact on development, business, and society."

1.1. Corporate Social Responsibility (CSR)

Heslin et al. [18] presented seven strategic CSR principles. They described financial issues, investment and also stakeholders. Their seven principles are 1- Cultivate the needed talent 2- Develop new markets 3- Protect labor welfare 4- Reduce your environmental footprint 5- Profit from by-products 6- Involve customers 7- Green your supply chain. Jennings et al. [22] surveyed the interrelationship between supply chain and social responsibility. They described the challenges of purchasing managers with social responsibility and the potential affects that purchasing social responsibility might have on supply chain. Their findings show that purchasing social responsibility has a direct and positive influence on supplier performances. Panwar et al. [30] carried out a demographic survey from social point of view while taking CSR into consideration. O'Connor et al. [29] presented a methodology for reporting CSR. Teraji [33] presented a model for organization's social performance related to social consent and moral behaviour. In this paper organization's social performance is discussed in interrelationship of customers and managers. Levis [26] has surveyed acceptance of CSR instructions by multinational corporations. In this research it is noticed that multinational corporations are increasingly advertising their commitment to CSR and informing others about the instructions. Galbreath [15] presented the procedure of creation of CSR as a part of organization's strategy. Holmqvist [20] presented CSR as a social control of organization. Hsueh et al. [21] presented equilibrium analysis and CSR for supply chain integration. They survived the advantages of cooperation between procedures and CSR are evaluated under network equilibrium. Results of this research show that, while taking social responsibility by organization, total profit of supply chain would increase with or without cooperation. Cruz et al. [7] developed a framework for modeling and analysis of supply chain network with CSR through integrated environmental decision making. They presented multi-criteria decision making behavior of different decision makers (suppliers, procedures, assemblers, distributors, retailers and customers) that consists of maximization of network returns, minimization of emissions (waste), and risk minimization. Cruz [8] developed a dynamic framework for the modeling and analysis of supply chain networks with CSR through integrated environmental decision-making considering profit maximization, pollution minimization, risk minimization. Ciliberti et al. [5] investigated CSR in supply chains with a Small and Medium-sized Enterprises (SME) perspective. Cruz et al. [9] surveyed multi level effects of CSR on supply chain networks, trade costs, emissions, and supply chain risk. Lin et al. [27] surveyed CSR affects on financial performance of organization. Alexander Dahlsrud [11] gathered 37 definitions of CSR in the appendix of his paper. Cruz [10] surveyed influence of CSR on supply chain management that has multi-criteria decision making approach. Estevez [11] presented a framework for CSR analysis.

1.2. Suppliers Selection

Croom et al. [6] presented an analytic framework for critical literature review in supply chain. Ghodsypour et al. [16] offered a model for contemplating total cost of logistics in supplier selection under conditions of multiple sourcing, multiple criteria and capacity constraint. Tan [32] presented a framework of supply chain management literature with two strategic and holistic approaches. This research discusses strategies of supply chain management and circumstances that lead to supply chain management. De Boer et al. [13] presented A review of methods supporting supplier selection in which decision making methods that are suggested and reported in process of choosing between suppliers are cited. Kouvelis et al. [24] reviewed the researches and the procedures in supply chain management. Chen et al. [4] suggested a fuzzy method for evaluating and choosing suppliers in supply chain management. They presented a fuzzy decision making method for the issue of choosing suppliers in supply chain system. Amid et al. [1] presented a fuzzy multi-objective linear model for supplier selection in a supply chain. Amid et al. [2] suggested a weighted additive fuzzy multi-objective model for the supplier selection problem under price breaks in a supply Chain. Giunipero et al. [17] surveyed the concepts of literature of supply chain historically in the past, present, and future. Ko et al. [23] reviewed the soft computing applications in supply chain management. They presented different techniques of soft computing such as fuzzy logic and genetic algorithm in developing efficiency and effectiveness of different issues of supply chain management. Boran et al. [3] presented a multi-criteria intuitive fuzzy group decision making for supplier selection with TOPSIS method. Lee et al. [25] presented a green supplier selection model for high-tech industries. Wang [34] presented a fuzzy linguistic computing approach to supplier evaluation. Ho et al. [9] reviewed Multi-criteria decision making approaches for supplier evaluation and selection. They analyzed the related papers from 2000 to 2008.

2. Modeling

Nowadays, organizations consider supplier evaluation as totally essential. Supplier evaluation is fulfilled by some criteria, the most important and recently attended ones include: cost, quality, delivery time and risk. Buyer organizations usually define some goals with the supplier organization, and to reach these goals that are sometimes discrepant on each other; they use mathematics, modeling, and various decision-making approaches to compromise a solution with suppliers. In fact, these evaluations show performance of suppliers according to the given criteria. Organizations are competing in an uncertain situation and to cope with it, they take actions. selecting a supplier is one of these actions, since by making their choices about suppliers and building a trustful relationship with them, a long-term relationship is built so that supplier and buyer organizations work in a healthy atmosphere that will lead not only to a competitive advantage for the organizations and improve their access to resources, but also to elimination of the uncertainty of the business environment. For selecting suppliers, organization's strategy plays an important role. Organization's strategies lead to specify objectives and to reach these objectives; organizations need solutions and in order to achieve these solutions, they are required to thoroughly specify the items they have to provide. This will also clarify the suppliers that can provide these items and eventually the required units of items will be allocated to the chosen suppliers, in a way that objectives that are set by strategies are fulfilled in an optimized way. Organizations try to develop suppliers to increase efficiency that results also in increment of effectiveness. Developing suppliers is a systematic effort to create a competent supply chain that includes all the required operations of current performance improvement. The main objective of supplier evaluation can be reducing buying risk, reducing cost, improving quality and reducing delivery time (increasing on time delivery). Dickson [12] neatly collected and reported some criteria including quality, delivery, performance history, guarantee and redress systems, equipments and manufacturing capacity, price, technical capability, financial status of the corporation, consistency to buyer's procedure, communication systems, organization's status in industry among competitors, supplier's tendency to do business, management and organizing, operation and control, after-sale services and attendance, supplier's behaviour, our perception of supplier, ability of packaging, efficiency level of supplier, geographical position, educational activities, mutual interrelationship. In this research, we intend to survey the problem of supplier selection as a multi-objective problem and survey CSR factors (organizations acclaim it every year as a percentage) in the model as a mathematical parameter. The objective of the presented model is to select and allocate quota for each of the suppliers, so that not only the common goals of this relation are satisfied, but also social responsibility of the every suppliers is maximized. In suppliers selection objectives such as cost minimization, quality maximization and maximization of on time delivery has already been surveyed and in this research some goals such as maximization of corporate social responsibility, minimization of sum total distance to suppliers, maximization of advantages of choosing from domestic suppliers (upcountry) are added. We also took into consideration the capacity constraints of producing suppliers and the demand for them. Observance of CSR will result in an increment of quality level and on time delivery and is linearly related to them. The model is presented by linear and integer programming and solved by MODM methods.

