IJE TRANSACTIONS B: Applications Vol. 28, No. 5, (May 2015) 738-745

International Journal of Engineering

Journal Homepage: www.ije.ir

A Two Stage Stochastic Programming Model of the Price Decision Problem in the Dual-channel Closed-loop Supply Chain

A. Ahmadi Yazdi , M. Honarvar*

Department of Industrial Engineering, Yazd University, Yazd, Iran

PAPER INFO

Paper history:
Received 27 November 2014
Received in revised form 19 January 2015
Accepted 13 March 2015

Keywords:
Logistic Network
Reverse Logistics
Ntegrated Logistics
Pricing Policy
Multi-channel Sale

ABSTRACT

In this paper, we propose a new model for designing integrated forward/reverse logistics based on pricing policy in direct and indirect sales channel. The proposed model includes producers, disposal center, distributers and final customers. We assumed that the location of final customers is fixed. First, a deterministic mixed integer linear programming model is developed for integrated logistics network design. Then, the stochastic counterpart of the proposed mixed integer linear programming model is developed by using scenario-based stochastic approach. We use the value of the stochastic solution (VSS) as a measure to evaluate the accuracy of stochastic programming approach. VSS value showed that using stochastic approach for solving the proposed model is sufficient. Moreover, we could obtain optimal values of sale prices in direct and indirect sale channel and service level by considering forward and reverse flow together.

doi*: 10.5829/idosi.ije.2015.28.05b.12*

1. INTRODUCTION

Logistic network design problem that takes into account the facility locations and the shipment of product flows have been an area of increasing attention during the last decade in both practice and academia [1]. While the traditional supply chain network design, namely forward logistic, considers the direct flow from producer to the customer in logistic networks, Nowadays, the emphasis on environmental, economic, legislative reasons and potentials of value recovery from the used products have caused many industries to focus on reverse logistic and recovery activities [2-8]. Reverse logistics (RL) is the process of planning, implementing, and controlling the cost effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin in order to reuse of products and raw materials or dispose them [9]. The literature of represented models concerning the logistics network design problem dividing into forward logistics network, reverse logistics network, and finally integrated forward/reverse logistics network [1]. A comprehensive review of reverse and integrated logistics can be found in (Fleischmann [2]; Pokharel and Mutha [6]; Govindan [8]). In this paper, we survey specific network design problems for reverse and integrated logistics network design problems. Some authors like Üster et al. [10], Amiri [11], Patia et al. [12], and Aras et al. [13] are those ones, who carried out investigations about the integrated logistics. Keyvanshokooh [1] presented a mixed-integer linear programming to consider dynamic pricing approach for used products, forward/reverse logistics network configuration and inventory. Kamali et al. [14] proposed a single product, multi-echelon, multi-period closed loop supply chain for high-tech products (which have continuous price decrease). Four heuristics-based methods including genetic algorithm (GA), particle swarm optimization (PSO), differential evolution (DE), and artificial bee colony (ABC) are proposed for solving their model. Sahraeian et al. [15] introduced a supply chain network design problem which contains environmental concerns in arcs and nodes of network and there are some routes such as road, rail and etc. in each pair of nodes. Demand uncertainty and uncertainty

---

*Corresponding Author's Email: Mhonarvar@yazd.ac.ir (M. Honarvar)

Please cite this article as: A. Ahmadi Yazdi , M. Honarvar,A Two Stage Stochastic Programming Model of the Price Decision Problem in the Dual-channel Closed-loop Supply Chain, International Journal of Engineering (IJE), TRANSACTIONS B: Applications Vol. 28, No. 5, (May 2015) 738-745

in the quality of returned products is an important factor to be considered in designing supply chain networks. Some researchers consider the uncertainty in reverse logistics. Pishvaee et al. [5] proposed an integrated logistic model. They presented a single-period and single-product Mixed Integer Linear Programming (MILP) for integration of their logistic model. Then, they developed the model using scenario-based stochastic approach. Their model was aimed at minimization of total costs. Pishvaee et al. [16] proposed a robust optimization model to design a closed-loop supply chain network. With presentation of single-product and single-period model, Pishvaee and Torabi [17] proposed a bi-objective possibilistic mixed integer-programming model. They considered two groups of customers: the recycled material customer and the product customers. To solve the presented possibilistic optimization model, an interactive fuzzy solution approach is used. Pishvaee et al. [18] suggests a dual-objective credibility-based fuzzy mathematical programming model to design a green logistic network under uncertainty conditions. Their model is aimed at minimization of environmental effects and total cost for creating network synchronously. Vahdani et al. [19] proposed a bi-objective model to design a reliable network of hybrid reliable facilities in logistic network under uncertainty conditions. They solved the model by combining queuing theory, fuzzy possibilistic programming and fuzzy multi-objective programming. Optimal decisions on price play a critical role in revenue management of supply chain.

