INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Reverse Logistics using Genetic Algorithm

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Abstract:
Assumptions about natural resources, that they are unlimited and its regeneration by the environment can reimburse for all human behaviours is no longer agreeable. Sustenance, in the era of depleting natural resources, is thus a crucial issue for the upcoming generations. The logistics sector is not far away from exploitation of the natural conventional resources. The environmental regulations imposed on companies, have made them not only cautious about the reusing the worn out products, but also have made them realize, the economic benefits of reiterating. Reverse logistics, deals with the collection, recovering, recycling, remanufacturing and assessment of the used products. Hence, an emphasis on developing an efficient reverse logistics network and making the supply chain more competitive by benefitting from the economic advantage obtained has become an important area. In this research, there is a development of a new optimized model for minimizing fuel consumption in reverse logistics for gathering and recycling used automobile alternators in supply chain. Hence the sole objective of the research is to critically examining and developing a model which would give both the economic and environmental advantage simultaneously. This objective of obtaining economic and environmental benefits simultaneously can be achieved using the Genetic Algorithm (economical) technique and the Green Logistics Model (environmental). Genetic Algorithm techniques have been used for solving troublesome problems regarding the supply chain. Genetic Algorithm stands its application in the development of the multiechelon reverse logistics networks for the collection of the worn out products. The second model for decreasing the environmental consumption is the Green Logistics model. This model can be implemented by developing an advanced model for collection and the recycling of the automobile alternators and thus minimizing the fuel consumption in the transportation. Thus the research briefs on Green Logistics and Genetic Algorithm through a case study based approach.

Keywords: *Natural resources, regeneration, Sustenance, logistics, exploitation reverse logistics, remanufacturing, supply chain, Genetic Algorithm, Green Logistics, Multi echelon reverse logistics, fuel consumption*

1. Introduction

Reverse logistics stands for all operations related to the reuse of products and materials. It is "the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal. More precisely, reverse logistics is the process of moving goods from their typical final destination for the purpose of capturing value, or proper disposal. Remanufacturing and refurbishing activities also may be included in the definition of reverse logistics." The reverse logistics process includes the management and the sale of surplus as well as returned equipment and machines from the hardware leasing business. Normally, logistics deal with events that bring the product towards the customer. In the case of reverse logistics, the resource goes at least one step back in the supply chain. For instance, goods move from the customer to the distributor or to the manufacturer.

When a manufacturer's product normally moves through the supply chain network, it is to reach the distributor or customer. Any process or management after the sale of the product involves reverse logistics. If the product is defective, the customer would return the product. The manufacturing firm would then have to organise shipping of the defective product, testing the product, dismantling, repairing, recycling or disposing the product. The product would travel in reverse through the supply chain network in order to retain any use from the defective product. The logistics for such matters is reverse logistics.

2. How Is Reverse Logistics Different from Traditional Logistics?

Reverse logistics is quite different from the traditional logistics, or forward logistics, activities. The below figure is a traditional logistics flow:

