Multi-Objective Multi Time Span Fractional Capacitated Transportation Problem in the Two Echelon Supply Chain with Multiform Items and Mixed Constraints

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Abstract— One of the most useful techniques for the transport companies is multi-level distribution to minimize the cost. This paper presents multi-objective multi time span fractional capacitated transportation problem (MOMTMIFCTP) in the two echelon supply chain with multiform items and mixed constraints. Moreover the fractional objective functions in the supply chain are important because many real life problems are based on the ratio of physical or economical values.

The goal of this investigation is to minimize damage cost, labor cost, the cost related to transportation, inventory carrying cost, quality cost and packing cost, also determine an optimal inventory level for the warehouse and distribution centers using fuzzy programming approach through LINGO software.

Key words: Fractional capacitated transportation problem, fuzzy programming approach, multiform items, multi -time span, two echelon supply chains.

1. INTRODUCTION

Transportation problem (TP) is a particular case of linear programming problem which was first developed by F. L. Hitchcock since 1941. The main objective of TP is to minimize the cost of transportation from sources to destinations so as to satisfy the supply and demand conditions. The classical TP deals with the transportation of single items with single objective. But in the present scenario single objective transportation problem is not fulfill the requirements. To overcome this situation Charnes and Cooper was introduced the concept of multi-objective transportation problem (MOTP) in the year 1961. There are several approaches available to find the solution of MOTP. One of the most efficient methods is goal programming approach which was first developed by Ignizio in the year 1978.

Due to the heavy competition in the market, a transport company refers to do the transporting business of the multi form items than that of single item to the loss of business.

Traditional transportation problems are confined to a particular period. But in reality, the distribution decisions are prolonged for more than one time frame, because it provides a chance to take advantage in lot sizing. This model is referred as multi-period TP.

The linear fractional programming is the generalization of linear programming problem in which the objective is the ratio of two linear functions. As many real life problems are based on the ratio of physical or economical values their role in transportation problem is significant.

During the transportation of goods the capacity of the transport is not specified, there are many issues related to storage, total budget, safety of environment. To tackle this situation, Wagner (1959) has studied the capacitated TP. Many researchers Sadia et al (2016), Srikant Gupta et.al (2018) etc., have discussed the fractional capacitated transportation problem.

Transportation plays a most important role in distribution of goods from the producers to the customers. Supply chain is describes the combination of producers, distributors and retailers. The main aim of supply chain is to provide the sustainable competitive advantage. Several researchers have studied supply chain (Beamon (1998), Ana maria and Rakesh (1999), Bilgen and Ozkarahan (2004), Gen and Syanf (2005), Stank and Goldsby (2000), Potter and Lalwani (2005), Disney and Jowill, 2003, Childhouse P., Jowill D.R. 2003, Bask A.H., 2001).

During the production of food products, producers must aware of quality of foods. To overcome this situation, appraisal cost or inspection cost is introduced. The amount spend during the inspection of products is defined as appraisal cost. This cost creates some aware about safety of foods.

Packaging cost represents a powerful part in supply chain. Packaging is highly convenient user friendly safe and hygienic to store any products such as ghee, oil etc. The system of packaging that involves efficient distribution and consumption of goods and hence packaging is important to all transportation to assure safety shipment.

Fuzzy programming technique is more efficient and consistent with dealing fractional objectives to find compromise solution. Several

Revised Manuscript Received on July 10, 2019.

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researchers have used fuzzy programming technique to solve MOCTP with fractional

objectives (Srikant Gupta et.al 2018).

According to the best of our knowledge none of the authors have discussed fractional objectives in supply chain.

This paper presents multi-objective multi time span fractional capacitated transportation problem (MOMTMIFCTP) in the two echelon supply chain with multiform items and mixed constraints.

The aim of the proposed model is to provide an optimal quantity of goods should be kept in ware house and distribution centers and also minimizing the total cost of the entire supply chain. Also this proposed model is applied for one of the leading ghee company as a case study to determine the optimal inventory level in warehouse, optimal quantity of items transferred from warehouse to distribution centers, distribution centers to retailers and the optimal inventory at distribution centers.

The summary of the research as follows: in section 2 Description of the problem, assumptions and notations are presented. In section 3 formulation of multi-objective, multi-form, multi time span fractional capacitated transportation problem in the two echelon supply chain with mixed constraint are discussed. In section 4 solution methodology is discussed. In section 5 an industrial case for implementing the feasibility of applying the proposed approach to real situations is presented. Results and conclusion are given in sections 6 and 7.