2.1. Assumptions and Notations

Symbols that are employed in the equation of single product and multi product models are described in Table 1 below. In accordance with corporate social responsibility from social point of view, it is assumed that, the advantages of supplying from domestic supplier (I) several times as much as supplying from foreign supplier (E) and as a result, under equal situations, domestic suppliers stand a better chance of being chosen. Under such circumstances, it can be claimed that buying organizations are considerate about employment, creating jobs in the society and prevention of foreign ownership, that ultimately helps the society’s economy and such results are related to social responsibility of organization among responsibilities of supplier organization. CSR leads to improvement of the organization's performance in its internal procedures that is linear and consist of performances such as improvement of quality in products and manufactured items and also performance improvement in on time delivery of items that customer requested [2]. In this research, it is intended to evaluate and select suppliers in a period and each supplier has a percentage of quality level and percentage of on time delivery in the initial condition. CSR is of the factors that can define maximum increment percentage of organization's performance by determining the percentage of quality level and percentage of on time delivery that are represented by parameters β and γ. For example, while surveying, if a supplier has a product quality level of seventy percent and according to experts, if this quality level can be increased up to fifty percent at most, by hundred percent observance of CSR, then in the end of survey period we expect the product quality of this supplier to be eighty five percent.

2.2. Mathematical Model in Single Product State

$$Z_1 = \sum_{i=1}^{n} P_i X_i + \sum_{i=1}^{n} O_i Y_i + \sum_{i=1}^{n} (f_i T_i) X_i \quad (1)$$

$$Z_2 = \sum_{i=1}^{n} [(\frac{\gamma_i(\alpha_i^1 - \alpha_i^0)}{(1-\alpha_i^0)}) Q_i + Q_i] X_i \quad (2)$$

$$Z_3 = \sum_{i=1}^{n} [(\frac{\beta_i(\alpha_i^1 - \alpha_i^0)}{(1-\alpha_i^0)}) F_i + F_i] X_i \quad (3)$$

$$Z_4 = \sum_{i=1}^{n} I K_i Y_i + \sum_{i=1}^{n} E(1 - K_i) Y_i \quad (4)$$

$$Z_5 = \sum_{i=1}^{n} \alpha_i^1 X_i \quad (5)$$

$$Z_6 = \sum_{i=1}^{n} f_i Y_i \quad (6)$$

s.t

$$X_i \le C_i \times Y_i \quad (7)$$

$$\sum_{i=1}^{n} x_i = D \quad (8)$$

$$X_i \ge 0 \quad (9)$$

$$Y_i : \begin{cases} 1 & \text{supplier i is chosen} \\ 0 & \text{otherwise} \end{cases} \quad (10)$$

Equation (1) indicates the total costs of buying, shipment and ordering; the first expression is the cost of buying from all suppliers, the second expression is the total cost of ordering, and the third expression indicates the total cost of shipment of products from suppliers to buyers. Equation (2) indicates the sum of reached quality level. According to equation (2), if supplier i reaches the maximum level of social responsibility observance ($\alpha_i^1 = 1$), then its current quality level Q_i will at most increase as much as γ_i, this goal is to be maximized. Equation (3) indicates the total percentage of on time delivery by suppliers. According to equation (3), if supplier i reaches the maximum level of social responsibility observance ($\alpha_i^1 = 1$), then the current percentage of on time delivery of supplier i from F_i will reach the maximum amount of $\gamma_i + F_i$, this goal is to be maximized. Equation (4) indicates the total advantage of using domestic and foreign suppliers. Creating jobs, preventing foreign ownership, etc. are some of the advantages of supplying from domestic suppliers that are related to CSR and the advantages of selecting domestic suppliers (I) is considered several times as much as advantages of supplying product from foreign suppliers

Table 1
Notation for single and multi product state

X_i : amount of allocated order to supplier i
D : total demand for a product in a period
C_i : capacity of supplier i for manufacturing product
F_i : percentage of on time delivery by supplier i
Q_i : percentage of quality level of products of supplier i
P_i : unit cost of product from supplier i
n : number of suppliers
f_i : distance of supplier i from buyer organization
T_i : unit cost of product shipment from supplier i in a unit time
α_i^0 : level of CSR for supplier i at initial condition
α_i^1 : level of CSR for supplier i in the end
β_i : maximum percentage of increment level of F_i considering α_i^1 (according to experts)
γ_i : maximum percentage of increment level of Q_i considering α_i^1 (according to experts)
I : advantages of supplying products from domestic suppliers (upcountry)
E : advantages of supplying products from foreign suppliers (abroad)
O_i : cost of ordering to and cooperating with supplier i
$K_i : \begin{cases} 1 & \text{supplier i is domestic} \\ 0 & \text{otherwise} \end{cases}$
$Y_i : \begin{cases} 1 & \text{supplier i is selected} \\ 0 & \text{otherwise} \end{cases}$
X_{ij} : amount of product j that is supplied by supplier i
D_j : demand for a product j
C_{ij} : capacity of supplier i for product j
F_{ij} : percentage of on time delivery of product j by supplier i
Q_{ij} : percentage of quality level of product j of supplier i
P_{ij} : unit cost of product j from supplier i
T_{ij} : unit cost of product shipment j from supplier i in a unit time
β_{ij} : maximum percentage of increment level of F_{ij} considering α_i^1 (according to experts)
γ_{ij} : maximum percentage of increment level of Q_{ij} considering α_i^1 (according to experts)

(E), this goal is to be maximized. Equation (5) indicates total expected social responsibility level of all suppliers. Social responsibility levels consist of environmental, social, economical, stakeholders, legal and charitable issues, this goal is to be maximized. Equation (6) indicates total distance of buying company from suppliers. By minimizing the selected supplier's distance, fuel consumption amount for transportation and environmental pollution amount (by automobile smokes for transportation) are also minimized, and such activities are in accordance with observance of environmental issues and organization's social responsibility. Equation (7) indicates constraint of product manufacturing capacity of suppliers. If a supplier is chosen ($Y_i = 1$), then the maximum amount of allocated product to this supplier is at most up to its manufacturing capacity. Equation (8) indicates demand constraints. The sum total of bought products and allocated products to suppliers must equal the total demand for products. Equation (9) indicates that variables are positive.

