Asian Journal of Applied Science and Technology (AJAST)
Volume 1, Issue 8, Pages 125-134, September 2017

Presenting a Novel Integrated Closed-loop Supply Chain Model by Considering Social Responsibility

Mohammadhossein Saeedi

Department of Industrial, Manufacturing and Systems Engineering, Texas Tech University, Lubbock, Texas, USA. Email: mohammad.saeedi@ttu.edu

Article Received: 05 August 2017 *Article Accepted: 19 September 2017* *Article Published: 24 September 2017*

ABSTRACT

The present paper developed an integrated closed-loop supply chain model by considering social responsibility. The novelty of this research is considering social responsibility in the model. In order to achieve this goal, a three-objective mathematical model was presented with the following aims: 1) Minimizing the costs, 2) Maximizing social responsibility or social benefits of the model, and 3) Minimizing the adverse environmental effects. The mathematical method which is applied proves the validity of the model.

Keywords: Mathematical modelling, Closed-loop supply chain, Social responsibilities and Environmental effects.

1. INTRODUCTION

Significant progress in civilization of human being has been made over 20th century. (Torabzade Khorasani & Almasifard, 2017) One of the most important type of these progresses is in sustainable supply chain management. Sustainable supply chain management is explained as the management of materials, data, and investment for cooperation between organizations during the supply chain and has been an important topic for studies during the past decade (Hsueh, 2015). Recently, sustainability in supply chain management (Hussain and Tiwari, 2015) and considering the environmental aspects and social factors have become vital topics (Brandenburg et al, 2014). Considering social responsibility for the environment are relatively complicated issues, but it has a great impact on the ability of different sectors of supply chain by adapting technologies, creating an environmentally friendly environment and considering environmental factors (Longoni et al, 2014).

Corporate social responsibility is the moral acceptance of business for achieving the sustainability and includes economic, environmental, and social conditions. Social responsibility is studied based on four aspects: 1) Economic responsibility: It is the most fundamental layer of social responsibility because shareholders demand for the return of their capital; it leads to economic growth and there is a direct relationship between economic growth and financial freedom (Çiftçioğlu & Almasifard, 2015). 2) Legal responsibility: Rules must be implemented based on international standards. 3) Moral responsibility: organizations must conduct the activities expected by society. 4) Humanitarian responsibility: It is the fourth aspect of social responsibility including such subjects as supporting the poor, preventing risk, reducing energy consumption, protecting natural resources, preventing pollution, etc. (Zeng et al,2014).

Social responsibility has been converted from small concepts into complicated ones and has influenced organizational decision-making for more than several decades. From an economic standpoint, the lagged value of final consumption expenditure has a significant effect on the share of final consumption expenditure in Gross Domestic Product (Almasifard & Saeedi, 2017). The combination of social responsibility, sustainability, and cost clarification helps shareholders to accept more social responsibility, have self–confidence, and make efforts for new innovations. This strategy has many effects on suppliers and organizational implementation helping to promote the safety of products, technology, and process in terms of environment. When organizations improve programs by implementing social responsibility, they should pay attention to the opinions and needs of shareholders and workers to improve working conditions, health, and job security in the long term (Bijoylaxmi et al, 2015).

The purpose of implementing social responsibility is to create consistency in supply chain, optimize social welfare, and reduce production costs leading to the reduction of price, stimulation of customers for more purchases, and optimization of supply chain profit. Analyzing the effect of social responsibility on 133 Eco-Responsible Spanish companies showed that it has non-economic effects such as organizational liability, creating motivation in employees, customer satisfaction, innovations, energy saving, material recycling, etc.(Reverte et al,2015). According to previous reviews, few articles applied quantitative models for supply chain sustainable management (Reverte et al,2015). Based on the importance of the subject and this research gap, the present study provided the mathematical model of sustainable closed-loop supply chain by considering social responsibility. As a result, a multi-objective quantitative model was presented to optimize the implementation cost and levels of social responsibility and reduce the environmental effects.

