Advances in Economics and Business Management (AEBM)
p-ISSN: 2394-1545; e-ISSN: 2394-1553; Volume 5, Issue 2; January-March, 2018, pp. 110-113

http://www.krishisanskriti.org/Publication.html

A Mathematical Model to Optimize Cost in Reverse Logistics

Sonu Kumar Suman[1*], Saurabh Chauhan[2] and Dr. D. K. Singh[3]

[1,2,3]*Division of MPA Engineering Netaji Subhas Institute of Technology, New Delhi – 110078*
Email: [1]sonuyou19@gmail.com, [2]aashumit@gmail.com, [3]dks662002@yahoo.com*

Abstract

Purpose- *The aim of this research paper is to design a reverse logistics system by optimizing different process parameters in the context of e-commerce.*

Design/Methodology/Approach- *Designing a possible mathematical model using transportation problem example and further optimizing it. The exercise is carried out in TORA application for linear programming.*

Findings-*The paper identifies the possibilities of applying this mathematical model of reverse logistics based on transportation problem to deal with returned products in context of e-commerce.*

Keywords: *Reverse logistics, Forward logistics, Supply chain, Transportation problem, TORA.*

1. INTRODUCTION

In context of e-commerce, reverse logistics refers to the return of products which are ordered on the Internet from customers to suppliers. Poor quality or other factors of customer dissatisfaction are generally the reasons for returned products. (Xiong, 2005). For a business to survive in a competitive market environment, it needs to consider the importance of reverse logistics for e-business. Formulation of a mathematical model to design a reverse logistics network that can minimize the overall costs, is such a solution. Current consumption pattern is shifting from traditional offline market to online e-business. E-business is gaining wide acceptance due to its high efficiency, low cost, and convenience. There are a number of research papers and review papers that detail reverse logistics, but very few of them incorporate mathematical analysis. The present paper includes mathematical analysis to decrease the cost of transportation associated with pickups from customers. E-commerce industries are focusing on reverse logistics management as a managerial strategy to survive in the competitive environment (Genchev, 2009). A firm has to manage returned products because of product recall, obsolete or expired product, surplus inventory, etc. All these issues are included in reverse logistics management. In addition, it also includes recycling programs, disposal of hazardous materials and calling back of obsolete equipment. The reverse flow of items initiates from multiple points and is merged at just a few (or one) destinations (Pohlen and Farris, 1999). The concepts such as green supply chain management which includes green purchasing and green manufacturing highly depends upon reverse logistics management. In USA, companies take back their products when their life end or expire. It necessitated to develop a proper and efficient pickup system for returned items. Carter and Ell ram (1998) states that the actual process of calling back expired products back in the system for remanufacturing or recycling is called reverse logistics. For example, Amazon launched a program called exchange and buy. They schedule pickup and delivery at the same time such that cost of transportation is reduced. Casco (1999) reports that combining delivery and pickups for supermarkets led to an industry wide saving of millions of dollars a year. Dowlatshahi (2000) defines Reverse logistics is the collection of processes by which retailer or vendor calls back their product that are to be recycled, rebuilt, or disposed. Lehtinen and Ahola (2010) describes reverse logistics as tool or scale to measure performance in supply chain management. The companies can get advantage over their competitors by performing reverse logistics effectively. Thus, reverse logistics plays critical role to differentiate the leaders from the rest of the competitors and provides opportunities to gain more profit. In this paper, we present the results obtained by optimizing the transportation problems related to Indian e-commerce industries dealing with reverse logistics operation in their organizations. The following are the main objective of this paper:

1. To develop a mathematical model, which can be incorporated in e-commerce industries.
2. Tooptimize the total costs associated with transportation with the help of multiple iteration using TORA application.
3. To identify the scope of implication of this research.

2. LITERATURE REVIEW

The overview of literature hints that science behind reverse logistics is different from that of forward logistics. Forward logistics can be predicted to an extent by using several forecasting techniques, therefore it is a visible process from origin to the customers' end. **Figure 1** shows the movement of products or services in forward logistics and reverse logistics.