2.3. Mathematical Model in Multi Product State

$$Z_1 = \sum_{i=1}^{n} \sum_{j=1}^{m} P_{ij} X_{ij} + \sum_{i=1}^{n} O_i Y_i + \sum_{i=1}^{n} \sum_{j=1}^{m} (f_i T_{ij}) X_{ij} \quad (11)$$

$$Z_2 = \sum_{i=1}^{n} \sum_{j=1}^{m} [(\frac{\gamma_{ij}(\alpha_i^1 - \alpha_i^0)}{(1-\alpha_i^0)}) Q_{ij} + Q_{ij}] X_{ij} \tag{12}$$

$$Z_3 = \sum_{i=1}^{n} \sum_{j=1}^{m} [(\frac{\beta_{ij}(\alpha_i^1 - \alpha_i^0)}{(1-\alpha_i^0)}) F_{ij} + F_{ij}] X_{ij} \tag{13}$$

$$Z_4 = \sum_{i=1}^{n} IK_i Y_i + \sum_{i=1}^{n} E(1 - K_i) Y_i \tag{14}$$

$$Z_5 = \sum_{i=1}^{n} \sum_{j=1}^{m} \alpha_i^1 X_{ij} \tag{15}$$

$$Z_6 = \sum_{i=1}^{n} f_i Y_i \tag{16}$$

$$X_{ij} \le C_{ij} \times Y_i \tag{17}$$

$$\sum_{i=1}^{n} x_{ij} = D_j \tag{18}$$

$$X_{ij} \ge 0 \tag{19}$$

$$Y_i : \begin{cases} 1 & \text{supplier i is chosen} \\ 0 & \text{otherwise} \end{cases} \tag{20}$$

Equation (11) indicates the total costs of buying, shipment and ordering, as first expression is cost of buying product j from all suppliers, second expression is total cost of ordering and third expression is total cost of shipment of product j from suppliers to buying company, this goal is to be minimized. Equation (12) indicates sum of reached quality level. According to equation (12), if supplier i reaches the maximum level of social responsibility observance ($\alpha_i^1 = 1$) then its current quality level Q_{ij} will at most increase as much as γ_{ij}, (α_i^1 increases percentage of quality level of product of supplier i), this goal is to be maximized. Equation (13) indicates total percentage of on time delivery by suppliers. According to equation (13), if supplier i reaches the maximum level of social responsibility observance ($\alpha_i^1 = 1$) then current percentage of on time delivery of supplier i from F_{ij} will reach the maximum amount of $\gamma_{ij} + F_{ij}$, (α_i^1 increases percentage of on time delivery of product j of supplier i), this goal is to be maximized. Equation (14) indicates total advantage of using domestic and foreign suppliers. (Creating jobs, prevent foreign ownership, etc. are some of the advantages of supplying from domestic supplier that are related to social responsibility of organization) and advantages of choosing domestic supplier (I) is considered several times as much as advantage of supplying product from foreign supplier (E), this goal is to be maximized. Equation (15) indicates total expected social responsibility level of all suppliers for manufacturing different types of product j. Social responsibility level consists environmental, social, economical, stakeholders, legal and charitable issues, this goal is to be maximized. Equation (16) indicates total distance of buying company from suppliers. By minimizing the chosen supplier's distance, fuel consumption amount for transportation and environmental pollution amount (by automobile smokes for transportation) are also minimized, and such activities are in accordance with observance of environmental issues and organization's social responsibility. Equation (17) indicates constraint of product manufacturing capacity of product j for suppliers i. If a supplier is chosen ($Y_i = 1$), then allocated amount of product j to this supplier is at most up to its product manufacturing capacity. Equation (18) indicates demand constraint for product j. Sum total of product j that is bought and allocated to suppliers must equal to total demand for product j. Equation (19) indicates that variables are positive.

3. Resolution Methods

3.1. Utility Function Method

Multi objective decision making problem can be considered as relation (21). This problem has K goal functions that must be maximized. There are m constraints and n decision variables. If we transform utility function of K goal functions to a U function, then relation (21) will change to relation (22). U can be defined in so many different ways, one of the simplest ways is weighted sum of present goal functions Maakuei [28] if goal functions are incongruous and of different dimensions then we should use one of non-scaling methods to non-scale goal function's coefficients.

$$\text{Max } [f_1(x), f_2(x), f_3(x), \dots, f_k(x)] \tag{21}$$

s.t.

$$g_i(x) \le 0 \tag{21-1}$$

$$(i = 1,2,3, \dots, m), \; x = (x_1, x_2, x_3, \dots, x_n)$$

$$\text{Max } U\,(f_1, f_2, f_3, \dots, f_k) \tag{22}$$

$$g_i(x) \le 0 \tag{22-1}$$

$$(i = 1,2,3, \dots, m)$$

$$U(f_1, f_2, f_3, \dots, f_k) = \sum_{j=1}^{k} w_j \times f_j \tag{22-2}$$

In weighted sum method, w_j is non-scale of weight of goal function j.

3.2. Step Method (STEM)

Pokharel [31] mentioned that step method (STEM) has been suggested by Benayon et al. in 1971. This method can be used both for linear and nonlinear applications. We assume that a multi objective problem is defined as relation (23).

$$\text{Max } [f_e(x)] \quad \forall e = 1,2,\dots,k,\dots,q \tag{23}$$

Where:

$$f_e(x) = a_e^1 x_1 + a_e^2 x_2 + \dots + a_e^m x_m \tag{23-1}$$

s.t.

$$x \in X \tag{23-2}$$

We initially attain optimum value of each goal function ($f_e(x)$) regardless of other goal functions ($f^*{}_e$). With the attained values for variables, contemplate the value of other goal functions. In this way, the goals-values goal function matrix is formed. By using maximum (minimum) values in each column of this matrix and the attained optimum value of each goal function, contemplate values of α_e for minimization (maximization) problem by using relation (24) and (24-1).

$$\alpha_e = \frac{f_e^* - f_e^{min}}{f_e^*} \left[\sum_{j=1}^{m} (a_e^j)^2\right]^{-1/2} \quad \forall e \tag{24}$$