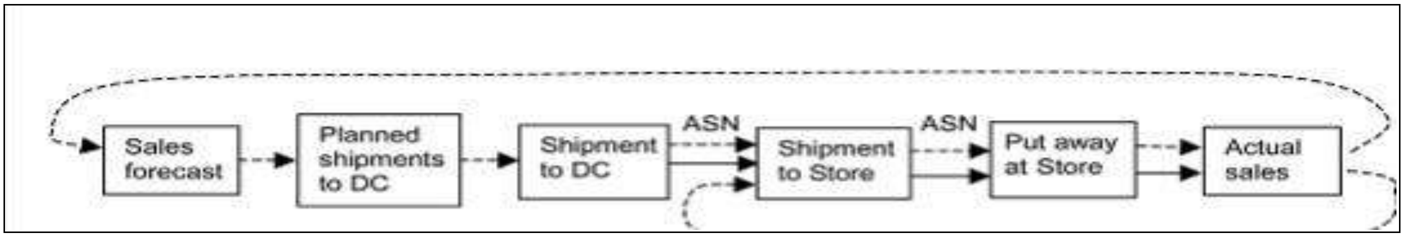

Figure 1: Traditional Logistics Flow

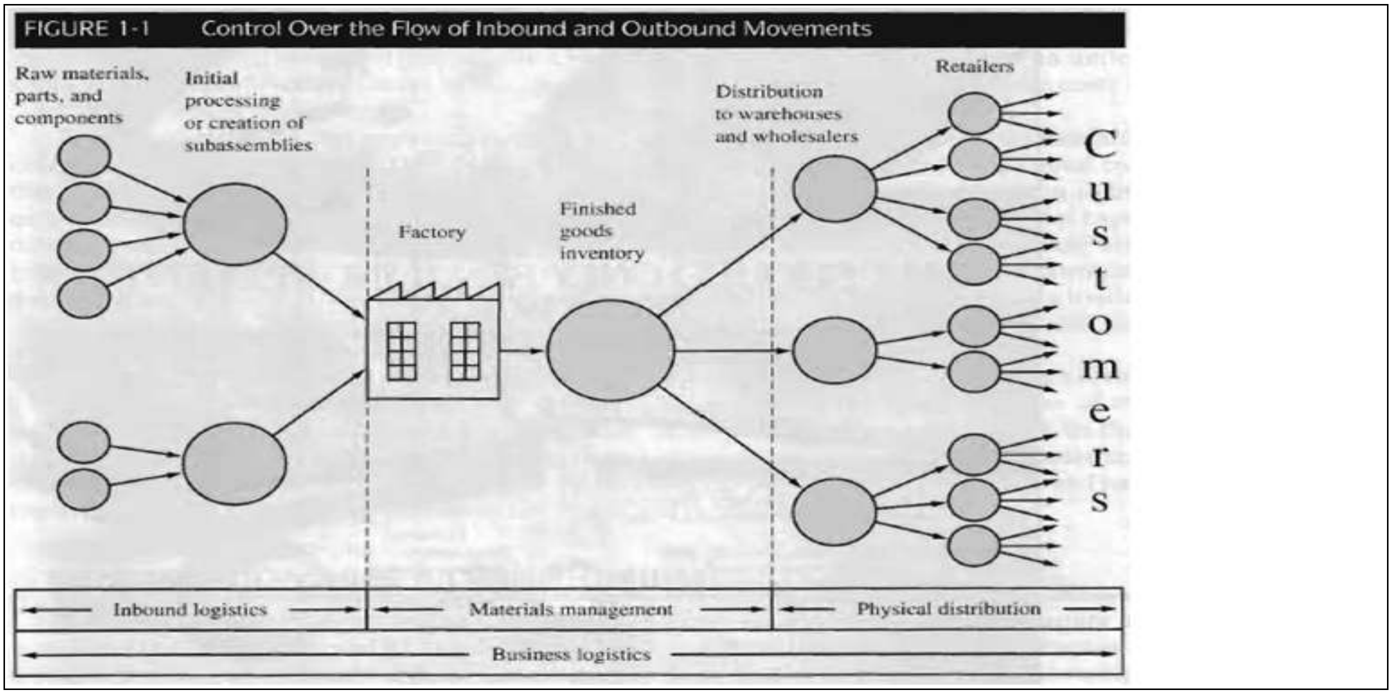

Figure 2

Sales forecast is used to project sale requirement, when certain amount product is required, they will be shipped to the DC (distribution center) and then shipped to the retail stores from DC. At every single level of the supply chain, ASNs (Advanced Shipping Notices) will be assisting the useful information as the products flow.

Reverse logistics flow, however, is a different story. Shippers generally do not initiate reverse logistics activity as a result of planning and decision making on the part of the firm, but in response to actions by consumers or downstream channel members. Here is the figure outlining what is reverse logistics flow:

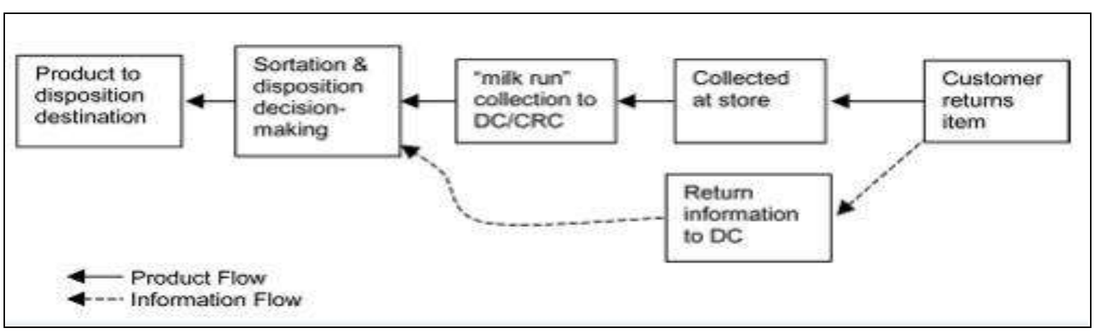

Figure 3: Reverse Logistics Flow

When a return occurs, the returned product will be collected (in many different ways) and sent to the distribution center. At the same time the relevant information about the return item description, condition at return, customer information etc., will be transferred to the return processing center, but unfortunately, given the current state of the reverse logistics status quo, this information capture process rarely occurs, or occurs with less accuracy.