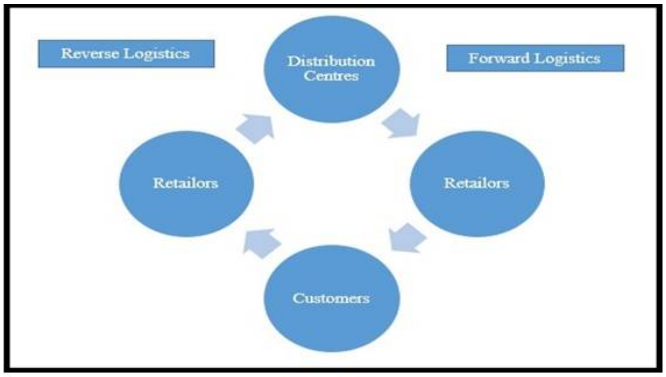


Figure 1

The left-hand side represents reverse logistics while the right-hand side represents forward logistics. Reverse logistics is the emerging field of research; much has been discussed about theoretical aspects of it in the literature for over a decade. Among all, reverse logistics management of recycled product is most common one. But very little has been discussed regarding mathematical approach to deal with reverse logistics (Stock, 1992, 1998; Pohlen and Farris, 1992). Council of logistic management (1999) defines logistics(forward) as the process that outline, execute and monitors the correct flow, inventory management and movement from the point of production to the point of delivery inorder to meet consumer's need. Rogers and Tibber-lembke (1999, 2001) defined reverse logistics as the movement of products or materials in reverse direction for the purpose of creating or reestablishing value or for proper disposal. Reverse logistics has very contradicting nature when we compare it with forward logistics. We observe that while forward logistics is very much neutral and visible in process, but reverse logistics, on the other hand, is reactive and less visible. Few industries do not include reverse logistics in their planning and decision-making, but based on the response of customers, they take actions. Thierry *et al.* (1995) overviewed the wide range of disposition options left with the retailer to deal with the returned products. These disposition options can be further made more specific from vendor and retailers point of view. Therefore, disposition options left with the retailer to deal with the returned products are the following:

- First preference is to sell item as new
- Send it back to the vendor and get full refund
- Sell the product to factory outlets
- Organize auction
- Remanufacturing (if possible)

Similarly, disposition options left with the vendor to deal with the returned products is different as compared to the retailers' point of view. Vendor has option to screen and go through each product and then decide the possible disposition option. Vendor has advantage to add value to the returned product and send it back to the retailer. Other than remanufacturing, vendor has option to recycle the product. This whole process involves capitals investment and therefore decreases the profit. Repackaging or remanufacturing involves logistics movement and capital investment. This paper aims to minimize this excess capital investment.

3. METHODOLOGY

In forward logistics, the transportation problem finds an optimized path to fulfill the demand and supply relations. In reverse logistics, transportation problem is designed to find optimized path to fulfill pick-ups and returns. In this paper, we try to reduce the total transportation cost associated with the returned products in bringing back to retailer. For this, we consider a transportation problem and try to optimize it in order to meet the pick-ups and return needs. A typical transportation problem has the following elements:

i. Source(s)
ii. Destination(s)
iii. Weighted edge(s)

In case of reverse logistics movement, we have the following elements:

i. Pick-up(s)
ii. Returns(s)
iii. Weighted edge(s)

To solve the transportation problem, we use TORA application. TORA application is widely used in industries to solve linear programming problem (here we have a transportation problem). The focus of reverse transportation problem is to find minimum transportation cost (in reverse direction) associated to an item from a given numbers of point-of-return (e. g. customers from different regions) to a given number of retailers (or vendors). Such problems are solved by the use of specific transportation algorithm. **Figure 2** depicts a transportation network with *m* pick-up locations and *n* delivery location.

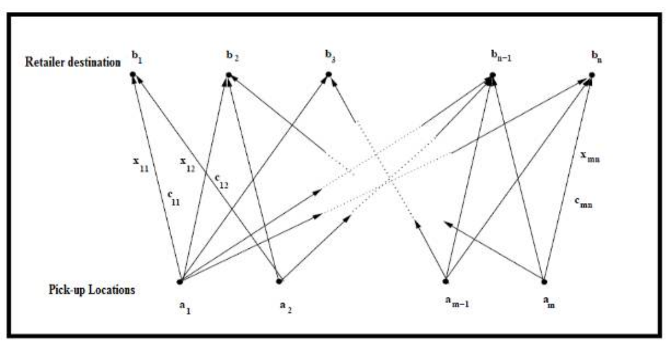


Figure 2

Each pick-up location and delivery destination is represented by a black dot. The transportation network consists of different possible routes. The route between pick-up location and delivery location is represented by arrows joining dots. Arrows starting head represents the pickup location whereas the end head represents delivery location. The amount of returns placed at pickup location $i$is a_i, and the demand required at destination j isb_j. The cost of transporting one unit between pickup source i and delivery destination(i. e. retailers location) j is c_{ij}.

