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Optimization of multi-product, multi-period closed loop supply chain under uncertainty in product return rate: case study in Kallehdairy company

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Abstract

Closed Loop production systems attempt to economic improvement, deliver goods to customers with the best quality, decrease in the return rate of expired material and decrease environmental pollution and energy usage. In this study, we solve a multi-product, multi-period closed loop supply chain network in Kalleh dairy company, considering the return rate under uncertainty. The objective of this paper is to develop a supply chain model including raw material suppliers, manufacturers, distributors and a recycle center for returned products. Solving this model helps us to make a good decision about providing materials, production, distribution and recovery. Our basic goal is to estimate optimum return rate of some products such as yoghurt, to production cycle. Once the products pass $\frac{3}{4}$of their shelf life, they are returned to production cycle. For this study, we develop a linear programming model with a consideration of chance constraints. Finally, this model is implemented by Lingo software with using real data. The obtained results by our model show 9.5 % decrease for total cost in comparison with the current status.

Keywords: Closed loop supply chain, Optimization, Multi-Product, Multi-Period

1.Introduction

1-1- Forward supply chain in Kalleh dairy company

Forward supply chain in Kalleh Company includes suppliers, manufacturers, sale organization and distributors. Supplier of Kalleh is a Pole company; Pole company supplies

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allmaterials, necessities and machineries of this company. In some cases such as buying milk, Pole company has all types of machines in whichthe selection of the optimum machineis one of the main decisions in their model. The major focus of the company through forward supply chain is supply and production, and also BanyChow Company is responsible for product distribution.

1.2. Reverse supply chain

Reverse logistics is defined by Fleischmann (2001) as the processes of planning, implementing and controlling the inbound flow, storage of secondary goods and related information opposite to the traditional supply chain directions for the purpose of recovering value and proper disposal.

Reverse supply chain includes initial collection centers and recovery centers. In Kalleh company, products are returned to an initial point by two cases: products that have passed $\frac{3}{4}$of their shelf life and products which were not produced with good quality. Therefore, this product is sold either in lower price or is entered to production cycle for producing other products. Moreover, wastages are sold.

1.3. Closed loop supply chain

Forward and reverse logistic activities are wholly in reaction with each other but we cannot consider a clear boundary between them. To decrease of costs and increase of competitive power and acquiring environmental and governmental rules, we should consider both forward and return chain, synchronously. Economic difficulties in Iran and increase of inflation lead to increase of accomplished cost for products. As a result, demand for dairy products decreased and people are seeking for buying products with lower price. Therefore, decrease of total cost is very important. Although recovery of expired products does not have any effect on total cost, but the total cost of the supply chain will have a significant impact in high production volume.

1.4. Recovery in Kalleh dairy company

In this study, two products with names of Dough and yogurt are investigated. In fact, the yogurt product after disapproval of quality control or passing $\frac{3}{4}$of shelf life is collected in initial collection points. Glasses of Dough are soldout. Recycle yogurt is transmitted to a saloon of cooking Dough and then it is converted to Dough.

2. Literature review

A major issue in the reverse distribution is integration of forward and reverse supply chain.returns, is that information captured should be integrated with forward supply chain information to achieve optimum planning and costs reduction. Ko and Evans (2007) proposed a mixed-integer nonlinear programmingmodel that was a multi period, two-echelon, multi commodity,and capacitated network design problem. They considered forward and reverse flows, simultaneously.

Barros, Dekker, and Scholten (1998) proposed a MILP model for a sand recycling network. A heuristic algorithm is also used to solve the problem. The results obtained for the sand recycling network in the Netherlands were summarized. Min, Ko, and Park (2005) formulated a mathematical model for a common closed loop supply chain network. Although this model could determine the optimum number of centers for separating segments; but processing suppliers selection was not considered. Authors considered only one supplier.