2. LITERATURE REVIEW

In recent years, some researchers studied and presented models for closed-loop supply chain. For example, Vahdani (2015) provided a multi-product and multi-period model for designing the closed-loop supply chain network under fuzzy environment. Demirel et al (2014) developed a multi-piece and multi-period hybrid linear planning for a closed-loop supply chain network. Fallah-Tafti et al (2014) in their study designed the supply chain network in an integrated way. Their proposed network is a multi-level network including assembly, customers, and collection and disposal centers. MA et al (2016) presented a bi-objective planning model for closed-loop supply chain under the conditions of uncertainty. The model that they provided was a single-objective mathematical model for closed-loop supply chain problem. Banasik et al (2017) presented the linear planning multi-objective model of closed-loop supply chain for mushroom production. Their model in direct logistics included producer and retailer level but other levels were not considered. In addition, in reverse logistics, the collection and rehabilitation centers were considered. Hassanzadeh Amin and Baki (2017) presented the multi-objective facility location model in closed-loop supply chain under fuzzy conditions. They modeled the reverse logistics facility location in their model.

Moreover, there are some studies that have been done in the field of social responsibility. Hussain et al (2015) used interpretive structural modeling (ISM) and analytical network process (ANP) for evaluating the appropriate alternatives of resources, time, and money in line with economic-environmental and social aspects in supply chain sustainable management. Furthermore, MCarment Suescun (2015) found that there are still lots of unknown problems according to the development of social responsibility area by studying the extractive industries of Latin America and the Caribbean (LAC). Saeidi et al (2014) studied 250 manufacturers in Iran and they concluded that there is a direct relationship between social responsibility and organizational programs; they also found a direct relationship between social responsibility and three factors of comparative advantage. Sustainability, liability, and customer satisfaction were considered as the probable intermediates between these two relationships.

3. MATHEMATICAL MODELING

The network studied in this research is a direct and reverse integrated logistic network that can be applied in industries which can recycle, bury, dispose, remanufacture, and repair the products that are at the end of life products. In the designed model, the return products are divided into recoverable products, remanufacturing products, recyclable products, and products for disposal.

Recoverable products are recovered in collection and rehabilitation centers and can be completely reused after the recovery. These products are sent to distribution centers for sale. Remanufacturing products can be recovered in production centers and enter the production line after the recovery. The products which cannot be used anymore, except in raw materials or convertible materials, are sent to recycling centers. The products which cannot be used anymore, even in raw materials preparation, are sent to burial and disposal centers for secure burial. This network can support a variety of industries like electronic and digital equipment (computers, cameras, etc.), automotive industries and other similar industries.

According to the issues mentioned above, the hypotheses considered for modeling are:

- The model is multi-period and multi-product. In addition, the capacity of all facilities is limited.
- The number is three-dimensional, and the solution space is discrete.
- The number of facilities is not predetermined.
- All customers' demands are responded and all return products are collected.
- Customer demand and values of return products are certain.
- The place of suppliers and producers are certain and fixed.
- The maintenance cost is dependent on the finishing point of period inventory and shortage is not allowed.
- The place of producers, suppliers, and customers is fixed and other places include potential distribution, collection, rehabilitation, recycling, burial, and disposal centers.

3.1 Parameters, Indices and Variables

3.1.1. Parameters

r_l^{st} : The amount of product *s* from customer center *I* at time *t*

d_l^{st} The amount of product demand *s* by customer *I* at time *t*

Bj^{st} : return product rate *s* from collection and rehabilitation center *m* to production center *j* at time *t*

Bn^{st} : return product rate s from collection and rehabilitation center m to burial and disposal center at time t

Bk^{st} Return product rate s from collection and rehabilitation center m to distribution center k at time t

Bp^{st} : return product rate s from collection and rehabilitation center m to supply center p at time t

f_k : The fixed costs of constructing the distribution center at place k

f_m : The fixed costs of constructing the collection and rehabilitation center m at place m

f_p : The cost of constructing the recycling center at place p

f_n : The cost of constructing the burial and disposal at place n

c_{ij}^{s} : All costs of transporting product s from supplier product I to producer center j

c^{s}_{jk} : All costs of transporting product s from producer product j to distribution center k

c^{s}_{kl} : All costs of transporting product s from distribution center k to customer center I

c^{s}_{lm} : All costs of transporting each return product from customer I to collection and rehabilitation center m

c^{s}_{mp} : All costs of transporting each return product from distribution and rehabilitation center m to recycling center p

c^{s}_{mn} : All costs of transporting each return product from distribution center m to burial and disposal center n

c^{s}_{mk} : All costs of transporting each return product from collection and rehabilitation center m to distribution center k