Cattani et al. [20] and Tsay and Agrawal [21] presented comprehensive reviews on multi-channel models. Balasubramanian [22] considered competition in the multiple-channel environment from a strategic viewpoint. Tsay and Agrawal [23] considered the channel conflicts in dual channel supply chain. Chiang et al. [24] studied a price-setting game between a manufacturer and its independent retailer in a dual channel based on the consumer choice model. Mirzahosseinian et al. [25] presented a dual channel inventory model based on queuing theory in a manufacturer-retailer supply chain, consisting of a traditional retail. They used simulated annealing to find a solution for inventory level in each echelon. The service level is rate of increase needed for the distributor to exert in order to raise the profit, demand, and customer's satisfaction. Defining the service level depends on type of production process and method of sale. Service level has significant effects on demand, profit, and pricing strategy. Ahmadvanda et al. [26] investigates the impact of provided service by the retailers and manufacturers on customers' demand and members' profit in a supply chain. In addition, in the most studied related to multi sales channel, the prices in each channel are determined without considering the production and transportation constraints. The main advantage of our model could be summarized as follows: 1) Designing a dual sales channel supply chain considering important constraints like production and transportation constraints, 2) the concept of dual sales channel is considered in integrated supply chain, beside the prices defined in each channel, 3) the service level of retailers is determined by optimization of model.

The proposed model may be widely employed in some industries such as manufacturing of electronic devices and personal computers (PCs), etc., in which there are both indirect and direct selling channels. Several famous companies like Dell, Sony and Apple have use multi sale channels. Therefore, this model may be a useful tool for such companies. An alternative way to incorporate more information about the demand uncertainty into the model is by formulating a stochastic linear program. To the best of our knowledge from a review of the literature, there is no existing joint pricing network design decision model in dual channel integrated supply chain based uponstochastic programming and scenario generation method. In the rest of this paper, in section 2 we develop our stochastic model. The index VSS is calculated for proposed stochastic model in section 3. Finally, concluding remarks are presented in section 4.

2. MODEL DEVELOPMENT

The proposed integrated logistic model in this paper is a single-period, single-product, and multi-stage model including producers, distributors, customers, collection centers, recovery centers, and disposal centers. For saving cost, it is assumed in this model that collection process is done through reverse flow by distribution centers and the producers in forward flow will carry out recovery and repairing operations. These centers are called hybrid centers in logistic networks, which are utilized for cost-saving. In Figure (1), a general view of the presented logistic network is shown. As it characterized in Figure (1), the final products are sent from the producer to distribution centers. After inspecting, the distribution centers returns the repairable products to the producers. The percentage of products that are not repairable, are sent to disposal centers. The rest products will be shipped to end users (customers). The returned products from customers are sent to collection-distributer centers. After inspection, the recoverable products are shipped to producers/ recovery centers and the rest irreparable products will be sent to disposal centers. In addition to a regular forward flow where the producers sell the products to retailers via retail channel, the producers can select direct flow and sale product via e-tail channel to customers.