Guide and Van Wassenhove (2009) categorized closed loop supply chain networks to five phases: (1) the golden age of remanufacturing. (2) From remanufacturing to valuing the reverse-logistics. (3) Coordinating the reverse supply chain. (4) Closing the loop. (5)Prices and markets. In addition, they stated that in reality, end of use, end of life, and commercial returns are the most important kinds of returns. Melo, Nickel, and Saldanha-da-Gama (2009) examined the application of facility location models in the supply chain management. In one of the categories, they divided the literature of reverse logistics to closed loop, and recovery networks.Krikke, Harten, and Schuur (1999) designed a MILP model for a two-stage reverse supply chain network for a copier manufacturer. In this model, both the processing costs of returned products and inventory costs were included in the objective function to minimize the total cost. Nagurney, and Dong (2002) investigated a close loop supply chain network in which demand and return of product is indeterminate. Hassanzadeh and zhang (2012) suggested a mixed integer programming model (0, 1)in which synchronous forward and backward current and mutual interactions were considered. Formulated problem was developed as a model for finding a place for non-capacity facilities and also an initiative algorithm based on Lagrangian was developed. Jayaraman,Guide,and Srivastava (1999)proposed a mixed-integer programming model. The model can determine the location of remanufacturing/distribution facilities, the transhipment, and production centers. Fleischmann et al. (1997) examined reverse logistics from an operations researcher view point. They categorized papers into three main groups including distribution - planning, inventory, and production planning. Lee, and Dong (2008) proposed a deterministic programming model by considering the hybrid processing facilities for systematically managing forward and EOL returned product flows. Due to the problem complexity and the large number of variables and constraints, a two-stage heuristic approach has been developed to decompose the integrated design of the multi-echelon forward and reverse logistics distribution networks into a location–allocation problem and a revised network flow problem. A tabu search algorithm was applied to obtain the improved solution of shipping the returned products. The numerical experiments have suggested that the proposed heuristic solution algorithm performed well in terms of solution quality and computational time consumed.Shi, Zhang, and Sha (2011) concentrated on a problem of increasing environmental concern of electric rubbishes and presented an integrated framework for modeling management of scraps that included recycling. Rogers, and Tibben-Lembke (1999) investigated a total close loop supply chain that including manufacturing, separating segments, remanufacturing and disposal sites. They suggested an integrated model that included two stages. In the first stage, a framework was presented for selection criteria of good suppliers in reveres logistic. In addition, a fuzzy method was designed for evaluation of suppliers based on the quality criteria. In the second stage, they suggested a mixed integer multi-objective linear programming model for determination of suppliers and remanufacturing sites that should be selected. Their objective function was maximizing suppliers profit and minimization of deterioration rate. Schultmann, Engels, and Rentz (2003) developed a hybrid method to establish a closed loop supply chain for spent batteries. The model included a two-stage (collection point-sorting – recycling or disposal) facility location problem. Lu and Bostel (2007) presented a two-level location problem with three types of facility to be located in a specific reverse logistics system, named a remanufacturing network (RMN). For this problem, they proposed a 0–1 mixed integer programming model, in which they simultaneously consider “forward” and “reverse” flows and their mutual interactions. An algorithm based on Lagrangian heuristics was developed and the model was tested on data adapted from classical test problems. Fleischmann et al. (2001) considered the integration of forward and reverse distribution, and gave a generic integer programming formulation. They took two cases of photocopier remanufacturing and paper recycling. They showed that there was a potential for cost savings if one undertook an integrated view rather than a sequential design of the forward and reverse distribution networks. Pishvaee, Rabbani, and Torabi (2011) presented a robust optimization approach for closed loop supply chain network design under uncertainty, and their model were include two sections. First, a deterministic mixed-integer linear programming model was developed for designing a closed loop supply chain network. Then, the robust counterpart of the proposed mixed integer linear programming model was presented by using the recent extensions in robust optimization theory. Finally, to assess the robustness of the solutions obtained, solutions were compared to those generated by the deterministic mixed-integer linear programming model. Listes (2007) proposed a generic scenario-based stochastic programming model for the design of integrated forward/reverse supply chain network design. A decomposition method was presented to solve the model in large-sized instances based on the branch-and-cut procedure.

Nowadays, a renewed focus on planning for agri-food supply chain has been appeared because food security is very important for each country. This food thread will be worse with population growth, loss of productive land and ungovernable inflation of food price (Tan, and Çömden, 2012). Quality variability during transportation and storage time becomes the most complicated issue to supply the perishable food consumers (Rong, Akkerman, and Grunow, 2011 and Yu, and Nagurney, 2013). However, the newborn attentions in food safety and quality invoke models of fresh agri-foods that consider simultaneously operational and biological research (Akkerman, Farahani, and Grunow, 2010).

Other one presents an integrated production and distribution model.Amorim, Günther, and Almada-Lobo (2012) considered customers who prefer products with higher freshness. Thus, they develop a multi-objective structure with two objective functions. The first objective minimizes total operational cost regarded to transportation, production and disposal practices. The second one maximizes revenue earned by satisfaction of customers. Rong, Akkerman, and Grunow (2011) also represented a production and distribution planning taking into account trade-off between preservation costs of reduction quality and saving cost caused by this preservation. They assumed quality value declining linearly over the time but this degradation was different for each temperature. At the end, Ahumada and Villalobos (2011) consider the perishability of fresh products with using two discrete ways through a loss function in an objective function and a constraint for prevention from passing shelf life. Some papers have discussed different models for supplier selection.Haji et. al. (2007) proposed a new model for price discount and stochastic initial inventory in the newsboy problem. Finally, Rajkumar, Sivakumar, and Arivarignan (2011) introduced a novel model for continuous review perishable inventory system with one supplier, one retailer and positive lead time.

3. Problem description

There is a consideration on closed loop chain for a supply chain of dairy product. In such situations, products with low quality and nearly ended their shelf life can be entered in to production cycle again. There is not any difference between recycled product and other products, and they can be sold with the same price. Dairy products supply chain includes two phases:

1- Forward supply chain includes suppliers, manufacturers and distributors.

2- Reverse supply chain includes initial collection points, recycle centers and production.

Determining optimum quantity of purchase in various periods, optimum vehicles for supplying raw materials, optimum quantity of production in various periods, optimum recycle rate are some question that we are going to answer. Figure 1 shows Close loop supply chain network in Kalleh dairy company.