c^{s}_{mj} : All costs of transporting each return product from collection and rehabilitation center m to production center j

c^{s}_{pj} : All costs of transporting each return product from recycling center p to production center j

c^{s}_{pi} : All costs of transporting each return product from recycling center p to supply center i

cq^{s}_{jj} : All costs of transporting product s from production center j to its warehouse

cq^{s}_{jk} : All costs of transporting product s from production warehouse k to distribution center k

ca_{i} : The capacity of supply center at place i

ca_{j} The capacity of production center at place j

ca_{jj} : The capacity of production center at place j

cr_{j} : The capacity of remanufacturing in production center at place j

ca_{k} : The capacity of distribution center at place k

cr_{k} The capacity of distributing the recovered products in distribution center at place k

cr_{i} : The capacity of producing raw materials from return products in supply center at place i

ca_{m} : The capacity of collection and rehabilitation center at place m

ca_{p} The capacity of recycling center at place p

ca_{n} : The capacity of burial and disposal center at place n

h^{s}_{j} : The maintenance cost of each product s in production warehouse at place j

α_k : The number of job opportunities created in the k-th distribution center

α_{inv} : The number of job opportunities created in the centers related to reverse logistics

sp_{js} : The average waste created in the j-th production center to produce each unit of product s

dp_{js} : The average dangerous materials used in the j-th production center to produce each unit of product s

θ_w : The weight factor of the produced waste (the weight of produced waste in the objective function)

θ_h : The weight factor of dangerous materials (the weight of dangerous materials in the objective function)

3.1.2. Indices

I: Fixed points set for supply centers $i \in I$

J: Fixed points set for production centers $j \in J$

K: Fixed points set for distribution centers $k \in K$

L: Fixed points set for customers $l \in L$

M: Fixed points set for collection and rehabilitation centers $m \in M$

P: Fixed points set for recycling centers $p \in P$

N: Fixed points set for burial and disposal centers $n \in N$

S: set of products $s \in S$

T: time $t \in T$

3.1.3. Variables

y_{mt} : If the collection and rehabilitation center is established at place m at period t, its value will be 1, otherwise it will be 0.

y_{kt} : If the distribution center is established at place k at period t, its value will be 1, otherwise it will be 0.

y_{pt} : If the recycling center is established at place p, its value will be 1, otherwise it will be 0.

y_{nt} : If the burial and disposal center is established at place n, its value will be 1, otherwise it will be 0.

x_{ij}^{st} : The stream amount of product s from supply center i to production center j at time t

x_{jk}^{st} : The stream amount of product from production center j to distribution center k at time t

Q_{jj}^{st} : The stream amount of product s from production center k to its warehouse at time t

x_{kl}^{st} : The stream amount of product s from distribution center k to customer I at time t

Q_{jk}^{st} : The stream amount of product from production center j to distribution center k at time t

x_{lm}^{st} : The stream amount of return product s from customer I to collection and rehabilitation center m at time t

x_{mk}^{st} : The stream amount of return product s from customer I to collection and rehabilitation center m to distribution center at time t

x_{mp}^{st} : The stream amount of return product s from customer I to collection and rehabilitation center m to recycling center p at time t

x_{mn}^{st} : The stream amount of return product s from customer I to collection and rehabilitation center m to disposal center n at time t

x_{mj}^{st} : The stream amount of return product s from customer I to collection and rehabilitation center m to production center j at time t

x_{pj}^{st} : The stream amount of return product s from recycling center p to production center j at time t

x_{pi}^{st} : The stream amount of return product s from recycling center p to supply center i at time t

U_{j}^{st} : The amount of remaining product s in production center warehouse j at time t

3.2 The Final Structure of Model

The objective function of the model refers to the minimization of supply chain costs and is presented as equation 1.