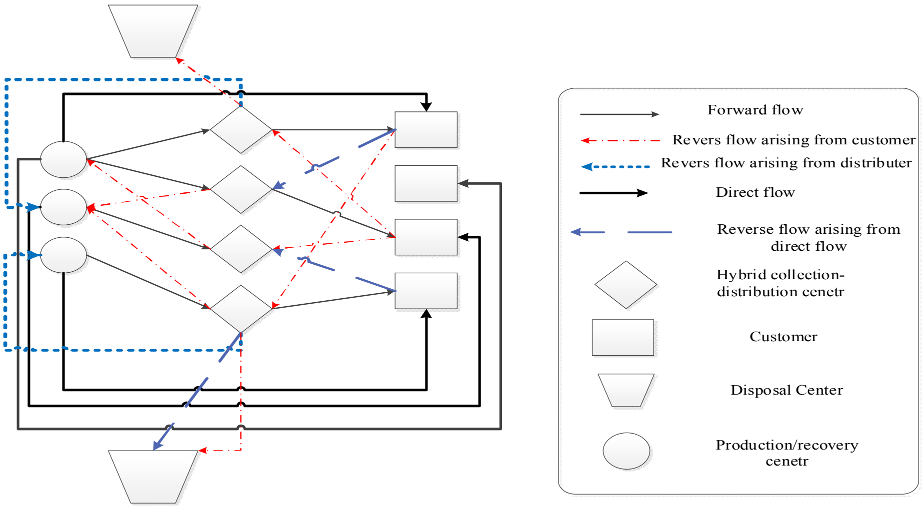

Figure 1. Proposed integrated logistic network

The defective or breakdown products received by customers in direct channel are also returned to collection-distributer centers as returned products in retail channel.

In the presented model, the subject of pricing is addressed within the close-loop integrated logistic network. The concept of pricing has been independently studied by various authors but it has been so far less proposed in the integrated logistic network and its relevant mathematical optimal model. The proposed model will be able to determine producer’s pricing policy in both retail and direct channels. The producers must set a direct channel price p_m and sell the product directly through the direct channel and the retailer competes against the direct channel by offering a mix of added service ss and retail price p_r to customers. We consider a centralized dual-channel supply chain in which an integrated manufacturer controls all three decisions: the traditional retail price, the direct sale price, and the service level in retail channel. Some parameters in logistics network design such as demand of customers, transportation costs and resource capacities are quite uncertain [27]. To handle this uncertainty and have a robust logistics network, we develop a stochastic integrated supply chain by incorporating demand uncertainty.

In the conducted studies regarding the pricing such as Chiang et al. [24] and Bin et al. [28], demand function is indicated by a linear function of base demand (dm_k, dr_K), direct and indirect sale prices (p_r, p_m) and service level (ss), as follows:

$$Dr_k = dr_K - br_1 p_r + bm_2 p_m + \psi m^* ss + \xi_k \qquad (1)$$

$$Dm_k = dm_k - bm_1 p_m + br_2 p_r - \psi r * ss + \xi'_k \qquad (2)$$

where, the coefficients br_1 and bm_1 are the coefficients of the price elasticity in the retail channel and direct channel demand functions, respectively. The cross-price sensitivities br_2 and bm_2 reflect the degree to which the goods are sold via two channels are substitutes, and ψm and ψr are the service sensitivity of the demand in the direct channel. If the service level ss increases by one unit, ψm units of demand (customers) will be lost from the direct channel, of which ψr units of demand will transfer to the retail channel. The total demand of the two channels should be downward sloping in the retailer’s price, direct sale price and upward sloping in the service level. Thus, we have $bm_2 < br_1$, $br_2 < bm_1$ and $\psi m < \psi r$. ξ_k and ξ'_k are random variable with PDF (probability density function) $f(.)$ and CDF (cumulative distribution function) $F(.)$, that does not depend on the price and service level and shift the demand randomly about the mean. The related works that considered linear-additive functional demand form include (Chen &Simchi-Levi [29]; Dana & Petruzzi [30]; Federgruen & Heching [31]).

We will formulate this problem as a two-stage stochastic recourse model. Such a model includes primary decisions at first stage according to the related decisions to opening or non-opening the centers, prices, and service level at any channel, and quantity of products that transfers from producer to any retailer in such a way that after their determination, the values of the stochastic events may be characterized and decisions are made at the second stage. The decisions at second stage include rate of supply by retailers, supply through direct channel and rates of the returned products. We employ the scenario-tree method to solve the stochastic model. For this purpose, suppose the given stochastic vector $\xi = (\xi_1, ..., \xi_K, \xi'_1, ..., \xi'_K)$ with certain number scenarios $\xi^s = (\xi_1^s, ..., \xi_K^s, \xi_1'^s, ..., \xi_K'^s)$ and probability ϑ^s while $s = 1 \ldots S$. With respect to the above-said definitions, the given indices, parameters, and the variables at first and second stage are defined according to the scenario as follows:

Sets

I Set of potential production/recovery center locations $i \in I$

J Set of hybrid distribution-collection center locations $j \in J$

K Set of fixed locations of customer zones $k \in K$

M Set of potential disposal center locations $m \in M$

Parameters

ϕ The Cost of providing a unit of service level

br_1 The coefficient of price elasticity in retail channel

br_2 The coefficient of cross-price sensitivities in retail channel

bm_1 The coefficient of price elasticity in direct channel

bm_2 The coefficient of cross-price sensitivities in direct channel

ψr The coefficient of service elasticity in retail channel

ψm The coefficient of service elasticity in e-tail channel

dm_k Base level of direct channel demand for customer k

dr_K Base level of retail channel demand for customer k

r_k Rate of return of used products from retail channel customer k

r'_k Rate of return of used products from direct channel customer k

γ_j Rate of return of products by distributer j to producers

λ Average disposal fraction in direct and indirect channels

λ' Average disposal fraction for returned products by distributors

f_i Fixed cost of opening production/recovery center i

g_j Fixed cost of opening hybrid distribution-collection center j

h_m Fixed cost of opening disposal center m

c_{ij} Shipping cost per unit of products from production/recovery center i to hybrid distribution-collection center j

ff_{ik} Shipping cost per unit of products from production/recovery center i to direct channel customer k

a_{jk} Shipping cost per unit of products from hybrid distribution-collection center j to retail channel customer k

b_{kj} Shipping cost per unit of products from customer k to hybrid distribution-collection center j

e_{ji} Shipping cost per unit of products from hybrid distribution-collection center j to production/recovery center i

π_{jm} Shipping cost per unit of products from hybrid distribution-collection center j to disposal center m

ρ_i Manufacturing cost per unit of product at production/recovery center i

θ_i Recovery cost per unit of product at production/recovery center i

v_j Processing cost per unit of product at hybrid distribution-collection center j

η_m Disposal cost per unit of product at disposal center m

τ_i Penalty cost per unit of non-utilized capacity at production/recovery center i

β_j Penalty cost per unit of non-utilized capacity at hybrid distribution-collection center j

α_m Penalty cost per unit of non-utilized capacity at disposal center m

cw_i Capacity of production/recovery center i

cy_j Capacity of handling products in forward flow at hybrid distribution-collection center j

cz_m Capacity of handling products at disposal center m

cyr_j Capacity of handling products in reverse flow at hybrid distribution-collection center j

cwr_i Capacity of recovery for production/recovery center i

$mservice$ Upper limit of service level in retail channel.

The first stage variables are $X_{ij}, N_{ji}, p_m, p_r, W_i, Y_j, Z_m$ and the second stage variables are as follows:

O_{ik}^{s} Quantity of products in direct channel shipped from production/recovery center *i* to customer zone *k* under scenario *s*

U_{jk}^{s} Quantity of products shipped from hybrid distribution-collection center *j* to customer zone *k* under scenario *s*

Q_{kj}^{s} Quantity of returned products shipped from customer zone *k* to hybrid distribution-collection center *j* under scenario *s*

V_{ji}^{s} Quantity of returned products shipped from hybrid distribution-collection center *j* to production/recovery center *i* under scenario *s*

T_{jm}^{s} Quantity of irreparable products shipped from hybrid distribution-collection center *j* to disposal center *m* under scenario *s*

M_{kj}^{s} Quantity of returned products from direct channel customer zone *k* to hybrid distribution-collection center *j* under scenario *s*

The formulation of proposed stochastic model is as follows;

$$\begin{aligned}
MaxZ = &\sum_{k}\sum_{i}\sum_{s}\vartheta^{s}p_{m}O_{ik}^{s}+\sum_{j}\sum_{k}\sum_{s}\vartheta^{s}p_{d}U_{jk}^{s}-\sum_{i}f_{i}W_{i}-\sum_{j}g_{j}Y_{j}-\\
&\sum_{m}h_{m}Z_{m}-\sum_{i}\sum_{k}\sum_{s}\vartheta^{s}\,ff_{ik}O_{ik}^{s}-\sum_{\varpi}(\sum_{i}\sum_{j}(\rho_{i}+c_{ij})X_{ij}-\\
&\sum_{j}\sum_{k}\sum_{s}\vartheta^{s}(\nu_{j}+a_{jk})U_{jk}^{s}-\sum_{k}\sum_{j}\sum_{s}\vartheta^{s}(\nu_{j}+b_{kj})(Q_{kj}^{s}+M_{kj}^{s})-\\
&\sum_{j}\sum_{i}\sum_{s}\vartheta^{s}(\theta_{i}+e_{ji})(V_{ji}^{s}+N_{ji})-\\
&\sum_{j}\sum_{m}\sum_{s}\vartheta^{s}(\eta_{m}+\pi_{jm})T_{jm}^{s}-\sum_{m}\sum_{s}\alpha_{m}(Z_{m}cz_{m}-\sum_{j}\vartheta^{s}T_{jm}^{s})\\
&-\sum_{i}\tau_{i}\left[(W_{i}cw_{i}-(\sum_{j}X_{ij}+\sum_{k}\sum_{s}\vartheta^{s}O_{ik}^{s})+(W_{i}cwr_{i}-(\sum_{j}\sum_{s}\vartheta^{s}V_{ji}^{s}+\sum_{j}N_{ji}))\right]-\\
&\sum_{j}\beta_{j}\left[(Y_{j}cy_{j}-\sum_{k}X_{jk})+(Y_{j}cyr_{i}-(\sum_{k}\sum_{s}\vartheta^{s}Q_{kj}^{s}+\sum_{k}\sum_{s}\vartheta^{s}M_{kj}^{s}))\right])-ss*\phi
\end{aligned} \tag{3}$$