2. DESCRIPTION OF THE PROBLEM, ASSUMPTIONS AND NOTATIONS:

The suggested model is a MOMTMIFCTP with mixed constraint model where NW warehouses, ND distribution centers and Nr retailers with limited capacities. In this model, multi item is distributed from the distribution centers to retailers according to their demand for every period and will be used as the quotation for distribution centers to transfer stocks from them to retailers in a particular time span t. The aim of this approach is to minimize the damage cost, labour cost , the cost related to transportation with inventory carrying cost, and cost related to quality, packing cost.

The following list of assumptions is the basics for this study's mathematical programming model.

1. Few objectives are of fraction types and other objectives are linear in nature.
2. The cost of transportation is depended on the number of products.
3. Charge of packing is directly related to the product and type of the package material.
4. There is limited availability of the products in the warehouse and distribution centers. Following notations are used in this study.

Index set

m	Ware houses	m = 1,2,... Nw
n	Distribution centers	n = 1,2...,N_D
l	Retailers	l = 1,2... N_R
u	product type	u = 1,2...Npr
v	Time span	v = 1,2,...T
w	stages	w = 1,2.

Objective function:

TC_{v1} Total cost in the first stage.

TC_{v2} Total cost in the second stage.

TC_{v} Total cost in time span v is equal to sum of TC_{v1} and TC_{v2} .

Decision Valuables:

IW_{vum} →Level of inventory of uth product in MOMTMIFCTP by mth WH in time span v.

TW_{vumn} →Units distributed of uth product in MOMTMIFCTP from mth WH to nth DC in time span v.

ID_{vun} → Inventory level of uth product in MOMTMIFCTP in jth DC in time span v.

TD_{vunl} →Units distributed of uth product in MOMTMIFCTP from jth DC to rth RT in time span v.

Parameters:

$ICW_{vum}{}^{a}$ → Actual unit cost of carrying the inventory of uth product in MOMTMIFCTP by mth WH in time span v.

$ICW_{vum}{}^{s}$ → Standard unit cost of carrying the inventory uth product in MOMTMIFCTP by mth WH in time span v.

TCW^{a}_{vumn} →Actual cost of transportation of uth product in MOMTMIFCTP from mth WH to nth DC in time span v.

TCW^{s}_{vumn} →Standard unit transportation cost of uth product in MOMTMIFCTP from mth WH to nth DC in time span v.

Q_{vumn} →Quality testing cost of uth product in MOMTMIFCTP from mth WH to nth DC in time span v.

y_{vumn} →Purity level of uth product in MOMTMIFCTP from mth WH to nth DC in time span v.

PC_{vum} →Packing charge of uth product in MOMTMIFCTP by mth WH in time span v.

dw_{vumn} →Damage cost of uth product in MOMTMIFCTP from mth WH to nth DC in time span v.

LW_{vumn} →Labor cost of uth product in MOMTMIFCTP from mth WH to nth DC in time span v.

ICD^{a}_{vun} → Actual unit cost of carrying the inventory of uth product in MOMTMIFCTP by nth DC in time span v.

ICD^{s}_{vun} $\rightarrow$ Standard unit cost of carrying the inventory of u[th] product in MOMTMIFCTP by n[th] DC in time span v.

TCD^{a}_{vuml} $\rightarrow$ Actual cost of transportation of u[th] product in MOMTMIFCTP from n[th] DC to l[th] RT in time span v.

TCD^{s}_{vunl} $\rightarrow$ Standard cost of transportation of u[th] product in MOMTMIFCTP from nth DC to l[th] RT in time span v.

dD_{vunl} $\rightarrow$ Damage cost of u[th] product in MOMTMIFCTP from nth DC to l[th] RT in time span v.

LD_{vunl} $\rightarrow$ Labor cost of u[th] product in MOMTMIFCTP from nth DC to l[th] RT in time span v.

FD_{vun} $\rightarrow$ Forecasted demand of u[th] product in MOMTMIFCTP of n[th] DC in time span v.

AD_{vun} $\rightarrow$ Actual demand u[th] product in MOMTMIFCTP of n[th] DC in time span v.

D_{uvl} $\rightarrow$ Demand of u[th] product in MOMTMIFCTP of r[th] RT in time span v.

C_{vm} $\rightarrow$ Capacity of u[th] warehouse in time span v.

C_{vn} $\rightarrow$ Capacity of n[th] distribution centre in time span v.