$$\begin{aligned}\min Z_1 = \sum_{t\in T}\Big(&\sum_{k\in K} f_k y_{kt} + \sum_{m\in M} f_m y_{mt} + \sum_{p\in P} f_p y_{pt} + \sum_{n} f_n y_{nt} + \sum_{s\in S}\sum_{i\in I}\sum_{j\in J} c_{ij}^{s} x_{ij}^{st} \\ &+ \sum_{s\in S}\sum_{j\in J} cq_{jj}^{s} Q_{jj}^{st} + \sum_{s\in S}\sum_{j\in J}\sum_{k\in K} c_{jk}^{s} x_{jk}^{st} + \sum_{s\in S}\sum_{ij\in J}\sum_{k\in K} cq_{jk}^{s} Q_{jk}^{st} + \sum_{s\in S}\sum_{k\in K}\sum_{l\in L} c_{kl}^{s} x_{kl}^{st} \\ &+ \sum_{s\in S}\sum_{l\in L}\sum_{m\in M} c_{lm}^{s} x_{lm}^{st} + \sum_{s\in S}\sum_{m\in M}\sum_{p\in P} c_{mp}^{s} x_{mp}^{st} + \sum_{s\in S}\sum_{m\in M}\sum_{n\in N} c_{mn}^{s} x_{mn}^{st} + \sum_{s\in S}\sum_{m\in M}\sum_{j\in J} c_{mj}^{s} x_{mj}^{st} \\ &+ \sum_{s\in S}\sum_{m\in M}\sum_{k\in K} c_{mk}^{s} x_{mk}^{st} + \sum_{s\in S}\sum_{p\in P}\sum_{i\in I} c_{pi}^{s} x_{pi}^{st} + \sum_{s\in S}\sum_{p\in P}\sum_{j\in J} c_{pj}^{s} x_{pj}^{st} + \sum_{s\in S}\sum_{j\in J} h_j^{s} U_j^{st}\Big)\end{aligned} \tag{1}$$

Second objective function: This target refers to the maximization of social responsibility or social benefits.

$$\max Z_2 = \sum_{t\in T}\Big(\sum_{k\in K} \alpha_k y_{kt} + \sum_{m\in M} \alpha_{inv} y_{mt} + \sum_{p\in P} \alpha_{inv} y_{pt} + \sum_{n\in N} \alpha_{inv} y_{nt}\Big) \tag{2}$$

Third objective function: the reduction of environmental effects

$$\min Z_3 = \theta_w \sum_{t\in T}\sum_{j\in J}\sum_{k\in K}\sum_{s\in S} sp_{js}(x_{jk}^{st} + Q_{jk}^{st}) + \theta_k \sum_{t\in T}\sum_{j\in J}\sum_{k\in K}\sum_{s\in S} dp_{js}(x_{jk}^{st} + Q_{jk}^{st}) \tag{3}$$

Limitations:

$$\sum_{k\in K} x_{kl}^{st} = d_l^{st}\, \forall l \in L, \forall s \in S, t \in T \tag{4}$$

$$\sum_{m\in M} x_{lm,qs}^{s} = r_l^s \forall l \in L, \forall s \in S, allquality-level \quad (5)$$

Expressions 4 and 5 guarantee that all customers' demands are satisfied in the direct stream, and all return products are collected from customers' centers in the return stream.

$$\sum_{k\in K} x_{mk}^{st} = Bk^{st} \sum_{l\in L} x_{lm}^{st} \forall m \in M, \forall s \in S, t \in T \quad (6)$$

$$\sum_{j\in J} x_{mj}^{st} = Bj^{st} \sum_{l\in L} x_{lm}^{st} \forall m \in M, \forall s \in S, t \in T \quad (7)$$

$$\sum_{i\in I} x_{mi}^{st} = Bi^{st} \sum_{l\in L} x_{lm}^{st} \forall m \in M, \forall s \in S, t \in T \quad (8)$$

$$\sum_{n\in N} x_{mn}^{st} = Bn^{st} \sum_{l\in L} x_{lm}^{st} \forall m \in M, \forall s \in S, t \in T \quad (9)$$

$$\sum_{j\in J} (x_{jk}^{st} + Q_{jk}^{st}) = \sum_{l\in L} x_{kl}^{st} - \sum_{m\in M} x_{mk}^{st} \forall k \in K, \forall s \in S, t \in T \quad (10)$$

$$\sum_{i\in I} x_{ij}^{st} + \sum_{m\in M} x_{mj}^{st} + \sum_{p\in P} x_{pj}^{st} = \sum_{k\in K} x_{jk}^{st} + Q_{jj}^{st} \forall j \in J, \forall s \in S, t \in T \quad (11)$$

$$U_j^{st} = Q_{jj}^{st} - \sum_{k\in K} Q_{jk}^{st} \forall j \in J, \forall s \in S, t \in T \quad (12)$$