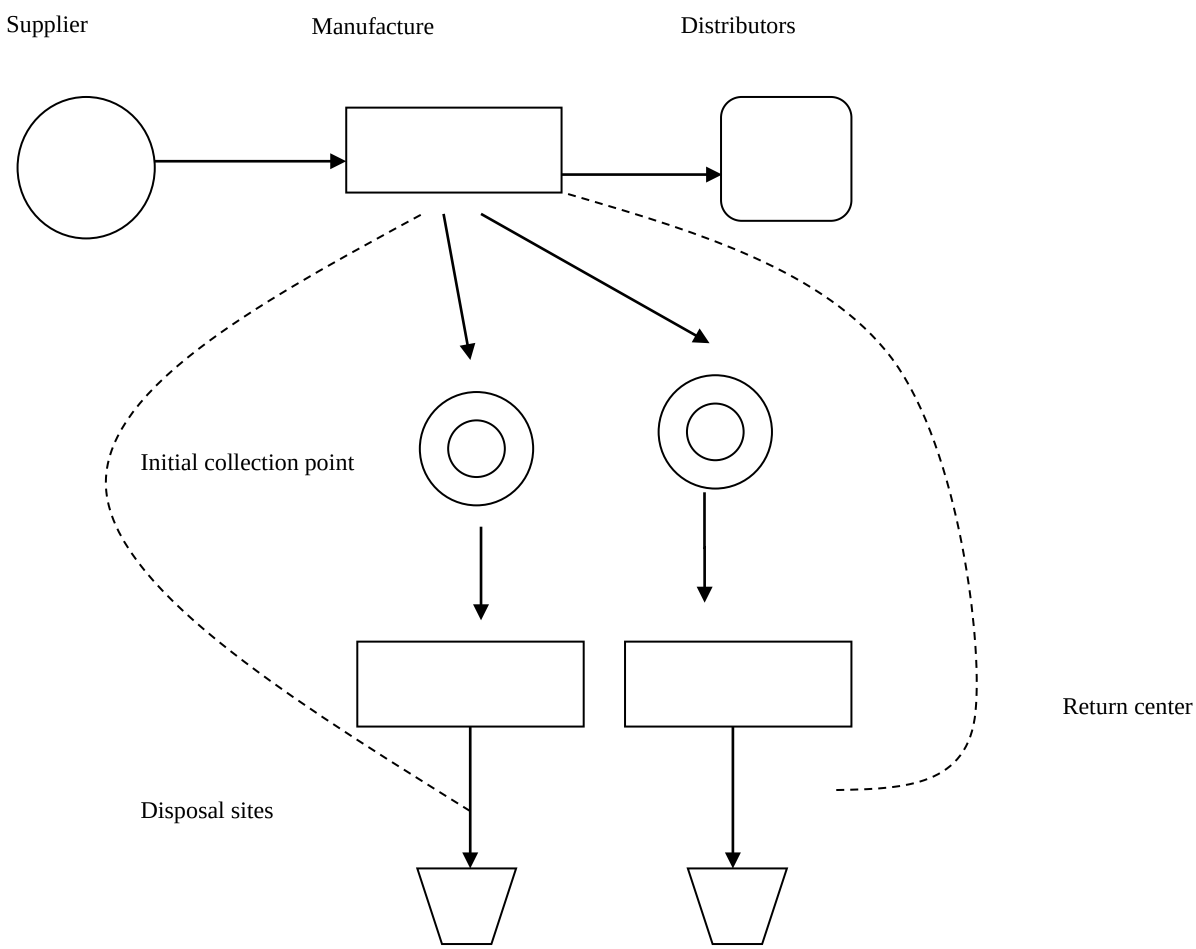

Figure 1. General Structure of the CLSC network in Kalleh Company

3.1. Assumptions

- The transportation cost per product from the supplier to the manufacturing plant is included in the raw material purchasing cost.
- The daily demand of the customer is deterministic, and shortages are not allowed.
- The transportation cost per product from each plant to all distributors is fixed for all the periods.
- The inventory maintenance cost per product, per period at each plant, each distributor, and each wholesaler remains the same throughout the planning period.
- The capacities are limited.
- The inspection cost per item for the returned products are included in the collection cost.
- The un-recyclable returned products will be sent to the disposal site after some pretreatment process
- Lead time is fixed.