s.t.

$$\sum_{j}U_{jk}^{s}\le(dr_{k}-br_{1}p_{r}+bm_{2}p_{m}+\psi r\times ss+\xi_{k}^{s})\quad\forall k\in K,\ s\in S \tag{4}$$

$$\sum_{i}O_{ik}^{s}\le(dm_{k}-bm_{1}p_{m}+br_{2}p_{r}-\psi r*ss+\xi_{k}^{'s})\quad\forall k\in K,\ s\in S \tag{5}$$

$$\sum_{j}Q_{kj}^{s}=r_{k}\sum_{j}U_{jk}^{s}\quad\forall k\in K,\ s\in S \tag{6}$$

$$\sum_{j}M_{kj}^{s}=r'_{k}\sum_{i}O_{ik}^{s}\quad\forall k\in K,\ s\in S \tag{7}$$

$$(1-\gamma_{j})\sum_{i}X_{ij}\ge\sum_{k}U_{jk}^{s}\quad\forall j\in J,\ s\in S \tag{8}$$

$$\sum_{i}V_{ji}^{s}-(1-\lambda)(\sum_{k}Q_{kj}^{s}+\sum_{k}M_{kj}^{s})=0\quad\forall j\in J,\ s\in S \tag{9}$$

$$\sum_{m}T_{jm}^{s}-\lambda(\sum_{k}Q_{kj}^{s}+\sum_{k}M_{kj}^{s})-\gamma_{j}(\lambda')\sum_{i}X_{ij}=0\quad\forall j\in J,\ s\in S \tag{10}$$

$$\sum_{i}N_{ji}=\gamma_{j}(1-\lambda')\sum_{i}X_{ij}\quad\forall j\in J \tag{11}$$

$$p_{m}\ge\rho_{i}\quad\forall i\in I \tag{12}$$

$$p_{d}\ge v_{j}\quad\forall j\in J \tag{13}$$

$$\sum_{j}X_{ij}+\sum_{k}O_{ik}^{s}\le cw_{i}W_{i}\quad\forall i\in I,\ s\in S \tag{14}$$

$$\sum_{i}X_{ij}\le cy_{j}Y_{j}\quad\forall j\in J \tag{15}$$

$$\sum_{k}Q_{kj}^{s}+\sum_{k}M_{kj}^{s}\le cyr_{j}Y_{j}\quad\forall j\in J,\ s\in S \tag{16}$$

$$\sum_{j}V_{ji}^{s}+\sum_{j}N_{ji}\le cwr_{i}W_{i}\quad\forall i\in I,\ s\in S \tag{17}$$

$$\sum_{j}T_{jm}^{s}\le cz_{m}Z_{m}\quad\forall m\in M,\ s\in S \tag{18}$$

$$ss\le Mservice \tag{19}$$

$$\begin{aligned}
&W_{i},Y_{j},Z_{m}\in\{0,1\}\quad\forall i\in I,\ \forall j\in J,\forall m\in M\\
&X_{ij},U_{jk}^{s},Q_{kj}^{s},V_{ji}^{s},T_{jm}^{s},N_{ji},M_{kj}^{s},O_{ik}^{s},p_{d},p_{m},ss\ge0\\
&\forall i\in I,\ j\in J,\ k\in K,\ m\in M,\ s\in S
\end{aligned} \tag{20}$$

Objective function is profit maximization including total revenue and costs from two channels. Constraints (4) and (5) guarantee that the sent products to the customer may meet the demand wholly or partially. The constraints (6) and (7) define respectively the collection of returned products in direct and indirect channel. The constraint (8) is the balancing constraint at production/recovery and hybrid distribution collection centers in forward flow.