C_{vl} $\rightarrow$ Capacity of l[th] retailer in time span v.

RW_{vunm} $\rightarrow$ Maximum restrictions on the amount of quantity to be transported from warehouse m to distribution center n in time time span v.

RD_{vunl} $\rightarrow$ Maximum restrictions on the amount of quantity to be transported from distribution center n to particular retailer.

3. PROBLEM FORMULATION

The diagrammatic representation of the proposed model for the time span t is shown in Fig: 1

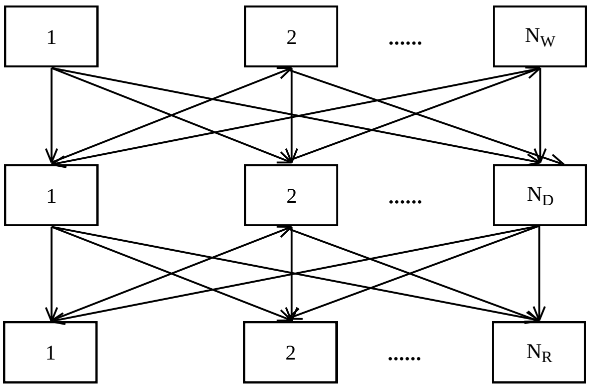

Fig 1: Two echelon supply chain model

The imprecise objective functions for the first stage are expressed as

$$Min\ F_1 = \sum_{m=1}^{N_W}\sum_{n=1}^{N_D} TW_{vumn} dW_{vumn} ,$$

$$Min\ F_2 = \sum_{m=1}^{N_W}\sum_{n=1}^{N_D} TW_{vumn}\ LW_{vumn}$$

$$Min\ F_3 = \frac{\sum_{m=1}^{N_W}\sum_{n=1}^{N_{pr}} IW_{vum} ICW^{a}_{vum}}{\sum_{m=1}^{N_W}\sum_{u=1}^{N_{pr}} IW_{vum}\ ICW^{s}_{vum}} + \frac{\sum_{m=1}^{N_W}\sum_{n=1}^{N_D}\sum_{u=1}^{N_{pr}} TW_{vumn} TCW^{a}_{vumn}}{\sum_{m=1}^{N_W}\sum_{n=1}^{N_D}\sum_{u=1}^{Npr} TW_{vumn} TCW^{s}_{vumn}}$$

$$Min\ F_4 = \sum_{m=1}^{N_W}\sum_{n=1}^{N_D}\sum_{u=1}^{N_{pr}} TW_{vumn} PC_{vum} + \sum_{m=1}^{N_W}\sum_{n=1}^{N_D}\sum_{u=1}^{N_{pr}} Q_{vumn} FD_{vun} \frac{(1-y_{vumn})}{y_{vumn}}$$

where $dw_{vumn}, LW_{vumn}, PC_{vum}, FD_{vun}$, Q_{vumn} denote the fuzzy cost coefficient.

The following are the constraints of the stage -I

1. The sum of the units of uth product from a WH to all DC should satisfy the warehouse inventory for a time span v.

$$\sum_{n=1}^{N_D} TW_{vumn} \le IW_{vumn,} m = 1,2...N_w, u = 1,2...N_{pr} \quad ....(4.1)$$

2. $\sum_{u=1}^{N_{pr}} IW_{vum} \le C_{vm}$ (ie) The sum of inventory at warehouse should be less than or equal to the warehouse capacity in time span v.

$$\sum_{u=1}^{N_W} TW_{vumn} \ge FD_{vum}, u = 1,2,...N_{pr}, n = 1,2...N_D \quad ....(4.2)$$

3. The sum of the units of product u transferred from all warehouse to a particular distribution center should be greater than or equal to the imprecise forecasted demand of that particular distribution center n in time span v.

$$\sum_{u=1}^{N_W} TW_{vumn} \ge FD_{vum}, u = 1,2,...N_{pr}, n = 1,2...N_D \quad ....(4.3)$$

4. The total distribution centers imprecise forecasted demand for a time span v should be less than or equal to all warehouse inventory of product u, in that particular time span

$$\sum_{m=1}^{N_W}\sum_{n=1}^{N_{pr}} TW_{vumn} \le C_{vn}, n = 1,2...N_D \quad ....(4.4)$$