3.2. Indices and sets

i: Index for raw materials

j: Index for manufacturing plants

x: Index for initial collection points

z: Index for disassembly/recycling plants

t: Index for time periods

s: Index for suppliers

k: Index for distributors

p: Index for products

l: Index for supplier transportation

d: Index for distribution transportation

y: Index for disposal sites

3.3. Notations

TC	Total closed loop supply chain costs
$TPUC$	Total purchasing costs
TPC	Total processing costs
$TPDTC$	Total transportation costs between manufacturing plant and distribution center
$TSPTC$	Total transportation costs between suppliers and manufacturing plant
$TRMIC$	Total carrying costs for raw material inventory at the manufacturing plant
$TFGIC$	Total carrying costs for finished goods inventory at the manufacturing plant
TCC	Total collection cost of the returned items
TDC	Total disposal costs
$TRPC$	Total disassembly/reclaiming cost at the disassembly/recycling plant
$TRPTC$	Total transportation costs between disassembly/recycling plant and manufacturing plant
PUC_{ist}	Purchasing cost of one unit of raw material ‘i’ from supplier ‘s’ during time period ‘t’
PC_{jpt}	Processing cost per product ‘p’ at manufacturing plant ‘j’ at time period ‘t’
$TCSP_{sjit}$	Transportation cost per unit for supplier ‘s’to manufacturing plant ‘j’for raw material ‘i’at period ‘t’transferred by vehicle ‘l’
$TCPD_{jkptd}$	Transportation cost per unit for manufacturing plant ‘j’to distributor ‘k’for product of ‘p’at period ‘t’transferred by vehicle ‘d’
TRC_{izt}	Total recycling cost from the disassembly/recycling plant to the third party
ICC_{pt}	Inventory carrying cost per unit, per period for returned products of product ‘p’ during the time period ‘t’
RMI_{ijt}	Inventory of raw material ‘i’ at the manufacturing plant ‘j’ during the time period ‘t’
RIC_{ijt}	Inventory carrying cost per unit, per period of raw material ‘i’ at the manufacturing plant ‘j’ during the time period ‘t’
RC_{izt}	Recycling cost of one unit of raw material ‘i’ sold to the third party from the disassembly/recycling plant ‘z’ during the time period ‘t’
X_i	Amount of raw material ‘i’ required to produce one item of product ‘p’
FGI_{jpt}	Amount of inventory for finished goods of product ‘p’ at the manufacturing plant ‘j’ during the time period ‘t’
FIC_{jpt}	Inventory carrying cost per unit, per period for finished goods of product ‘p’ at the manufacturing plant ‘j’ during the time period ‘t’
CC_{xpt}	Collection cost per item of returned products ‘p’ at the initial collection point ‘x’ during the time period ‘t’
CI_{pt}	Returned products inventory for product ‘p’ at the centralized return center during the time period ‘t’
$TCIC_{xpt}$	Transportation cost per unit from the initial collection point ‘x’ to the centralized return center of product ‘p’ at time period ‘t’
PRS_j	Capacity for raw material storage at the manufacturing plant ‘j’
$PFSj$	Capacity for finished goods storage at the manufacturing plant ‘j’
SC_{is}	Capacity for supplier ‘s’
PT_j	Available processing time in plant ‘j’
DSC_k	Storage capacity for the distributor ‘k’
DC_{ypt}	Disposal cost per unit of useless returned product ‘p’ in the disposal site ‘y’ at the time period ‘t’

CD_{zpt}	Capacity of the disassembly/recycling plant ‘*z*’ for product ‘*p*’ at time period ‘*t*’
DD_{pt}	Amount of demand for retailer ‘*m*’ for product ‘*p*’ at time period ‘*t*’
QC_{xp}	Quantity of returned items of product ‘*p*’ collected at the initial collection points ‘*x*’ during the time period ‘*t*’
DR_p	Disposal rate of product ‘*p*’ at time period ‘*t*’
QRP_{pt}	Quantity of returned products ‘*p*’ received during the time period ‘*t*’
TSP_{lsjt}	Transportation vehicle type ‘*l*’ of supplier ‘*s*’ to manufacturing plant ‘*j*’ at period ‘*t*’
TDP_{djkt}	transportation vehicle type ‘*d*’ of manufacturing plant ‘*j*’to *j*’to distributor ‘*k*’at period ‘*t*’

3.4. Decision variables

RMP_{isjt}	Amount of raw material ‘*i*’ purchased from supplier ‘*s*’ by manufacturing plant ‘*j*’ during time period ‘*t*’
QP_{ipt}	Quantity processed of product ‘*p*’ at manufacturing plant ‘*j*’ during time period ‘*t*’
$QTSP_{sjitl}$	Quantity transported of raw material ‘*i*’ from supplier ‘*s*’ to manufacturing plant ‘*j*’ at time period ‘*t*’by Vehicle*l*.
$QTPD_{jkptd}$	Quantity transported of product ‘*p*’ from manufacturing plant ‘*j*’ to distributor ‘*k*’ at time period ‘*t*’by vehicle *d*.
$QTCD_{ypt}$	Quantity of useless returned products ‘*p*’ transported from the centralized return center to the disposal site ‘*y*’ at the time period ‘*t*’
RMS_{izt}	Amount of recycled raw material ‘*i*’ at the disassembly/recycling plant ‘*z*’ that are sold to the third party during the time period ‘*t*’.
$RMRP_{izjt}$	Amount of required reclaimed raw material ‘*i*’ for new battery production transported from the disassembly/recycling plant ‘*z*’ to the manufacturing plant ‘*j*’ during the time period ‘*t*’

3.5. Mathematical formulation

The objective function of the multi echelon, multi period, and multi product closed loop supply chain model is given by the following equation:

$$\textbf{\textit{Minimize TC}} = TPUC + TPC + TPDTC + TSPTC + TRMIC + TFGIC + TCC + TICTC + TDC + TCICC + TRPC + TRC + TRPTC\ .$$

Purchasing costs – The total purchasing costs of virgin raw material can be determined as follows:

$$TPUC = \sum_i \sum_s \sum_j \sum_t \quad (RMP_{istj} * PUC_{jst}\ )$$

In order to produce these two kinds of products in Kalleh Company, we need 6 raw materials that can be provided from different suppliers.