The constraint (9) insures that, the flow of repairable products existing from hybrid distribution/collection centers is equal to the flow entering to production/recovery centers. The constraint (10) indicates quantity of the transferred products to disposal centers. The constraint (11) shows the amount of products, which are returned by distributor to the producer. The constraints (12) and (13) denote the sale prices should be greater than process costs at production and distribution/collection centers.

Constraints (14-18) are capacity constraints that ensure the production capacity in each center is not exceeded. Finally, the constraint (19) identifies the upper bound for the distributor's service level.

TABLE 1. Computational results for VSS and the stochastic programming solutions with respect to different probability distributions

	Uniform (-400, 400)			**Uniform (-1000, 1000)**		
	Q^*	**EEV**	**VSS**	**Q^***	**EEV**	**VSS**
Optimal values	4410584	3318367	1092217	4354760	342602	4012158
	5016065	3277029	1739036	4450002	1043372	3406630
	4739643	3210228	1529415	2958003	1083916	1874087
	4524917	3182271	1342646	3618077	334466	3283611
	4663731	4032283	631448	5908565	1162397	4746168
	EXP(500)			**EXP(1000)**		
	Q^*	**EEV**	**VSS**	**Q^***	**EEV**	**VSS**
Optimal values	6390871	4331456	2059415	6927227	4788495	2138732
	5943686	4256678	1687008	10795918	4635916	6160002
	5489227	4633543	855684	8657453	4900606	3756847
	6427444	4292808	2134636	8468587	4719520	3749067
	6240829	4498743	1742086	6962835	4881446	2081389
	Normal(100)			**Normal(1000)**		
	Q^*	**EEV**	**VSS**	**Q^***	**EEV**	**VSS**
Optimal values	4275990	3695557	580433	12421250	8199371	4221879
	4391981	3449710	942271	10857782	9246283	1611499
	4460511	3783662	676849	11569736	4671529	6898207
	4404930	3737229	667701	11397324	2374829	9022495
	4229052	4058084	170968	9463103	4543860	4919243

3. VALUE OF STOCHASTIC PROGRAMMING

Stochastic programs are computationally expensive and difficult to solve. Therefore, for real-world problems, simpler models have been considered. For example, some researchers have solved the deterministic program by replacing all random variables with their expected values. The Value of the Stochastic Solution (VSS) has been used as measure of the accuracy in these studies. The concept of VSS can be used to determine whether putting extra effort into modeling and solving stochastic programming can be beneficial. Let $\bar{Z}(\bar{\xi})$ be the optimal decision of the first stage in deterministic problem where all random variables are replaced by their expected values. The VSS is then defined as $VSS = Q^* - EEV$, with $EEV = E_{\xi}(Q(\bar{Z}(\bar{\xi}), \xi))$. EEV is expected result of using EV (expected value program) solution. If this difference is large enough, it indicates that using the stochastic programming approach is beneficial. In this section, we compute this measure and study the effect of the distribution function type and variance of stochastic factor ξ in demand function, on VSS. For this purpose, sensitivity analysis has been carried out for different probabilistic functions as follows: In Table 1, it can be seen that as the mean value and variance of distributions increase, the VSS also increases. In Table 1, VSS value in mode (Uniform [-1000, 1000]) is greater than mode (Uniform [-400, 400]) in all cases.The VSS values for distributions with greater mean and variance are higher than the VSS values for distributions with lower mean value and variance at all modes.

4. CONCLUSION

In this paper, we proposed a new mixed integer linear programming model for designing integrated forward/reverse logistics based on pricing policy in direct and indirect sales channel. We could calculate the optimal sale prices in direct and indirect sales channels using our model. The stochastic counterpart of the proposed MILP model was also developed by using scenario-based stochastic approach, considering uncertain demand with specific probability distribution.

Value of stochastic solution (VSS) was calculated to evaluate the accuracy of stochastic programming approach. By considering different probability distribution for uncertain demands, the results showed that the VSS values for distribution with greater mean and variance are higher than the VSS values for distributions with lower mean value and variance at all cases.