Let x_{ij}denote the total number of picked up product transported from pickup location i to nearby retailers' destination j. The cost associated with this movement is given as $=x_{ij}c_{ij}$. The cost of delivering the commodity from pickup location to retailers' destination is given by

$$\sum_{j=1}^{n} c_{ij}x_{ij} = c_{i1}x_{i1} + c_{i2}x_{i2} + \cdots + c_{in}x_{in}.$$

Thus, the total cost of transportation for all returned products back to retailers' destinations is

$$\text{Total Cost} = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij}$$

$$\begin{aligned} &= c_{11}x_{11} + c_{12}x_{12} + \cdots + c_{1n}x_{1n} + \\ &= c_{21}x_{21} + c_{22}x_{22} + \cdots + c_{2n}x_{2n} + \\ &\quad \vdots \\ &= c_{m1}x_{m1} + c_{m2}x_{m2} + \cdots + c_{mn}x_{mn} \end{aligned}$$

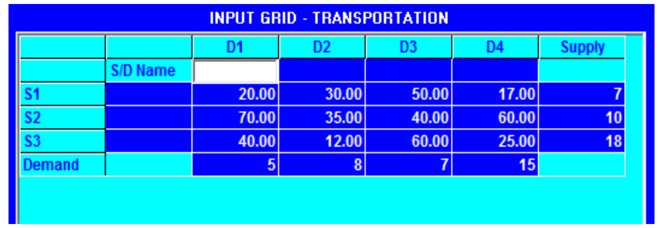
We have the following constraints of the reverse transportation problem. Transportation constraints are assumed to be linear and higher order variables are neglected.

Consider the following problem in which a company calls back its product from four pick-up locations and delivers it to the nearby 3 retailers. The objective is to find optimum allocation to minimize the total cost. **Table 1**shows the assumed reverse transportation problem based on reverse logistics constraints. TORA is applied to find the solution of the problem. The input table for TORA is given below. Subsequently two iterations are provided. At the end, the final solution appears.

Table1

	D1	D2	D3	D4	Pickup
S1	20	30	50	17	7
S2	70	35	40	60	10
S3	40	12	60	25	18
Return	5	8	7	15	

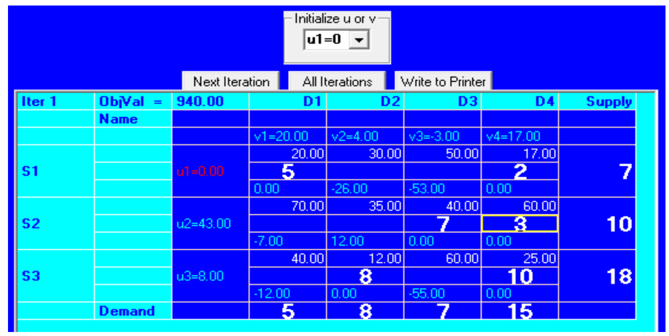
Input Table



INPUT GRID - TRANSPORTATION

		D1	D2	D3	D4	Supply
	S/D Name					
S1		20.00	30.00	50.00	17.00	7
S2		70.00	35.00	40.00	60.00	10
S3		40.00	12.00	60.00	25.00	18
Demand		5	8	7	15	