The main point is quantity of purchase in the first period and the second period, which is different with regard to production rate in that period. For example, drinks production in the first period is more than the second period. Therefore, raw material purchase in the first period will be more than the second period.

Processing costs: The total processing costs involved in all manufacturing plants can be determined as follows:

$$TPC = \sum_j \sum_p \sum_t \quad QP_{jpt} * PC_{jpt}$$

Transportation costs: The total transportation costs involved in the forward supply chain included the transportation costs from all suppliers to manufacturing plants, from manufacturing plants to all distributors can be determined as follows:

$$TSPTC = \sum_S \sum_J \sum_i \sum_t \sum_l \quad (QTSP_{sjitl} * TCSP_{sjitl})$$

Distribution transportation cost: All costs of distribution - transportation including transportation cost from producer to distributer is determined as follow:

$$TPDTC = \sum_j \sum_k \sum_p \sum_t \quad \sum_d \quad (QTPD_{jkptd} * TCPD_{jkptd})$$

Distribution vehicles in Kalleh Company include three types: single wheel vehicles, 10 wheels and trails that are determined according to sale demand and using optimum mass of occupied space. In dairy industry, rapid transportation is very important because products have expiration period of time, and for this purpose, increase of product consumption time is considered as a very important criterion.

Inventory maintenance cost: Inventory costs of raw material in production factory, inventory maintenance cost of finished goods in productive factory, inventory maintenance cost in distributer are determined as follows:

$$TRMIC = \sum_i \sum_j \sum_t \quad (RMI_{ijt} * RIC_{ijt})$$

$$RMI_{ijt} = RMI_{ij(t-1)} + \sum_s \quad RMP_{isjt} - \sum_p \quad (X_{ip} * QP_{jpt}) + \sum_z \quad RMRP_{izjt}$$

Amount of inventory during period *t*is equal to inventory of the previous period plus optimum amount of buying minus consumption rate during period *t*and finally plus amount of raw materials that is gotten from recycling center.

Collection costs: The total collection costs of returned products at the initial collection points can be determined as follows:

$$TCC = \sum_X \sum_P \sum_T \quad (QC_{xpt} * CC_{xpt})$$

Reclaiming costs: The total disassembly/reclaiming costs involved in all the disassembly/recycling plant can be determined as follows:

$$TRPC = \sum_z \sum_p \sum_t \quad (QPDR_{zpt} * DRC_{zpt})$$

In this study, returned products can be caused by two factors. First, the product that is stored in finished goods warehouse but it reaches to $\frac{3}{4}$ of its shelf life.This problem happens when there is not any demand from sale organization. Therefore, the product will be transported to recycle center to do disassembly operations. It is important to determine the returned product volume because we can make decision under two policies. In the first way, we try to reduce return rate of product or increase the recycle process on the products. The second factor for returning products during or after production is because of quality problems due to improper packing or the quality of products. Expired products collecting costs including loading and transporting them to the recycling center.

Recycling costs: The total recycling cost from the disassembly/recycling plant sold to the third party for other applications can be computed as follows:

$$TRC = \sum_i \sum_z \sum_t \quad (RMS_{izt} * RC_{izt})$$

Disposal costs: The total disposal costs can be computed as follows:

$$TDC = \sum_y \sum_p \sum_t \quad (QTCD_{ypt} * DC_{ypt})$$

Chance constraint programming

Product return rate is uncertain in Kalleh Co. So, we applied chance constraint programming to model uncertainty for product return rate.

$$P(QRP \geq 10) \leq 0.05$$
$$P(QRP * D_{rp} \geq 10) \leq 0.05$$
$$P(D_{rp} \geq \frac{10}{QRP}) \leq \beta$$
$$\frac{10}{QRP} = A$$
$$\int_A^{\beta} \frac{1}{\beta-\alpha} \, dD_{rp}$$
$$\frac{\beta - A}{\beta - \alpha} \leq 0.05$$
$$\beta - A \leq 0.05 * (\beta-\alpha)$$
$$A \geq \beta - 0.05 * (\beta-\alpha)$$
$$\frac{10}{QRP} \geq \beta - 0.05 * (\beta-\alpha)$$
$$QRP \leq \frac{10}{\beta - 0.05(\beta-\alpha)}$$

Constraints:

The constraints involved in the closed loop supply chain model are as follows:

$\sum_i \sum_s \sum_t \quad RMP_{istj} \leq PRS_j \qquad \forall j$ (1)

$\sum_p \sum_t \quad QP_{jpt} \leq PF_{Sj} \qquad \forall j$ (2)

$\sum_s \sum_j \sum_i \sum_t \quad QTSP_{sjitl} \leq TSP_{lsjt} \qquad L=1,2,3$ (3)

$\sum_j \sum_k \sum_p \sum_t \quad QTPD_{jkptd} \leq TDP_{djkt} \qquad d=1,2,3$ (4)