(For maximization goal functions)

$$\alpha_e = \frac{f_e^{max} - f_e^*}{f_e^{max}} \left[\sum_{j=1}^{m} (a_e^j)^2\right]^{-1/2} \quad \forall e \tag{24-1}$$

(For minimization goal functions)

Values of π_e are obtained by using (24), (24-1) and (25).

$$\pi_e = \frac{\alpha_e}{\sum_{e=1}^{q} \alpha_e} \tag{25}$$

Thus, problem transforms to a single objective problem which is relation (26)-(26-4) that by resolving it, get the optimum resolvents.

$$\text{Min } \delta \tag{26}$$

s.t.

$$x \in X \tag{26-1}$$

$$\pi_e(f_e^* - f_e) \le \delta \ , \forall e = 1,2,\dots,u \subset q \, , (u \le q) \tag{26-2}$$

maximization goals

$$\pi_e(f_e^* + f_e) \le \delta \ , \forall e = 1,2,\dots,q-u \subset q \tag{26-3}$$

minimization goals

$$\delta \ge 0 \tag{26-4}$$

3.3. Goal Programming Method

In this method we should specify a vector of our ideals from goal function and then we rank the goal functions. Two different types of constraints are defined that first is systemic constraints and second is ideal constraints. If constraints are systemic then only values are accepted for variables and if constraints are ideal then we want value of variables to be as close as possible to a distinct figure. It will be ideal if value of variables is equal to a distinct figure, but a little bit less or more is also acceptable. For ideal constraints we define a deviation variable and we call the right side of the constraint, ideal. While all goal functions and constraints of the problem become ideal then goal function of the goal programming problem is to minimize sum of deviation variables considering the conditions of the problem. We should take this fact into attention that, since goal function ranking should be seen in goal function of goal programming problem and systemic constraints should have the first order in the ranking, Goal programming model can be considered as relation (27)-(27-4).

$$\text{Min}[P_1 h_1(d^-, d^+), P_2 h_2(d^-, d^+), \dots, P_k h_k(d^-, d^+)] \tag{27}$$

s.t.

$$g_i(x) \le 0 \, , (i = 1,2,3, \dots, m) \tag{27-1}$$

$$f_j(x) + d_j^- - d_j^+ = b_i \ , \ (j = 1,2,3, \dots, k) \tag{27-2}$$

$$d^-, d^+ \ge 0 \tag{27-3}$$

$$d^- . d^+ = 0 \tag{27-4}$$

4. Numerical Example in Single Product State

Considering the information in Table 2, we are going to select suppliers between three domestic suppliers S_1,S_2,S_4 (k1=k2=k4=1) and a foreign supplier S_3 (k3=0) and allocate required amount of product to each supplier according to the model. Total demand for the product is 300 units and I=1 and E=0.2 are assumed for the advantage of choosing from domestic suppliers. According to experts, level of γ_i & β_i that are interrelated to activity level of CSR would be up to fifty percent (it means that if quality level is 0.7 at present and noticing that increment in CSR activity from zero to one can increase quality level up to 0.15 which, is fifty percent of 0.3 that comes from (1-0.7) that is considered linear). Values of other parameters are according to Table 2 and according to this information; general problem model is as (28)-(40).

Table 2
Values of model parameters (state one)

	S_1	S_2	S_3	S_4
C_i	170	155	140	160
F_i	0.7	0.5	0.8	0.6
Q_i	0.6	0.7	0.8	0.8
P_i	200	250	200	300
O_i	750	800	1200	800
f_i	120	145	1200	100
T_i	120	150	140	140
α_i^0	0.2	0.2	0.3	0.3
α_i^1	0.7	0.8	0.8	0.9
β_i	0.15	0.25	0.1	0.2
γ_i	0.2	0.15	0.1	0.1

$$\text{Min} \quad \begin{matrix} Z_1 = 200x_1 + 250x_2 + 200x_3 + 300x_4 + 750y_1 \\ +800y_2 + 1200y_3 + 800y_4 + \\ 14400x_1 + \\ 21750x_2 + 168000x_3 + 14000x_4 \end{matrix} \tag{28}$$

$$\text{Max } Z_2 = .725x_1 + .8125x_2 + .871x_3 + .885x_4 \tag{29}$$

$$\text{Max } Z_3 = .794x_1 + .6875x_2 + .871x_3 + .685x_4 \tag{30}$$

$$\text{Max } Z_4 = y_1 + y_2 + .2y_3 + y_4 \tag{31}$$

$$\text{Max } Z_5 = .7x_1 + .8x_2 + .8x_3 + .9x_4 \tag{32}$$

$$\text{Min } Z_6 = 120y_1 + 145y_2 + 1200y_3 + 100y_4 \tag{33}$$

s.t.

$$x_1 \le 170y_1 \tag{34}$$

$$x_2 \le 155y_2 \tag{35}$$

$$x_3 \le 140y_3 \tag{36}$$

$$x_4 \le 160y_4 \tag{37}$$

$$x_1 + x_2 + x_3 + x_4 = 300 \tag{38}$$

$$x_i \ge 0 \tag{39}$$

$$Y_i\!:\begin{cases} 1 & \text{supplier i is chosen} \\ 0 & \text{otherwise} \end{cases} \tag{40}$$

4.1. Resolving by utility function method

Considering the fact that goal functions are incongruous and have different dimensions, though initially non-scale the coefficients of the goal functions and for doing so, use linear non-scaling. In linear non-scaling that goal functions are both to minimize and to maximize use relation (41) for maximizing functions and relation (42) for minimizing functions. In this section goal functions are shown by Z_i' so it looks different from main goal functions.

$$C_i' = \frac{C_i}{\max\{C_i\}} \tag{41}$$

$$C_i' = \frac{\min\{C_i\}}{C_i} \tag{42}$$

After non-scaling, apply weight factor (W) in coefficients of goal functions and by using relation (43) simply transform the problem, to a single objective linear programming problem:

$$(W) = (w_1, w_2, w_3, w_4, w_5, w_6) = (.2, .15, .15, .1, .3, .1)$$

$$\text{Max } U = \textstyle\sum_{i=1}^{k} W_i f_i \tag{43}$$

$$\begin{aligned} \text{Max } U = \{ & \left[.2\begin{pmatrix} -x_1 - .8x_2 - x_3 - .67x_4 - .27y_1 \\ -.25y_2 - .17y_3 - .25y_4 - .014x_1 \\ -.0092x_2 - .001x_3 - .014x_4 \end{pmatrix}\right] \\ & +[.15(.81x_1 + .91x_2 + .983x_3 + x_4)] \\ & +[.15(.91x_1 + .79x_2 + x_3 + .79x_4)] \\ & +[.1(y_1 + y_2 + .2y_3 + y_4)] \\ & +[.3(.78x_1 + .89x_2 + .89x_3 + x_4)] + \\ & [.1(-.84y_1 - .69y_2 - .084y_3 - y_4)]\} \end{aligned} \tag{44}$$

s.t.