5. The total number of units transferred from all warehouse to a particular distribution center should be less than or equal to that distribution center capacity

$$\sum_{m=1}^{N_W}\sum_{n=1}^{N_{pr}} TW_{vumn} \le C_{vn}, n = 1,2...N_D \quad ....(4.5)$$

6. The units distributed of product p from warehouse m to distribution centre n in time span v is less than or equal to maximum restrictions on the amount of quantity to be distributed from warehouse to particular distribution centers.

$$0 \le TW_{vumn} \le RW_{vumn} \quad ....(4.6)$$

Stage-II:

The objective functions for the second stage are expressed as follows:

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

$$Min\ F_1 = \sum_{n=1}^{N_D}\sum_{l=1}^{N_r} TW_{vunl} dD_{vunl} \quad , \quad Min\ F_2 = \sum_{n=1}^{N_D}\sum_{l=1}^{N_r} TW_{vunl} LD_{vunl}$$

$$Min\ F_3 = \frac{\sum_{n=1}^{N_D}\sum_{u=1}^{N_{pr}} ID_{vun}\ ICD^a_{vun}}{\sum_{n=1}^{N_D}\sum_{u=1}^{N_{pr}} ID_{vun} ICD^s_{vun}} + \frac{\sum_{n=1}^{N_D}\sum_{l=1}^{N_r}\sum_{u=1}^{N_{pr}} TD_{vunl} TCD^a_{vunl}}{\sum_{n=1}^{N_D}\sum_{l=1}^{N_r}\sum_{p=1}^{N_{pr}} TD_{vunl}\ TCD^s_{vunl}}$$

where dD_{tpjr} , LD_{tpjr} denote the fuzzy cost coefficients.

The constraints of stage-II are as follows:

1. The inventory of product p at a particular distribution center at the end of stage one is equal to the difference between total number of units received from all warehouse by that distribution center and the actual demand of that particular distribution center in time span t.

$$ID_{vun} = \sum_{j=1}^{N_W} TW_{vumn} - AD_{vuj,\, l=1,2\ldots N_{pr}} \quad \ldots.(5.1)$$

(If this value is negative $ID_{vun} = 0$).

2. The sum of units of product u transferred from all distribution centers to a Particular retailer should be greater than or equal to the demand of that particular retailer in time span v.

$$\sum_{n=1}^{N_D} TD_{vunl} \geq D_{vul}, u = 1,2\ldots.N_{pr}, l = 1,2\ldots N_r \ \ldots.(5.2)$$

3. The sum of units of product P transferred from a particular distribution center to all retailers should be less than or equal to the actual demand of that particular distribution center in time span v.

$$\sum_{n=1}^{N_D} TD_{vunl} \leq AD_{vun}, n = 1,2\ldots.N_D, u = 1,2\ldots.N_{pr} \ \ldots.(5.3) \qquad (5)$$

4. The total number of units transferred from all distribution centers to a particular retailer should be less than or equal to that retailer capacity.

$$\sum_{n=1}^{N_D}\sum_{u=1}^{N_{pr}} TD_{vunl} \leq C_{vl}, l = 1,2\ldots N_{pr} \quad \ldots..(5.4)$$

5. The units distributed of product P from distribution center n to retailer l in time span v is less than or equal to maximum restrictions on the amount of quantity to be transported from distribution center to particular retailer

$$0 \leq TD_{vunl} \leq RD_{vunl} \qquad \ldots.(5.5)$$

5. SOLUTION METHODOLOGY

The proposed model of MOMTMIFCTP can be converted into single objective problem by using the fuzzy programming approach.

The membership function for the K^{th} objective function in the first stage is given below:

$$\mu_k\ (F_k(TW)) = \begin{cases} 1 & if\ F_k(TW) \leq LB_k \\ \dfrac{UB_k - F_k(TW)}{UB_k - LB_k} & if\ LB_k \leq F_k(TW) \leq UB_k \\ 0 & if\ F_k(TW) \geq UB_k \end{cases}$$

Where UB_k and LB_k are the upper and lower tolerance limit.

Now, the equivalent linear model as follows.

$$Max\ D(\mu) = \sum_{k=1}^{K} \mu_k(F_k(TW))$$

Subject to

$$\mu_k\ (F_k(TW)) = \frac{UB_k - F_k(TW)}{UB_k - LB_k}, k = 1,2\ldots K$$

and (5)

$$0 \leq \mu_k\ (F_k(TW)) \leq 1, k = 1,2\ldots K$$

The membership function for the K^{th} objective function in the second stage is given below:

$$\mu_k\ (F_k(TD)) = \begin{cases} 1 & if\ F_k(TD) \leq LB_k \\ \dfrac{UB_k - F_k(TD)}{UB_k - LB_k} & if\ LB_k \leq F_k(TD) \leq UB_k \\ 0 & if\ F_k(TD) \geq UB_k \end{cases}$$

where UB_k and LB_k are the upper and lower tolerance limit.