$\sum_i \sum_j \quad RMP_{isjt} \leq SC_S \qquad \forall\ t=1,2$ (5)

$\sum_i \sum_s \sum_t \quad RMP_{isjt} \leq PR_{Sj}$ (6)

$\sum_x \sum_t \quad QC_{xpt} \leq \sum_z \sum_t \quad CD_{zpt} \qquad \forall p$ (7)

$QRP \leq \frac{10}{\beta - 0.05(\beta - \alpha)}$ (8)

$\sum_p \quad QP_{jt} \leq PF_{Sj} \qquad \forall j, \forall t$ (9)

$QP_{jpt} \leq PT_{jp} \qquad \forall p, \forall j, \forall t$ (10)

$\sum_j \sum_p \quad QTPD_{jkpt} \leq DS_{CK} \qquad \forall k, \quad \forall t$ (11)

$\sum_j \sum_p \sum_t \quad QP_{jpt} \geq \sum_m \sum_p \sum_t \quad DD_{mpt}$, (12)

$\sum_j \quad QTPD_{jkpt} \geq DD_{mpt} \qquad \forall m, \forall p, \forall t$ (13)

All variables are continuous and positive

In constraint (1), we have the minimum amount of purchase and it is due to distance and the consumption of saloon production. In constraint (2), quantity of product '*p*' in each plant must be equal or less than finished goods storage capacity in the same plant. According to constraint(3), in transportation capacity, optimum transportation quantity of material *i* with supply vehicle *l* should be less than transportation capacity of each supply vehicle. According to constraint(4), in transportation capacity, the optimum transportation amount in distribution of product '*p*' with distribution of vehicle '*d*' must be less than transportation capacity of each vehicle. According to constraint (5),amount of raw material purchased from a particular supplier for all manufacturing plants should be less than or equal to the supply capacity of that particular supplier**.** According to constraint(6), quantity of all types of raw materials received by each plant from all the suppliers should be less than or equal to the storage capacity of that plant. According to constraint(7),quantity of collected returned items should be less than or equal to the capacity of the disassembly/recycling plant. Set constraint(8) represents the uncertainty in product return rate. According to constraint(9),processed quantity at each plant for all products should be less than or equal to the finished goods storage capacity of that plant. According to constraint(10),total processing time required to process all product types at a particular plant should be less than or equal to the available processing time. According to constraint(11),transported quantity from all plants to a particular distributor should be less than or equal to the storage capacity of that distributor. According to constraint(12),total retailers' demands should be less than or equal to the total production rate. According to constraint(13),transported quantity from all plants to a particular distributor should be less than or equal to the storage capacity of that distributor.
Optimum quantity of production (QP) of each product 1&2 in Kalleh dairy company was given in Table 1.The results indicate changes in quantity of product according to quantity of purchase, initial inventory, final and demand and other factors.

Table 1. Optimum quantity of production

product NO	Period	Actual amount (Ton)	Optimum amount (Ton)	decrease/increase
1	1	400	480	80
	2	300	360	60

2	1	700	600	-100
	2	400	360	-40

Figures 2 and 3 are the comparison of optimum quantity with actual quantity of production in for both products. It can be found that amount of production achieved by the proposed mathematical model is more than current status.