$$x_1 \le 170y_1 \tag{45}$$

$$x_2 \le 155y_2 \tag{46}$$

$$x_3 \le 140y_3 \tag{47}$$

$$x_4 \le 160y_4 \tag{48}$$

$$x_1 + x_2 + x_3 + x_4 = 300 \tag{49}$$

$$x_i \ge 0 \tag{50}$$

$$Y_i\!:\begin{cases} 1 & \text{supplier i is chosen} \\ 0 & \text{otherwise} \end{cases} \tag{51}$$

After resolving the problem by Lingo8 software it resulted in Table 3.

Table 3
Results of the problem (state one)

$x_1 = 0$	$Z_1' = 251.26$	$Z_1^* = 25838000$
$x_2 = 0$	$Z_2' = 297.62$	$Z_2^* = 263.54$
$x_3 = 140$	$Z_3' = 284$	$Z_3^* = 231.54$
$x_4 = 160$	$Z_4' = 1.2$	$Z_4^* = 1.2$
$y_1 = 0$	$Z_5' = 284.6$	$Z_5^* = 256$
$y_2 = 0$	$Z_6' = 1.084$	$Z_6^* = 1300$
$y_3 = 1$		
$y_4 = 1$		
U=115/89		

Hence, supplier 3 and 4 that are in the order foreign and domestic suppliers are chosen and buyer organization buy 140 units from the first one and 160 units from the second one. Now by making some slight changes in the problem we are going to survey the role of CSR in selecting suppliers and allocated product to be bought from each supplier. Considering the information in Table 4 we are going to choose suppliers between three domestic suppliers S_1,S_2,S_4 (k_1=k_2=k_4=1) and a foreign supplier S_3 (k_3=0) and allocate required amount of product to each supplier according to the model. Total demand for the product is 300 units and I=1 and E=0.2 are assumed for the advantage of choosing from domestic suppliers. According to experts, level of γ_i & β_i that are interrelated to activity level of CSR would be up to fifty percent. Values of other parameters are according to Table 4. According to information of Table 4 problem model is formulated and after resolving by Lingo8 software it resulted in Table 5.

Table 4
Values of model parameters (state two)

	S_1	S_2	S_3	S_4
C_i	170	155	140	160
F_i	0.7	0.5	0.8	0.6
Q_i	0.6	0.7	0.8	0.8
P_i	200	250	200	300
O_i	750	800	1200	800
f_i	120	145	1200	100
T_i	120	150	140	140
α_i^0	0.2	0.2	0.3	0.3
α_i^1	0.9	0.2	0.3	0.9
β_i	0.15	0.25	0.1	0.2
γ_i	0.2	0.15	0.1	0.1

Table 5
Results of resolving definite single product problem (state two)

$x_1 = 140$	$Z_1^{'} = 251.92$	$Z_1^{*} = 4333550$
$x_2 = 0$ $x_3 = 0$ $x_4 = 160$ $y_1 = 1$ $y_2 = 0$ $y_3 = 0$ $y_4 = 1$ U=809.97	$Z_2^{'} = 283.9$ $Z_3^{'} = 284$ $Z_4^{'} = 2$ $Z_5^{'} = 300$ $Z_6^{'} = 1.84$	$Z_2^{*} = 248.5$ $Z_3^{*} = 236.2$ $Z_4^{*} = 2$ $Z_5^{*} = 270$ $Z_6^{*} = 220$

Hence, suppliers1 and 4 are selected and allocated amount will be in the order 140 units and 160 units. In state one that almost all suppliers monotonously increase their activity level of CSR, supplier 3 and 4 with 140 and 160 allocated amounts are selected. In state two suppliers 1 and 4 has increased their CSR level, though with same parameters and given values of example one, we resolve the problem again and supplier 1 and 4 are selected and the allocated amount is in the order, 140 units and 160 units. With this example we came to know that, presented model select the supplier with more increment in CSR.

4.2. Resolving by Goal Programming Method

For resolving by goal programming method, we initially consider systemic constraints and then consider other constraints according to their rank. By resolving the problem by Lingo8 software it resulted in Table 6. Hence, supplier 1, 2 and 4 are selected and in the order are allocated 122, 18, 160 units.

Table6
Results of resolving problem by goal programming method

$d_1^- = 0$	$d_1^+ = 71$	$Z_1^{'} = 178.21$	$Z_1^{*} = 4467550$
$d_2^- = 0$	$d_2^+ = 0$	$Z_2^{'} = 275.2$	$Z_2^{*} = 244.67$
$d_3^- = 0$	$d_3^+ = 35$	$Z_3^{'} = 251.64$	$Z_3^{*} = 218.84$
$d_4^- = 0$	$d_4^+ = 51$	$Z_4^{'} = 3$	$Z_4^{*} = 3$
$d_5^- = 0$	$d_5^+ = 0$	$Z_5^{'} = 271.18$	$Z_5^{*} = 243.8$
$d_6^- = .5$	$d_6^+ = 0$	$Z_6^{'} = 2.53$	$Z_6^{*} = 365$
$x_1 = 122$ $y_1 = 1$	$x_2 = 18$ $y_2 = 1$	$x_3 = 0$ $y_3 = 0$	$x_4 = 160$ $y_4 = 1$
U = 20000			

4.3. Resolving by STEM Method

In this method, we attain optimum, minimum, and maximum values as Table 7.

Table 7
Optimum values of goal programming function and Minimums and maximums of other functions.