Now, the equivalent linear model as follows.

$$Max\ D(\mu) = \sum_{k=1}^{K} \mu_k(F_k(TD))$$

Subject to

$$\mu_k\ (F_k(TD)) = \frac{UB_k - F_k(TD)}{UB_k - LB_k}, k = 1,2\ldots K$$

and (5)

$$0 \leq \mu_k\ (F_k(TD)) \leq 1, k = 1,2\ldots K$$

D is called a fuzzy achievement function or fuzzy decision function. This is a single objective optimization problem which can be solved by using LINGO software.

5. IMPLEMENTATION AND COMPUTATIONAL ANALYSIS

One of the leading ghee company located in Tamil Nadu is chosen for the application of the proposed methodology. This paper focuses only on the transportation of the ghee which is coming in two different packs such as Retailer pack and Bulk pack. We have considered the forecasted demand for these two products in two different time periods. The company has planned to frame a mathematical model to minimize the damage cost, labor cost, the cost related to transportation, inventory carrying cost, and the cost related to packing cost, quality cost in the supply chain by optimizing the inventory levels at warehouse and distribution centers. This research assumes the same damage cost, labor cost, Inventory carrying cost and packaging cost for all the two products in two different time spans.

The following data is collected for substantiate the above developed model.

Let us consider problem of two types products to be transported from one warehouse to three DC and then it distributed to four different retailers in two time periods.

The input data for warehouse distribution centers and retailers are given in tables 1-13.

Table: 1 Inputs for WH:

Inventory carrying cost per unit in Rs		Rs $\frac{1.2}{1.3}$ /kg
warehouse capacity in units		7,00,000
Packing charge	Retailer	1
	Bulk	3

Table: 2 Unit cost of transportation from WH to DC in Rs.

Transportation cost in Rs from WH to	DC		
	D1	D2	D3
	$\frac{1.4}{1.2}$	$\frac{0.5}{0.4}$	$\frac{1.3}{1.2}$

Table: 3 Unit damage cost from WH to DC in Rs.

Damage cost from WH to	DC		
	D1	D2	D3
	0.02	0.02	0.02

Table: 4 Unit labor cost from WH to DC in Rs.

Labor cost from WH to	DC		
	D1	D2	D3
	0 .1	0 .1	0 .18

Table: 5 Distribution centers demand

		DC					
Time Span	Items	D1		D2		D3	
		Forecasted demand	Actual demand	Forecasted demand	Actual demand	Forecasted demand	Actual demand
t_1	R	3094	3080	7000	6930	3080	3080
	B	2821	2821	728	728	1729	1729
t_2	R	2475	2464	5600	5544	2464	2464
	B	2539	2539	655	655	1556	1556

Table: 6 Capacitated Restrictions on the route from WH to DC

Time span	Items	DC		
		D1	D2	D3
t1	R	3200	7000	3250
	B	3000	800	2000
	R	2500	6000	3000
t2	B	2800	700	1800

Table: 7 Inputs for DC

	DC		
	D1	D2	D3
Inventory carrying cost per unit in Rs	$\frac{1.6}{1.4}$	$\frac{1.4}{1.2}$	$\frac{1.4}{1.3}$
capacity in units	1,61,000	2,80,000	10,000

Table:8 Unit transportation cost from DC to RT in Rs

DC/RT	R1	R2	R3	R4
D1	$\frac{0.02}{0.01}$	$\frac{0.04}{0.03}$	$\frac{0.4}{0.3}$	$\frac{0.2}{0.1}$
D2	$\frac{0.3}{0.2}$	$\frac{0.3}{0.2}$	$\frac{0.004}{0.003}$	$\frac{0.2}{0.1}$
D3	$\frac{0.2}{0.1}$	$\frac{0.18}{0.15}$	$\frac{0.3}{0.2}$	$\frac{0.01}{0.01}$

Table: 9 Unit Damage cost from DC to RT in Rs.