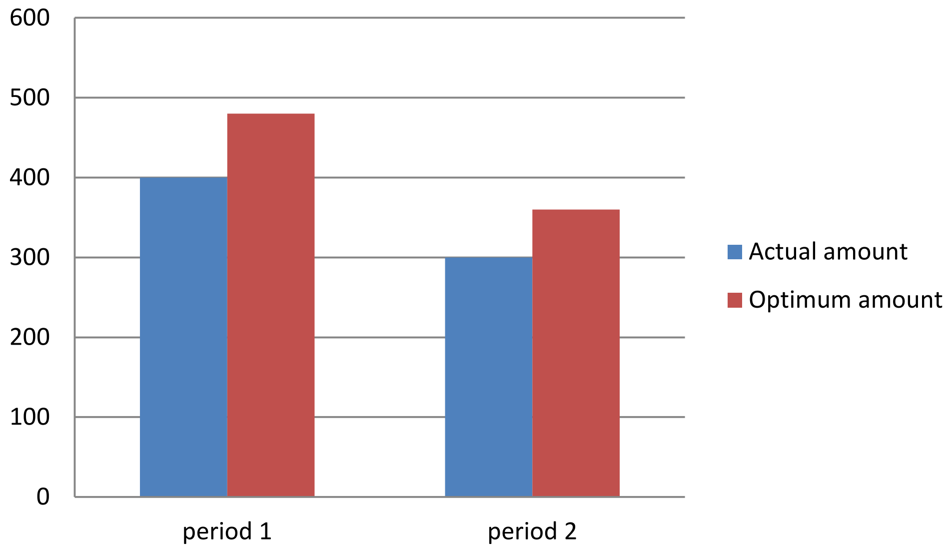

Figure 2. Compare of actual amount and optimum amount for product 1

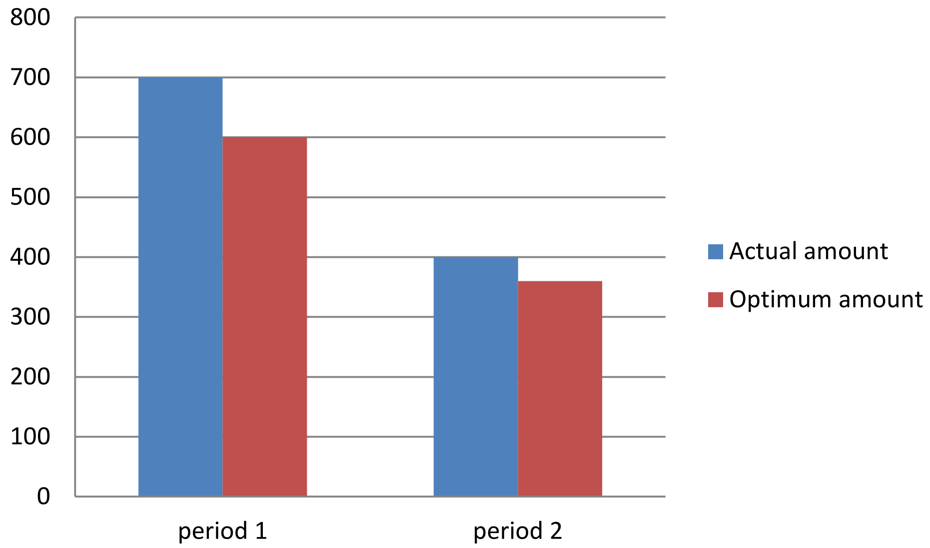

Figure 3. Compare of actual amount and optimum amount for product 2

Usable vehicles for supplying required material of Kalleh Company was given in Table 2.This table indicates that for supplying material *i* which vehicle should be used.

Table2. Optimum vehicle for supply.

Material No	Vehicle No	Real rate (Ton)
1	3	**270**
2	3	**10**
3	2	**15**
4	2	**10**
5	3	**10**
6	3	**10**

Table 3 indicates that for distributing Kalleh dairy company products, which vehicles should be used.

Table 3. Optimum vehicle for distribution

Product No	Vehicle No	Real rate(Ton)
1	2	**80**
2	2	**100**

Optimum quantity of purchase foreach required raw material for Kalleh dairy company was shown in Table 4.The results represent that purchase of raw materials by the proposed model is less than the current status.

Table4. Amount of raw material purchase

Purchase of material '*i*'	Period	Optimum quantity of purchase(Ton)	Actual amount(Ton)
1	1	850	1000
	2	750	950
2	1	30	50
	2	20	50

Table.4 Continue

Purchase of material '*i*'	Period	Optimum quantity of purchase(Ton)	Actual amount(Ton)
3	1	120	200
	2	100	200
4	1	10	20
	2	10	20
5	1	50	80
	2	40	80
6	1	10	20
	2	10	20

Figure 4 shows comparisons of optimum purchase with actual purchase. In period 1, optimum purchase is greater than actual purchase and in period 2 optimum purchases is less than actual purchase.