	$Z_1^{'}$	$Z_2^{'}$	$Z_3^{'}$	$Z_4^{'}$	$Z_5^{'}$	$Z_6^{'}$
1	223	287.4	237	2	284.6	1.69
2	250	297	266.4	2.2	284.6	1.084
3	302.2	267.2	285	2.2	249.4	0.924
4	278.57	256	257.61	3.2	248.41	2.6
5	223	287.4	237	2	284.6	1.96
6	260	265.5	284.7	2	284.3	0.924

By using Table 7 and relation (24), we contemplate the value of $\alpha_e$and by using the value of α_e and relation (25), we contemplate the values of $\pi_e$for goal functions:

$\alpha_1 = 0.145$, $\alpha_2 = 0.0745$,

$\alpha_3 = 0.096$,

$\alpha_4 = 0.2137$

$\alpha_5 = 0.0714$,

$\alpha_6 = 0.419$

$\pi_1 = 0.1422$, $\pi_2 = 0.073$

, $\pi_2 = 0.073$, $\pi_3 = 0.094$, $\pi_4 = 0.21$,

$\pi_5 = 0.014$, $\pi_6 = 0.4232$

Now, by using Table 7 and values of $\pi_e$and relation (26), single objective linear programming model is formulated and after resolving by Lingo8 software it resulted in Table 8. Hence, supplier 2 and 4 are selected and in the order are allocated 140 and 160 units of product.

Table 8
Results of resolving problem by STEM method

$x_1 = 0$	$y_1 = 0$	$Z_1^{'} = 223$	$Z_1^{*} = 5369600$
$x_2 = 140$	$y_2 = 1$	$Z_2^{'} = 287.4$	$Z_2^{*} = 255.35$
$x_3 = 0$	$y_3 = 0$	$Z_3^{'} = 237$	$Z_3^{*} = 205.85$
$x_4 = 160$	$y_4 = 1$	$Z_4^{'} = 2$	$Z_4^{*} = 2$
		$Z_5^{'} = 284.6$	$Z_5^{*} = 256$
$\delta = 63.45$		$Z_6^{'} = 1.69$	$Z_6^{*} = 245$

5. Numerical Example in Multi Product State

Considering the information in Table 9, we are going to select suppliers between two domestic suppliers S_1,S_1,(k_1=k_2=1) and a foreign supplier S_3(k_3=0) and allocate required amount of product to each supplier according to the proposed model. we assume that three types of product are required and supplier one can supply type one and two, supplier two can supply type one and three and supplier three can supply all types. Total demand for product one is 250 units, for product two it is 200 units and for product three it is 150 units and parameters I=1 and E=0.2 are assumed for the advantage of choosing from domestic suppliers. According to experts, level of γ_i & β_i that are interrelated to activity level of CSR would be up to fifty percent. According to the information in Table 9, model of problem is as (52)-(69).

Table 9
Value of parameters in definite multi product model (state one)

C_{11}=150	C_{12}=250	C_{13}=0
C_{21}=200	C_{22}=0	C_{23}=200
C_{31}=100	C_{32}=200	C_{33}=150
F_{11}=0.6	F_{12}=0.6	F_{13}=0
F_{21}=0.7	F_{22}=0	F_{23}=0.6
F_{31}=0.6	F_{32}=0.7	F_{33}=0.7
Q_{11}=0.5	Q_{12}=0.5	Q_{13}=0
Q_{21}=0.6	Q_{22}=0	Q_{23}=0.6
Q_{31}=0.5	Q_{32}=0.6	Q_{33}=0.5
P_{11}=200	P_{12}=150	P_{13}=0
P_{21}=250	P_{22}=0	P_{23}=200
P_{31}=150	P_{32}=100	P_{33}=250
O_1=500	O_2=600	O_3=1500
f_1=250	f_2=200	f_3=2000
T_{11}=150	T_{12}=130	T_{13}=0
T_{21}=170	T_{22}=0	T_{23}=100
T_{31}=160	T_{32}=150	T_{33}=120
α_1^0=0.1	α_2^0=0.15	α_3^0=0.3
α_1^1=0.8	α_2^1=0.65	α_3^1=0.8
β_{11}=0.2	β_{12}=0.2	β_{11}=0
β_{21}=0.15	β_{22}=0	β_{23}=0.2
β_{31}=0.2	β_{32}=0.15	β_{33}=0.15
γ_{11}=0.25	γ_{12}=0.25	γ_{13}=0
γ_{21}=0.2	γ_{22}=0	γ_{23}=0.2
γ_{31}=0.25	γ_{32}=0.2	γ_{33}=0.25

$$\text{Min}\ \begin{matrix} Z_1 = 200x_{11} + 150x_{12} + 250x_{21} + 200x_{23} \\ +150x_{31} + 100x_{32} + 250x_{33} + 500y_1 + \\ 600y_2 + 1500y_3 + 37500x_{11} + 32500x_{12} \\ +34000x_{21} + 20000x_{23} + 320000x_{31} + \\ 300000x_{32} + 240000x_{33} \end{matrix} \tag{52}$$

$$\text{Max}\ \begin{matrix} Z_2 = .69x_{11} + .69x_{12} + .71x_{21} + \\ .71x_{23} + .67x_{31} + .74x_{32} + .67x_{33} \end{matrix} \tag{53}$$

$$\text{Max}\ \begin{matrix} Z_3 = .75x_{11} + .75x_{12} + .78x_{21} + \\ .71x_{23} + .74x_{31} + .8x_{32} + .8x_{33} \end{matrix} \tag{54}$$

$$\text{Max}\ Z_4 = y_1 + y_2 + .2y_3 \tag{55}$$

$$\text{Max}\ \begin{matrix} Z_5 = .8x_{11} + .8x_{12} + .65x_{21} \\ +.65x_{23} + .8x_{31} + .8x_{32} + .8x_{33} \end{matrix} \tag{56}$$

$$\text{Min}\ Z_6 = 250y_1 + 200y_2 + 2000y_3 \tag{57}$$

s.t.

$$x_{11} \leq 150y_1 \tag{58}$$

$$x_{12} \leq 250y_1 \tag{59}$$

$$x_{21} \leq 200y_2 \tag{60}$$

$$x_{23} \leq 200y_2 \tag{61}$$

$$x_{13} \leq 100y_3 \tag{62}$$

$$x_{32} \leq 200y_3 \tag{63}$$

$$x_{33} \leq 150y_3 \tag{64}$$

$$x_{11} + x_{21} + x_{31} = 250 \tag{65}$$

$$x_{12} + x_{32} = 200 \tag{66}$$

$$x_{23} + x_{33} = 250 \tag{67}$$

$$x_{ij} \geq 0 \tag{68}$$

$$Y_i: \begin{cases} 1 & \text{supplier i is chosen} \\ 0 & \text{otherwise} \end{cases} \tag{69}$$