5. REFERENCES

1. Keyvanshokooh, E., Fattahi, M., Seyed-Hosseini, S. and Tavakkoli-Moghaddam, R., "A dynamic pricing approach for returned products in integrated forward/reverse logistics network design", ***Applied Mathematical Modelling***, Vol. 37, No. 24, (2013), 10182-10202.

2. Fleischmann, M., Bloemhof-Ruwaard, J.M., Dekker, R., Van der Laan, E., Van Nunen, J.A. and Van Wassenhove, L.N., "Quantitative models for reverse logistics: A review", ***European Journal of Operational Research***, Vol. 103, No. 1, (1997), 1-17.
3. Srivastava, S.K., "Network design for reverse logistics", ***Omega***, Vol. 36, No. 4, (2008), 535-548.
4. Du, F. and Evans, G.W., "A bi-objective reverse logistics network analysis for post-sale service", ***Computers & Operations Research***, Vol. 35, No. 8, (2008), 2617-2634.
5. Pishvaee, M.S., Jolai, F. and Razmi, J., "A stochastic optimization model for integrated forward/reverse logistics network design", ***Journal of Manufacturing Systems***, Vol. 28, No. 4, (2009), 107-114.
6. Pokharel, S. and Mutha, A., "Perspectives in reverse logistics: A review", ***Resources, Conservation and Recycling***, Vol. 53, No. 4, (2009), 175-182.
7. Georgiadis, P., "An integrated system dynamics model for strategic capacity planning in closed-loop recycling networks: A dynamic analysis for the paper industry", ***Simulation Modelling Practice and Theory***, Vol. 32, (2013), 116-137.
8. Govindan, K., Soleimani, H. and Kannan, D., "Reverse logistics and closed-loop supply chain: A comprehensive review to explore the future", ***European Journal of Operational Research***, Vol. 240, No. 3, (2015), 603-626.
9. Lambert, S., Riopel, D. and Abdul-Kader, W., "A reverse logistics decisions conceptual framework", ***Computers & Industrial Engineering***, Vol. 61, No. 3, (2011), 561-581.
10. Uster, H., Easwaran, G., Akçali, E. and Cetinkaya, S., "Benders decomposition with alternative multiple cuts for a multi-product closed-loop supply chain network design model", ***Naval Research Logistics (NRL)***, Vol. 54, No. 8, (2007), 890-907.
11. Amiri, A., "Designing a distribution network in a supply chain system: Formulation and efficient solution procedure", ***European Journal of Operational Research***, Vol. 171, No. 2, (2006), 567-576.
12. Pati, R.K., Vrat, P. and Kumar, P., "A goal programming model for paper recycling system", ***Omega***, Vol. 36, No. 3, (2008), 405-417.
13. Aras, N., Aksen, D. and Tanugur, A.G., "Locating collection centers for incentive-dependent returns under a pick-up policy with capacitated vehicles", ***European Journal of Operational Research***, Vol. 191, No. 3, (2008), 1223-1240.
14. Kamali, H., Sadegheih, A., Vahdat-Zad, M. and Khademi-Zare, H., "Deterministic and metaheuristic solutions for closed-loop supply chains with continuous price decrease", ***International Journal of Engineering***, Vol. 27, No. 12, (2014), 1897-1906.
15. Sahraeian, R., Bashiri, M. and Moghadam, A.T., "Capacitated multimodal structure of a green supply chain network considering multiple objectives", ***International Journal of Engineering-Transactions C: Aspects***, Vol. 26, No. 9, (2013), 963-974.
16. Pishvaee, M.S., Rabbani, M. and Torabi, S.A., "A robust optimization approach to closed-loop supply chain network design under uncertainty", ***Applied Mathematical Modelling***, Vol. 35, No. 2, (2011), 637-649.
17. Pishvaee, M. and Torabi, S., "A possibilistic programming approach for closed-loop supply chain network design under uncertainty", ***Fuzzy Sets and Systems***, Vol. 161, No. 20, (2010), 2668-2683.
18. Pishvaee, M., Torabi, S. and Razmi, J., "Credibility-based fuzzy mathematical programming model for green logistics design under uncertainty", ***Computers & Industrial Engineering***, Vol. 62, No. 2, (2012), 624-632.
19. Vahdani, B., Tavakkoli-Moghaddam, R. and Jolai, F., "Reliable design of a logistics network under uncertainty: A fuzzy possibilistic-queuing model", ***Applied Mathematical Modelling***, Vol. 37, No. 5, (2013), 3254-3268.
20. Cattani, K.D., Gilland, W.G. and Swaminathan, J.M., Coordinating traditional and internet supply chains, in Handbook of quantitative supply chain analysis,(2004), Springer, 643-677.
21. Tsay, A.A. and Agrawal, N., Modeling conflict and coordination in multi-channel distribution systems: A review, in Handbook of quantitative supply chain analysis,(2004), Springer, 557-606.
22. Balasubramanian, S., "Mail versus mall: A strategic analysis of competition between direct marketers and conventional retailers", ***Marketing Science***, Vol. 17, No. 3, (1998), 181-195.
23. Tsay, A.A. and Agrawal, N., "Channel conflict and coordination in the e-commerce age", ***Production and Operations Management***, Vol. 13, No. 1, (2004), 93-110.
24. Chiang, W.-y.K., Chhajed, D. and Hess, J.D., "Direct marketing, indirect profits: A strategic analysis of dual-channel supply-chain design", ***Management Science***, Vol. 49, No. 1, (2003), 1-20.
25. Mirzahosseinian, H., Makui, A., Teimoury, E., Ranjbar-Bourani, M. and Amoozad-Khalili, H., "Impact of transportation system on total cost in a two-echelon dual channel supply chain", ***International Journal of Engineering, Transactions B: Applications***, Vol. 24, (2011), 27-36.
26. Ahmadvand, A., Asadi, H. and Jamshidi, R., "Impact of service on customers' demand and members' profit in supply chain", ***International Journal of Engineering***, Vol. 25, No. 3, (2012), 213-222.
27. Yang, G. and Liu, Y., "Designing fuzzy supply chain network problem by mean-risk optimization method", ***Journal of Intelligent Manufacturing***, (2013), 1-12.
28. Dan, B., Xu, G. and Liu, C., "Pricing policies in a dual-channel supply chain with retail services", ***International Journal of Production Economics***, Vol. 139, No. 1, (2012), 312-320.
29. Chen, X. and Simchi-Levi, D., "Coordinating inventory control and pricing strategies with random demand and fixed ordering cost: The finite horizon case", ***Operations Research***, Vol. 52, No. 6, (2004), 887-896.
30. Dana Jr, J.D. and Petruzzi, N.C., "Note: The newsvendor model with endogenous demand", ***Management Science***, Vol. 47, No. 11, (2001), 1488-1497.
31. Federgruen, A. and Heching, A., "Combined pricing and inventory control under uncertainty", ***Operations Research***, Vol. 47, No. 3, (1999), 454-475.