First Iteration

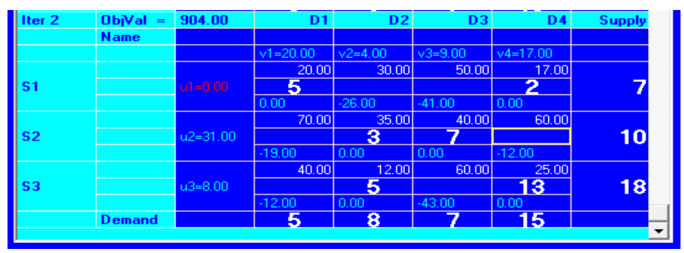


Initialize u or v: u1=0

Next Iteration | All Iterations | Write to Printer

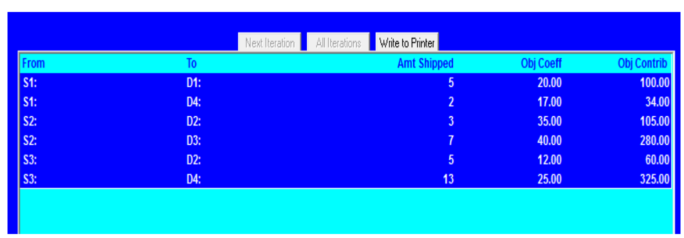
Iter 1	ObjVal = Name	940.00	D1	D2	D3	D4	Supply
			v1=20.00	v2=4.00	v3=-3.00	v4=17.00	
S1		u1=0.00	20.00	30.00	50.00	17.00	7
			5			2	
			0.00	-26.00	-53.00	0.00	
S2		u2=43.00	70.00	35.00	40.00	60.00	10
					7	3	
			-7.00	12.00	0.00	0.00	
S3		u3=8.00	40.00	12.00	60.00	25.00	18
				8		10	
			-12.00	0.00	-55.00	0.00	
	Demand		5	8	7	15	

Second Iteration



Iter 2	ObjVal = Name	904.00	D1	D2	D3	D4	Supply
			v1=20.00	v2=4.00	v3=9.00	v4=17.00	
S1		u1=0.00	20.00	30.00	50.00	17.00	7
			5			2	
			0.00	-26.00	-41.00	0.00	
S2		u2=31.00	70.00	35.00	40.00	60.00	10
				3	7		
			-19.00	0.00	0.00	-12.00	
S3		u3=8.00	40.00	12.00	60.00	25.00	18
				5		13	
			-12.00	0.00	-43.00	0.00	
	Demand		5	8	7	15	

Final Solution



Next Iteration | All Iterations | Write to Printer

From	To	Amt Shipped	Obj Coeff	Obj Contrib
S1:	D1:	5	20.00	100.00
S1:	D4:	2	17.00	34.00
S2:	D2:	3	35.00	105.00
S2:	D3:	7	40.00	280.00
S3:	D2:	5	12.00	60.00
S3:	D4:	13	25.00	325.00

4. CONCLUSION

A reverse transportation network is developed on the basis of known constraints. Vogel approximation and further MODI method for optimization is used to do the mathematical calculations. All mathematical modeling and calculation are performed in the TORA application, and final results are shown in the paper. There is approximately 4% decrease in total cost because of the two iterations performed in TORA.

REFERENCES

[1] Carter, Craig R, Ellram, Lisa M (1998). Reverse Logistics: A Review of the Literature and Framework for Future Investigation, *Journal of Business Logistics,* 19 (1), 85-102.

[2] De Brito, M. P. and Dekker, R. (2004). A Framework for Reverse Logistics, *Springer Berlin Heidelberg.*

[3] S. Dowlatshahi, (2000). Developing a Theory of Reverse Logistics, *Interfaces*, 30(3), 143-155.

[4] S. E. Genchev, (2009). Reverse Logistics Program Design: A Company Study, *Business Horizons, 52* (2)

[5] JussiLehtinenTuomasAhola. (2010). Is Performance Measurement Suitable for an Extended Enterprise?, *International Journal of Operations & Production Management*, 30(2), 181-204.

[6] Rogers, D. S. , Tibben-Lembke R. S. , (1999). Going Backwards: Reverse Logistics Trends and Practices, Reverse Logistics Executive Council, *Center for Logistics Management, Pittsburgh, PA.*

[7] Stock, (1992). Product Returns Processing: An Examination of Practices of Manufacturers, Wholesalers and Retailers, *Journal of Business Logistics*, 30 (1), 33-63.

[8] Ronald S. TibbenLembke (2002). Life after Death: Reverse Logistics and the Product Life Cycle, International Journal of Physical Distribution & Logistics Management, 32 (3), 223-244.

[9] Thierry, M. , Salomon, M. , (1995). Strategic Issues in Product Recovery Management, *California Management Review,* 37 (1), 114-135.

[10] Y. Xiong, (2005). Reverse Logistics Profit-Maximization Model and its Application Strategy based on E-business, *Journal of Shanghai Institution of Technology,* 5 (3), 180.