5.1. Resolving by Utility Function Method

$$\text{Max U} = \left[.2 \begin{pmatrix} -.5x_{11} - .67x_{12} - .4x_{21} - .5x_{23} - \\ .67x_{31} - x_{32} - .4x_{33} \\ -.2y_1 - .16y_2 - \\ .067y_3 - .0027x_{11} \\ -.003x_{12} - .003x_{21} \\ -.005x_{23} - .0003x_{31} - \\ .00034x_{32} - .0004x_{33} \end{pmatrix} \right]$$

$$+ \left[.15 \begin{pmatrix} .93x_{11} + .93x_{12} + .95x_{21} + \\ .95x_{23} + .9x_{31} + x_{32} + .9x_{33} \end{pmatrix} \right] +$$

$$\left[.15 \begin{pmatrix} .93x_{11} + .93x_{12} + .97x_{21} + .88x_{23} \\ +.92x_{31} + x_{32} + x_{33} \end{pmatrix} \right]$$

$$+[.1(y_1 + y_2 + .2y_3)]$$

$$+ \left[.3 \begin{pmatrix} Z5 = x_{11} + x_{12} + .81x_{21} \\ +.81x_{23} + x_{31} + x_{32} + x_{33} \end{pmatrix} \right] +$$

$$[.1(.8y_1 + y_2 + .1y_3)] \tag{70}$$

s.t.

$$x_{11} \le 150y_1 \quad (71)$$

$$x_{12} \le 250y_1 \quad (72)$$

$$x_{21} \le 200y_2 \quad (73)$$

$$x_{23} \le 200y_2 \quad (74)$$

$$x_{13} \le 100y_3 \quad (75)$$

$$x_{32} \le 200y_3 \quad (76)$$

$$x_{33} \le 150y_3 \quad (77)$$

$$x_{11} + x_{21} + x_{31} = 250 \quad (78)$$

$$x_{12} + x_{32} = 200 \quad (79)$$

$$x_{23} + x_{33} = 250 \quad (80)$$

$$x_{ij} \ge 0 \quad (81)$$

$$Y_i:\begin{cases} 1 & \text{supplier i is chosen} \\ 0 & \text{otherwise} \end{cases} \quad (82)$$

Resolving by Lingo8 software, it resulted in Table 10.

Table 10
Results of resolving the problem

$x_{11} = 150$	$Z_1^{'} = 310.78$	$Z_1^{*} = 51650100$
$x_{12} = 200$	$Z_2^{'} = 555.5$	$Z_2^{*} = 413$
$x_{13} = 0$	$Z_3^{'} = 572.5$	$Z_3^{*} = 460.5$
$x_{21} = 100$	$Z_4^{'} = 2.2$	$Z_4^{*} = 2.2$
$x_{22} = 0$	$Z_5^{'} = 581$	$Z_5^{*} = 465$
$x_{23} = 0$	$Z_6^{'} = 1.9$	$Z_6^{*} = 2450$
$x_{31} = 0$		$y_1 = 1$
$x_{32} = 0$		$y_2 = 1$
$x_{33} = 150$	U=281.37	$y_3 = 1$

Hence, supplier 1, 2, 3 are selected that supplier 1 and 2 are domestic and supplier 3 is foreign and buyer organization buy 150 units of product 1 and 200 units of product 2 from supplier 1, 100 units of product 1 from supplier 2 and 150 units of product 3 from supplier 3. Now by making some slight changes in the problem we are going to survey the role of CSR in selecting suppliers and allocation of product unit to be bought from each supplier. Considering the information in Table 11 we are going to select suppliers between two domestic suppliers S_1, S_2, (k_1=k_2=1) and a foreign supplier S_3 (k_3=0) and allocate required amount of product to each supplier according to the given multiproduct proposed model.

Table 11
Values of parameters in definite multi product model (state two)

C_{11}=150	C_{12}=250	C_{13}=0
C_{21}=200	C_{22}=0	C_{23}=200
C_{31}=100	C_{32}=200	C_{33}=150
F_{11}=0/6	F_{12}=0/6	F_{13}=0
F_{21}=0/7	F_{22}=0	F_{23}=0/6
F_{31}=0/6	F_{32}=0/7	F_{33}=0/7
Q_{11}=0/5	Q_{12}=0/5	Q_{13}=0
Q_{21}=0/6	Q_{22}=0	Q_{23}=0/6
Q_{31}=0/5	Q_{32}=0/6	Q_{33}=0/5
P_{11}=200	P_{12}=150	P_{13}=0
P_{21}=250	P_{22}=0	P_{23}=200
P_{31}=150	P_{32}=100	P_{33}=250
O_1=500	O_2=600	O_3=1500
f_1=250	f_2=200	f_3=2000
T_{11}=150	T_{12}=130	T_{13}=0
T_{21}=170	T_{22}=0	T_{23}=100
T_{31}=160	T_{32}=150	T_{33}=120
α_1^0=0/1	α_2^0=0/15	α_3^0=0/3
α_1^1=0/1	α_2^1=0/9	α_3^1=0/9
β_{11}=0/2	β_{12}=0/2	β_{11}=0
β_{21}=0/15	β_{22}=0	β_{23}=0/2
β_{31}=0/2	β_{32}=0/15	β_{33}=0/15
γ_{11}=0/25	γ_{12}=0/25	γ_{13}=0
γ_{21}=0/2	γ_{22}=0	γ_{23}=0/2
γ_{31}=0/25	γ_{32}=0/2	γ_{33}=0/25

We assume that three types of products are required and supplier one can supply type one and two, supplier two can supply type one and three and supplier three can supply all types. The total demand for product one is 250 units, for product two it is 200 units, and for product three it is 150 units and parameters I=1 and E=0.2 are assumed for the advantage of choosing from domestic suppliers. According to experts, level of γ_i & β_i that are interrelated to activity level of CSR would be up to fifty percent. According to information of Table 11 problem model is formed and after being resolved by lingo8 software it resulted in Table 12.