Limitations 6 to 12 are related to the stream balance in nodes.

$$\sum_{k\in K} Q_{jk}^{st} \le Q_{jj}^{s} \forall j \in J, \forall s \in S, t \in T \quad (13)$$

Expression 13 guarantees that the amount of output stream from production warehouse is less than the total input to production warehouse.

$$\sum_{s\in S} \sum_{j\in J} x_{ij}^{st} \le ca_i \forall i \in I, t \in T \quad (14)$$

$$\sum_{s\in S} \sum_{k\in K} x_{jk}^{st} + \sum_{s\in S} Q_{jj}^{st} \le ca_j \forall j \in J, t \in T \quad (15)$$

$$\sum_{s\in S} \sum_{l\in L} x_{kl}^{st} \le ca_k y_{kt} \forall k \in K, t \in T \quad (16)$$

$$\sum_{s\in S} \sum_{k\in K} x_{mk}^{st} + \sum_{s\in S} \sum_{j\in J} x_{mj}^{st} + \sum_{s\in S} \sum_{n\in N} x_{mn}^{st} + \sum_{s\in S} \sum_{p\in P} x_{mp}^{st} \le ca_m y_{mt} \forall m \in M, t \in T \quad (17)$$

$$\sum_{s\in S}\sum_{m\in M} x_{mk}^{st} \le cr_k y_{kt} \forall k \in K, t \in T \tag{18}$$

$$\sum_{s\in S}(\sum_{m\in M} x_{mj}^{st} + \sum_{p\in P} x_{pj}^{st}) \le cr_j \forall j \in J, t \in T \tag{19}$$

$$\sum_{s\in S}\sum_{p\in P} x_{pi}^{st} \le cr_i \forall i \in I, t \in T \tag{20}$$

$$\sum_{s\in S}\sum_{m\in M} x_{mn}^{st} \le ca_n y_{nt} \forall n \in N, t \in T \tag{21}$$

$$\sum_{s\in S}\sum_{m\in M} x_{mp}^{st} \le ca_p y_{pt} \forall p \in P, t \in T \tag{22}$$

$$\sum_{s\in S} U_j^{st} \le ca_{jj} \forall j \in J, t \in T \tag{23}$$

Expressions 14 to 23 guarantee that the stream is only between the points in which feasibility is established and the total stream in feasibility does not exceed its capacity.

$$\sum_{k\in K} y_{kt} \ge 1 \tag{24}$$

$$\sum_{m\in M} y_{mt} \ge 1 \tag{25}$$

$$\sum_{p\in P} y_{pt} \ge 1 \tag{26}$$

$$\sum_{n\in N} y_{nt} \ge 1 \tag{27}$$

Expressions 24 to 27 guarantee that at least one of the potential centers is active.

$$Bk^{st} + Bj^{st} + Bp^{st} + Bn^{st} = 1 \forall s \in S, t \in T \tag{28}$$

Expression 28 guarantees that the total coefficients of return products are equal to 1.

$$y_{mt}, y_{kt}, y_{pt}, y_{nt} \in \{0,1\} \forall m \in M, \forall k \in K, \forall p \in P, \forall n \in N, t \in T \tag{29}$$

$$\begin{gathered} x_{ij}^{st}, x_{jk}^{st}, Q_{jj}^{st}, U_j^{st}, x_{kl}^{st}, Q_{jk}^{st}, x_{lm}^{st}, x_{mj}^{st}, x_{mk}^{st}, x_{mp}^{st}, x_{mn}^{st} \ge 0 \\ \forall i \in I, \forall j \in J, \forall k \in K, \forall l \in L, \forall m \in M, \forall n \in N, \forall p \in P, t \in T \end{gathered} \tag{30}$$

Limitations 29 and 30 are the logical and obvious limitations related to decision variables of the problem.

4. CONCLUSION

In this study, a three-objective model for the integrated closed-loop supply chain was studied. In this model, social responsibilities were considered. The objectives considered for the proposed model were minimizing the supply chain costs, maximizing social responsibility or social benefits, and minimizing the environmental effects. The proposed model is a novel one according to the objectives of the model. For further researches, it is suggested to solve this model by different softwares and compare the results of problem solving so as to make sure about the validity of the model. Another interesting topic could be considering more objectives and make the model more complicated.