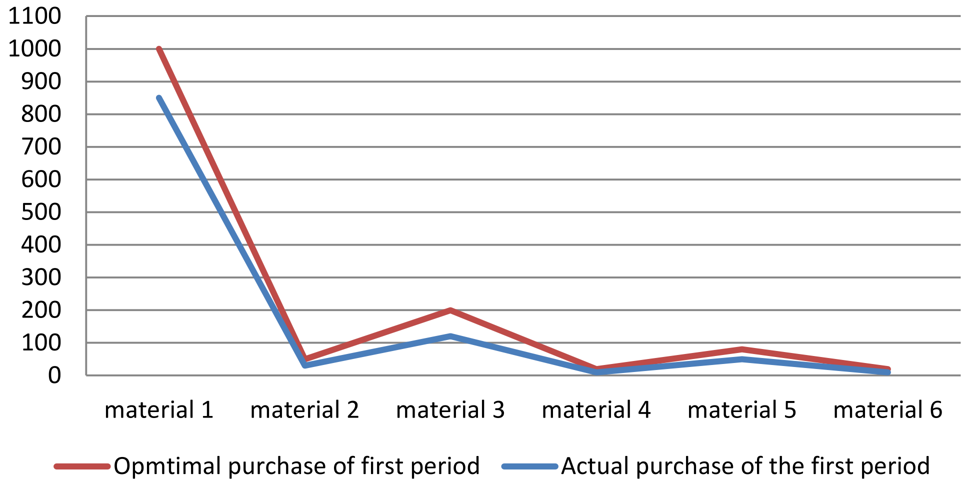

Figure 4. Compare of optimum and actual purchases in period 1

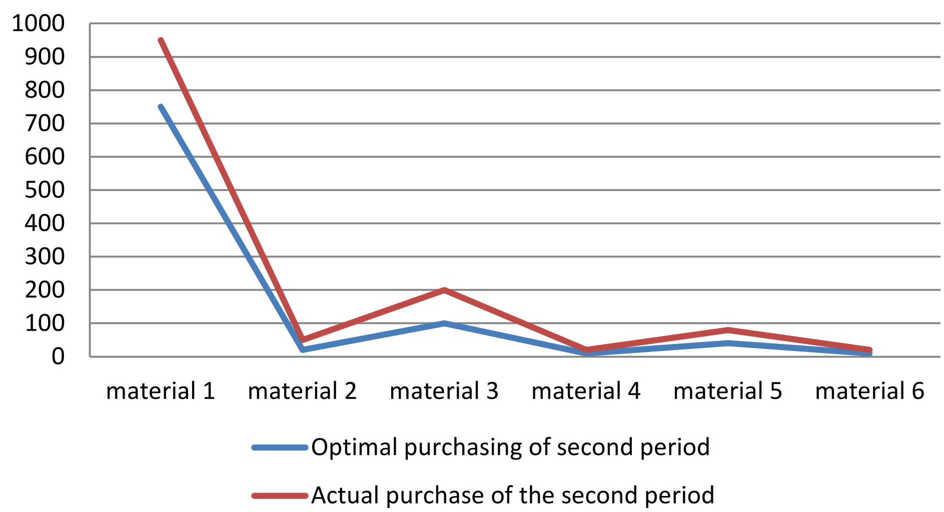

Figure 5. Compare of optimum and actual purchase in period 2

Optimum quantity of recycle product *p* was shown in Table5.

Table 5. amount of product recycle

Site NO	Product Recycling	Period	Optimum amount (Ton)	Actual amount (Ton)

1	1	1	10	0
		2	8	0
	2	1	15	0
		2	10	0
2	1	1	10	0
		2	8	0
	2	1	15	0
		2	15	0

Optimum quantity of recycling raw materialsform recycle factory *z*was shown in theTable 6.

Table 6. Amount of material recycle

Material recycle '*i*'	**Period**	**Recycle amount (Ton)**	**Actual amount (Ton)**
1	1	0	0
	2	0	0
2	1	0.5	0
	2	0.1	0
3	1	0.8	0
	2	0.6	0
4	1	0	0
	2	0	0

Amount of required reclaimed raw materials for producing new product were shown in Table 7.

Table 7. Amount of required reclaimed raw material '*i*'

Reclaimed material '*i*'	Period	Recycle amount (Ton)	Actual amount
1	1	0	0
	2	0	0
2	1	0.08	0
	2	0.05	0
3	1	0.1	0
	2	0.08	0
4	1	0	0
	2	0	0
5	1	0.08	0
	2	0.04	0
6	1	0	0
	2	0	0

Calculated total closed loop supply chain cost was shown in Table 8.

Table 8. Total close-loop supply chain cost(Toman)

Total cost in year	Total output cost of model	2,123,650,000
	Total actual cost	2,526,589,000

Figure 6 shows 9.5 % reduction and improvement in total closed loop supply chain cost comparison with current total supply chain cost. This improvement in the total costs is because of application of the proposed mathematical model.

4. Conclusion

Closed loop supply chain, by considering reverse case especially in recycling material, causes decrease of cost in all chain systems. Other discussed problems in this area are using proper vehicle for supply transportation and distributing issues. In addition, we had some changes in optimum buying for each material. All these changes lead to costs reduction all parts of the system. In this research, we first referred to present problem on Kalleh dairy company, and then we designed a network and mathematical model according to constraints available in Kalleh

Company. Linear programming model was developed with stochastic limitation for this study. Considering capacities such as supply capacity, production, transportation, distribution in Kalleh Company is one of the features of this model that was modeled exactly based on data or information of Kalleh Company. The final result of the current study illustrated that importing product with $\frac{1}{3}$of stability to production cycle causes decrease of cost for the closed loop supply chain.

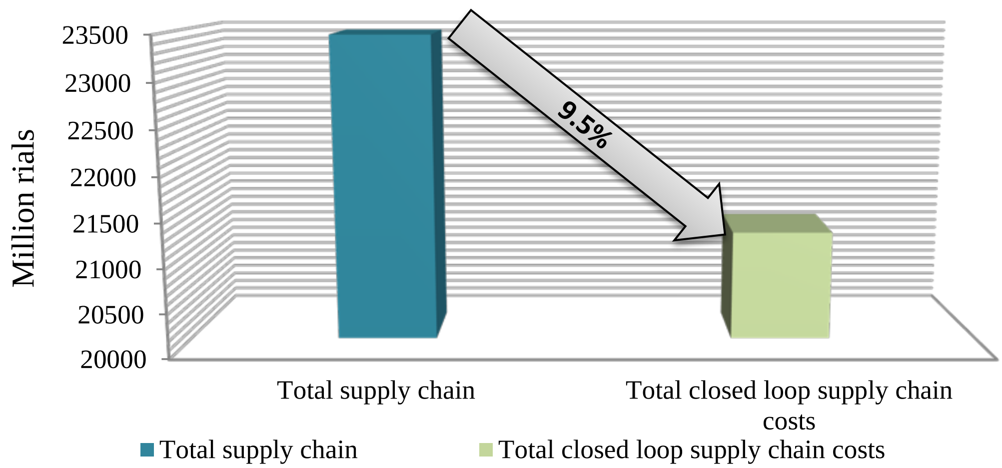

Figure.6.compare of total supply chain cost comparison with closed loop supply chain cost

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