Table 12
Results from resolving the problem

$x_{11} = 0$	$Z_1' = 374.45$	$Z_1^* = 118917100$
$x_{12} = 0$	$Z_2' = 584$	$Z_2^* = 450$
$x_{13} = 0$	$Z_3' = 589$	$Z_3^* = 488.5$
$x_{21} = 200$	$Z_4' = 1.2$	$Z_4^* = 1.2$
$x_{22} = 0$	$Z_5' = 600$	$Z_5^* = 540$
$x_{23} = 0$	$Z_6' = 1.1$	$Z_6^* = 2200$
$x_{31} = 50$		$y_1 = 0$
$x_{32} = 200$		$y_2 = 1$
$x_{33} = 150$	U=281	$y_3 = 1$

Hence, supplier 2 and 3 are chosen that supplier 2 is domestic and supplier 3 is foreign and we buy 200 units of product 1 from supplier 2 and 50 units of product 1, 200 units of product 2 and 150 units of product 3 from supplier 3. Comparing the attained resolvents of the two examples, we come to know that the supplier which, has increased his CSR's level more than others are selected and allocated more units of product for supplying. In the first example CSR level increment of supplier one was 70 percent that led to selecting of this supplier, but in the second example, since the CSR level increment of supplier one was zero, thus it was not chosen by solving the model.

5.2. Resolving by Goal Programming Method

For resolving by goal programming method we initially consider systemic constraints and then we consider other constraints according to their rank. By resolving the problem by lingo8 software it resulted in Table 13.

Table 13
Results of resolving the problem

$d_1^- = 0$	$d_1^+ = 281$	$x_{11} = 50$	$y_1 = 1$
$d_2^- = 0$	$d_2^+ = 99$	$x_{12} = 200$	$y_2 = 1$
$d_3^- = 0$	$d_3^+ = 0$	$x_{21} = 200$	$y_3 = 1$
$d_4^- = 0$	$d_4^+ = 0$	$x_{23} = 100$	$Z_1^* = 53325100$
$d_5^- = 0$	$d_5^+ = .5$	$x_{31} = 0$	$Z_2^* = 450.5$
$d_6^- = 0$	$d_6^+ = 0$	$x_{32} = 0$	$Z_3^* = 516$
U = 1016712		$x_{33} = 150$	$Z_4^* = 2.2$
$Z_1' = 375.71$	$Z_2' = 652.5$	$Z_3' = 664.5$	$Z_5^* = 430$
$Z_4' = 2.2$	$Z_5' = 643$	$Z_6' = 1.9$	$Z_6^* = 2450$

Hence, supplier1, 2 and 3 are selected that supplier 1 and 2 are domestic and supplier 3 is foreign and buyer organization buy 50 units of product 1 and 200 units of product 2 from supplier 1, 200 units of product 1 and 100 units of product 3 from supplier 2 and 150 units of product 3 from supplier 3.

5.3. Resolving by STEM Method

In this method we attain optimum, minimum, and maximum values as Table 14.

Table 14
Optimum values of goal programming function and minimums and maximums of other functions

	Z1	Z2	Z3	Z4	Z5	Z6
Z1	328.25	553.5	573.5	2.2	571.5	1.9
Z2	427.25	681.5	666.5	2.2	624	1.9
Z3	417	678.5	678.5	2.2	643	1.9
Z4	375.5	655.5	648.5	2.2	643	1.9
Z5	367.25	650.5	660.5	2.2	662	1.9
Z6	337.5	550.5	567.5	1.2	600	0.9

By using Table 14 and relation (24), we contemplate the value of α_e and by using the value of α_e and relation (25), we contemplate the values of π_e for goal functions:

$\alpha_1 = 0.1363$, $\alpha_2 = 0.0769$,
$\alpha_3 = 0.0654$, $\alpha_4 = 0.3182$,
$\alpha_5 = 0.0547$ $\alpha_6 = 0.4052$
$\pi_1 = 0.1289$, $\pi_2 = 0.0727$,
$\pi_3 = 0.0619$, $\pi_4 = 0.3011$,
$\pi_5 = 0.0517$ $\pi_6 = 0.3835$

Now, by using Table 14 and values of π_e and relation (26), single objective linear programming model is formulated and after resolving by Lingo8 software it resulted in Table 15.

Table 15
Results of resolving problem

$x_{11} = 50$	$Z_1' = 300.8$	$Z_1^* = 51305100$
$x_{12} = 200$	$Z_2' = 554.5$	$Z_2^* = 385.5$
$x_{13} = 0$	$Z_3' = 573.5$	$Z_3^* = 439$
$x_{21} = 200$	$Z_4' = 2.2$	$Z_4^* = 2.2$
$x_{22} = 0$	$Z_5' = 562$	$Z_5^* = 340$
$x_{23} = 0$	$Z_6' = 1.9$	$Z_6^* = 2450$
$x_{31} = 0$		$y_1 = 1$
$x_{32} = 0$		$y_2 = 1$
$x_{33} = 150$	U=81.13	$y_3 = 1$

Hence, supplier1, 2 and 3 are selected and buyer organization buy 50 units of product 1 and 200 units of product 2 from supplier 1, 200 units of product 1 from supplier 2 and 150 units of product 3 from supplier 3.

6. Conclusion

Due to the significant importance of evaluation and selecting suppliers in SCM issues and also striking concerns of organizations in recent years about issues related to CSR, in this paper, a mathematical model of evaluation and supplier selection is presented, considering parameters of CSR. This model is developed in linear and integer programming and presented as a multi objective decision making (MODM) problem. The objective functions of the model are: cost function to be minimized, quality to be maximized, on time delivery to be maximized, CSR to be maximized, advantages of choosing domestic supplier to be maximized, supplier distance to be minimized. By developing the model and resolving numerical examples in different states, we come to know that organizations with higher levels of CSR are selected and to witch quota of product is allocated. This issue is fully presented by different examples, and in one of the examples with just the same data, and different in CSR. The one with higher CSR is selected by the proposed model. Different resolving methods result in different resolvents, that is because of the difference in the essence of the methods: i.e., Utility Function, STEM and Goal programming. All in all, the proposed model selects organizations with higher level of CSR and allocates products to be supplied by them. In recent years, corporate responsibility has become crucially important in the society. In this paper, we developed a mathematical model that prioritizes the suppliers according to their observance of corporate social responsibilities as a new factor in addition to other aspects such as economical responsibilities that lead to select a supplier. Observance of CSR leads to quality improvement and on time delivery increment of supplier's product that has a linear relationship that is fully taken into consideration in this paper. By maximization of CSR, as one of our objective functions, the model chooses the supplier with higher CSR that is quite different from the situation that it is taken voluntarily and aims to measure the difference of CSR observance. By minimizing the distance between suppliers and buyer organizations, we also decreased the consumption of fuel and pollution that are both environmental, social and economical aspects of CSR.

7. References

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