REFERENCES

- Almasifard, M., & Saeedi, M. (2017). Financial Development and Consumption. *International Conference on Education, Economics and Management Research (ICEEMR 2017)* (pp. 510-512). ATLANTIS PRESS.

- Banasik, A., Kanellopoulos, A., Claassen, G.D.H., M. Bloemhof-Ruwaard, J., G.A.J. van der Vorst, J., Closing loops in agricultural supply chains using multi-objective optimization: A case study of an industrial mushroom supply chain. International Journal of Production Economics, Volume 183, Part B, January 2017, Pages 409–420.

- Bijoylaxmi, S., Ul Islamb, J., Rahmanc, Z. (2015). Sustainability, social responsibility and value co-creation: A case study based approach. Procedia - Social and Behavioral Sciences, 189, 314 – 319.

- Brandenburg, M., , Govindan, K ., Sarkis, J, Seuring, S. (2014). Quantitative models for sustainable supply chain management: Developments and directions. European Journal of Operational Research, 233, 299–312.

- Çiftçioğlu, S., & Almasifard, M. (2015). The Response of Consumption to Alternative Measures of Financial Development and Real Interest Rate in a Sample of Central and East European Countries. *Journal of Economics*, 1-6.

- Deb, K., et al., A fast and elitist multiobjective genetic algorithm: NSGA-II. IEEE transactions on evolutionary computation, 2002. 6(2): p. 182-197.

- Demirel, N., E. Özceylan, T. Paksoy, and H. Gökçen. 2014. "A genetic algorithm approach for optimising a closed-loop supply chain network with crisp and fuzzy objectives." International Journal of Production Research 52(12):3637-3664.

- Fallah-Tafti, A.l., R. Sahraeian, R. Tavakkoli-Moghaddam, and M. Moeinipour. 2014. "An interactive possibilistic programming approach for a multi-objective closed-loop supply chain network under uncertainty." International Journal of Systems Science 45(3):283-299.

- Hassanzadeh Amin, S., Baki, F., A facility location model for global closed-loop supply chain network design. Applied Mathematical Modelling, Volume 41, January 2017, Pages 316–330.

- Hsueh, (2015). A bilevel programming model for corporate social responsibility collaboration in sustainable supply chain management. Transportation Research Part E, 73, 84–95.

- Hussain, A. A., Manoj Kumar Tiwari. (2015). An ISM-ANP integrated framework for evaluating alternatives for sustainable supply chain management. Applied Mathematical Modelling.

- Longoni, A., Cagliano, R., Golini, R . (2014). Developing sustainability in global manufacturing networks: The role of site competence on sustainability performance. Int. J. Production Economics, 147, 448–459.

- Ma, R., YAO, L., JIN, M., REN, P., LV, ZH., Robust environmental closed-loop supply chain design under uncertainty. Chaos, Solitons & Fractals, Volume 89, August 2016, Pages 195–202.

- MCarmen Suescun Pozas, Nicole Marie Lindsay, Marı´a Isabel du Moncea arı´a del (2015) 'social responsibility and extractives industries in Latin America and the Caribbean: Perspectives from the ground. The Extractive Industries and Society, 2, 93–103.

- Reverte, E. G. o.-M., Juan Gabriel Cegarra-Navarro. (2015). The influence of corporate social responsibility practices on organizational performance: evidence from Eco-Responsible. Spanish firms corporate social responsibility . Journal of Cleaner Production, 1-15.

- Saeidi, S.P. , Sofiana, S., Saeidi, P., Saeidi, S.P (2014). How does corporate social responsibility contribute to firm financial performance? The mediating role of competitive advantage, reputation, and customer satisfaction. Journal of Business Research.

- S.X S. Zeng a, H.Y. Ma a, H. Lin a, R.C. Zeng b, Vivian W.Y. Tam. (2014). Social responsibility of major infrastructure projects in China. International Journal of Project Management.

- Torabzade Khorasani, S., & Almasifard, M. (2017). Evolution of Management Theory within 20 Century: A Systemic Overview of Paradigm Shifts in Management. *International Review of Management and Marketing*, 134-137.

- Vahdani, B. 2015. "An Optimization Model for Multi-objective Closed-loop Supply Chain Network under uncertainty: A Hybrid Fuzzy-stochastic Programming Method." Iranian Journal of Fuzzy Systems 12(4):33-57.