A Two Stage Stochastic Programming Model of the Price Decision Problem in the Dual-channel Closed-loop Supply Chain

A. Ahmadi Yazdi , M. Honarvar

Department of Industrial Engineering, Yazd University, Yazd, Iran

PAPER INFO

Paper history:
Received 27 November 2014
Received in revised form 19 January 2015
Accepted 13 March 2015

Keywords:
Logistic Network
Reverse Logistics
Ntegrated Logistics
Pricing Policy
Multi-channel Sale

چکیده

در این مقاله, یک مدل جدید برای لجستیک یکپارچه پیشرو/معکوس بر اساس سیاست قیمت گذاری در کانال فروش مستقیم و غیر مستقیم پیشنهاد شده است. مدل پیشنهادی شامل تولید کننده, مراکز دفن, توزیع کننده و مشتری نهایی می‌باشد. ما فرض کردیم که مکان مشتری‌های نهایی ثابت است. درابتدا, یک مدل برنامه ریزی خطی مختلط عدد صحیح قطعی برای طراحی شبکه لجستیک یکپارچه توسعه داده می‌شود. سپس مدل احتمالی همتای مدل خطی عدد صحیح مختلط پیشنهادی با استفاده از رویکرد سناریو سازی توسعه داده می‌شود. ما از شاخص ارزش حل احتمالی به عنوان یک معیار اندازه‌گیری برای دقت رویکرد برنامه‌ریزی احتمالی استفاده می‌کنیم. مقدار VSS نشان داد که استفاده از رویکرد احتمالی برای حل مدل پیشنهادی مناسب می‌باشد. علاوه بر این, ما توانستیم مقادیر بهینه قیمت فروش در کانال مستقیم و غیر مستقیم فروش و سطح خدمت را با در نظر گرفتن توام جریان مستقیم و معکوس به دست بیاوریم.

.***doi***: *10.5829/idosi.ije.2015.28.05b.12*