DC/RT	R1	R2	R3	R4
D1	0 .02	0 .02	0 .02	0 .02
D2	0 .02	0 .02	0 .02	0 .02
D3	0 .02	0 .02	0 .02	0 .02

Table:10 Unit labor cost from DC to RT in Rs

DC/RT	R1	R2	R3	R4
D1	0 .1	0 .1	0 .1	0 .1
D2	0 .1	0 .1	0 .1	0 .1
D3	0.18	0.18	0.18	0.18

Table:11 Retailer demand.

		RT			
Time Span	Items	R1	R2	R3	R4
t1	R	800	1000	1000	200
	B	700	900	900	300
t2	R	800	800	600	200
	B	700	800	600	300

Table:12 Capacitated Restrictions on the route from DC to RT

			RT			
	Time Span	Items	R1	R2	R3	R4
D1	t_1	R	900	1200	1200	250
		B	750	950	1000	350
	t_2	R	800	850	700	200
		B	750	800	600	350
D2	t_1	R	2500	3000	750	1000
		B	250	200	200	150
	t_2	R	1500	1600	1500	1000
		B	250	200	150	160
D3	t_1	R	1000	1200	800	500
		B	500	600	550	100
	t_2	R	900	800	750	250
		B	500	350	500	350

Table:13 Input data for Retailer

	R1	R2	R3	R4
Retailer Capacity	1,20,000	75,000	60,000	50,000

6. RESULTS

The above problem can be solved by the proposed method with the help of LINGO software in two stages, the optimal solution for the case study are obtained these results are tabulated in tables: 14-20.

Table:14 Optimal warehouse stock

Time Span	Items	Number of units
t_1	R	IW 111 = 13174
	B	IW 121 = 5278
t_2	R	IW 211 = 10539
	B	IW 221 = 4769

Table:15 Optimal number of units transported from WH to DC

Time span	Items	Numbers of units		
		D1	D2	D3
t_1	R	3094	7000	3080
	B	2821	728	1729
t_2	R	2475	5600	2464
	B	2558	655	1556

Table: 16 Optimal level of inventory at DC

Time span	Items	DC		
		D1	D2	D3
t_1	R	ID111= 14	ID112 =70	ID113 = 0
	B	ID121 = 0	ID122 =0	ID123 = 0
t_2	R	ID211=11	ID212 = 56	ID213 = 0
	B	ID221=19	ID222 = 0	ID223 = 0

Table: 17 Optimal numbers of units transferred from DC to RT

			RT			
DC	Time span	Items	R1	R2	R3	R4
D1	t_1	R	TD1111 900	TD1112 1200	TD1113 250	TD1114 0
		B	TD1211 700	TD1212 900	TD1213 700	TD1214 300
	t_2	R	TD2111 800	TD2112 850	TD2113 0	TD2114 0
		B	TD2211 700	TD2212 600	TD2213 0	TD2214 300
D2	t_1	R	TD1121 1100	TD1122 0	TD1123 750	TD1124 0
		B	TD1221 0	TD1222 0	TD1223 200	TD1224 0
	t_2	R	TD2121 200	TD2122 0	TD2123 1000	TD2124 900
		B	TD2221 0	TD2222 200	TD2223 128	TD2224 0
D3	t_1	R	TD1131 0	TD1132 800	TD1133 0	TD1134 400
		B	TD1231 0	TD1232 0	TD1233 0	TD1234 0
	t_2	R	TD2131 0	TD2132 150	TD2133 0	TD2134 0
		B	TD2231 0	TD2232 0	TD2233 472	TD2234 0

Table: 18 Optimal Cost

	Stage:1	Stage:2	Optimal total cost
Damage	F1 = 1077.08	F1 = 498	1575.08
Labor	F2 = 9152.32	F2 = 3826.8	12979.12
IC+TC	F3 = 2.103398	F3 = 2.369645	4.473043
PC+QC	F4 = 54024.10	-	-

7. CONCLUSION

This methodology presents MOMTMIFCTP in the two-echelon supply chain with mixed constraints. The main aim of this MOMTMIFCTP is to minimize the cost related to quality, packing charge of the entire supply chain also provide an optimal inventory level for warehouse and distribution centers. In the proposed model the objective function related transportation cost and inventory carrying cost is expressed as linear fractional function which would help the decision maker to take appropriate decision in the supply chain. An industry is taken for a case study and proposed procedure is applied to determine the feasibility in a supply chain. The developed methodology provides optimal solution for practical applications. In particular, this methodology can be easily extended too many real life situations. In future this methodology can be developed to fuzzy models and new solution approach is used to obtain the optimal solution.

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