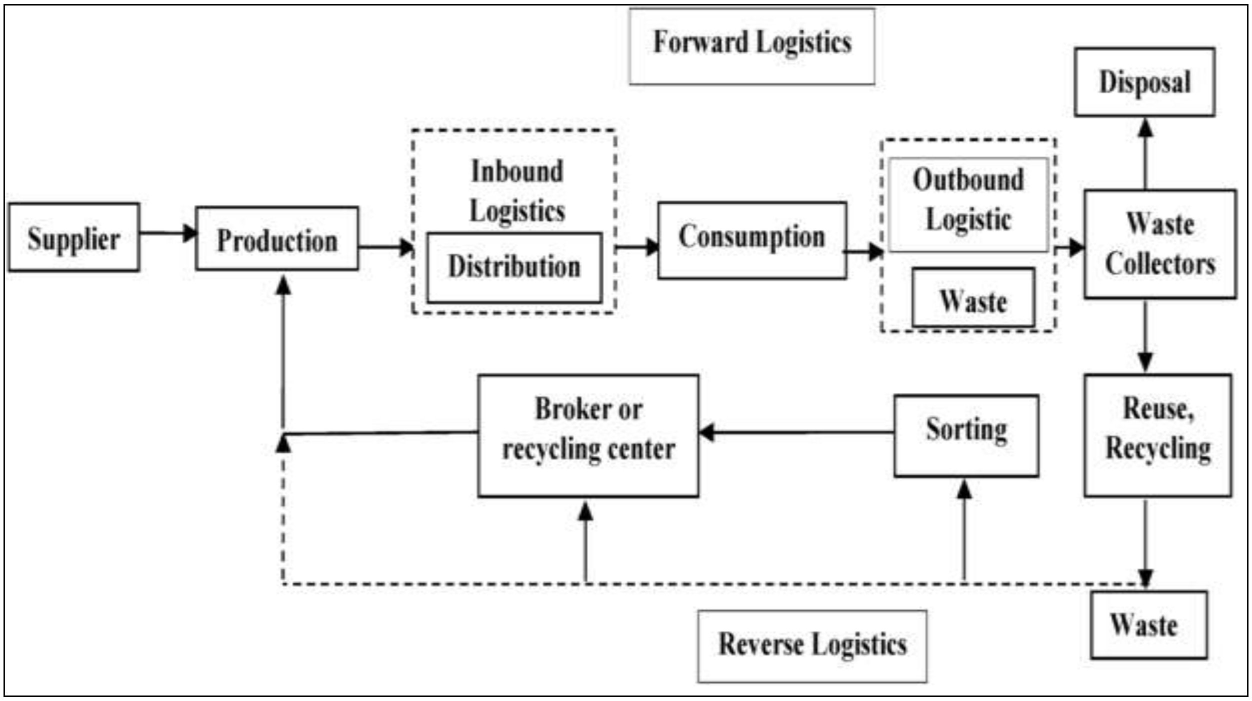

Figure 4

3. Literature Review

References	Contribution in Literature	Research angle	Remarks if any
Roodneymoore, (2005)	To understand how to treat reverse logistics as it is a another business not a return department	Reverse Logistics the least used differentiator	ISM,SAP-LAP Analysis
Jitesh Thakkar (2006)	To propose an integrated qualitative and quantitative approach to the development of a balanced scorecard (BSC) for a real life case company.	An integrated approach of Interpretive Structural Modeling	Performance measures
S. K. Sharma, B. N. Panda, S. S. Mahapatra, and S. Sahu (2011)	To understand and utilizes the Interpretive Structural Modeling (ISM) methodology to understand the mutual influences among the barriers so that barriers that are at the root of some more barriers (called driving barriers) and those which are most influenced by the others (called driven barriers) are identified.	Analysis of Barriers for Reverse Logistics: An Indian Perspective	ISM methodology
Neena Sohani, Nagendra Sohani,(2012)	To understand the development of Interpretive Structural Model (ISM) for quality framework of higher education institution.	Developing Interpretive Structural Model for Quality Framework in Higher Education: Indian Context	ISM methodology
Rajesh Attri, Nikhil Dev and Vivek Sharma,(2013)	To understand ISM methodology for Identifying relationships among specific items and methodology for identifying relationships among specific items,	Interpretive Structural Modelling (ISM) approach: An Overview.	ISM Analysis

Harwinder Singh, Jaimal Singh Khamba (2013)	It is aimed at developing an understanding for improving the utilization level of new technologies in an Indian manufacturing enterprise using flexible systems methodology	Indian manufacturing organization for utilization of advanced manufacturing technologies	Utilization of advanced manufacturing technologies
V Ravi, Ravi Shankar, (2015)	To investigate the current status of reverse logistics practices used on four sectors of Indian manufacturing industry, namely, auto, paper, food and beverage processing, and electronics.	Survey of reverse logistics Practices in manufacturing industries	Nationwide questionnaire e-based survey
Surendra S. Yadav, Ravi Shankar (2015)	This paper deals with the role of reverse logistics in an effective supply chain.	Linear versus reverse supply chain	Analysis on reverse supply chain
Veera Pandiyan, et al (2015)	To review and identify clear definition of Reverse Logistics, comparison Reverse Logistics with Forward Logistics in order to have a better understanding and finally future direction of Reverse Logistics in gaining competitive advantages.	Future Directions of Reverse Logistics	Review of Reverse logistics
Curtis Greve , Derry Davis, (2015)	To understand the logistics and supply chain of UPS	Recover lost profits by improving reverse logistics	ISM Analysis

Table 1

4. Methodology

The methodology used for studying the reverse logistics is Genetic Algorithm. Genetic algorithms were formally introduced in the United States in the 1970s by John Holland at University of Michigan. The continuing price and performance improvements of computational systems have made them attractive for some types of optimization. In particular, genetic algorithms work very well on mixed, combinatorial problems. They are less susceptible to getting 'stuck' at local optima than gradient search methods.

Genetic algorithms are implemented in a computer simulation in which a population of abstract representations called chromosomes or the genotype of the genome of candidate solutions called individuals, creatures, or phenotypes to an optimization problem gives better solutions. Traditionally, solutions are represented in binary as strings of 0s and 1s, but other encodings are also possible. The evolution usually starts from a population of randomly generated individuals and happens in generations. In each generation, the fitness of every individual in the population is evaluated, multiple individuals are stochastically selected from the current population, and modified to form a new population.

The new population is then used in the next iteration of the algorithm. Commonly, the algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population. If the algorithm has terminated due to a maximum number of generations, a satisfactory solution may or may not have been reached. Genetic algorithms find application in bioinformatics, phylogenetics, computational science, engineering, economics, chemistry, manufacturing, mathematics, physics and other fields.

5. Calculations

Notations

1. Cu = Product cost at collection center.
2. Iuv = No. of products from u to v
3. Ivw = No. of products from v to w
4. β = Inventory cost constant
5. Tuv = Transportation cost from u to v
6. Tvw = Transportation cost from v to w
7. Rv = Cost of remanufacturing at facility v
8. Fv = Fixed cost for running at v
9. N = Total number of products collected.
10. RE = Remanufacturing capacities
11. MC = Marketing facilities
12. The objective function = Sum of Retrieval, Transportation, Remanufacturing, Inventory and Fixed costs

Therefore,

$$Z = \{\sum_{u=1}^{n}\sum_{v=1}^{n} C_{uv} I_{uv}\} + \{\sum_{u=1}^{n}\sum_{v=1}^{n} T_{uv} I_{uv} + \sum_{u=1}^{n}\sum_{w=1}^{n} T_{uw} I_{uw}\} + \{\sum_{v=1}^{n}\sum_{w=1}^{n} R_{vw} I_{vw}\} + \{\sum_{u=1}^{n}\sum_{v=1}^{n} \beta C_{uv} I_{uv}\} + \{\sum_{v=1}^{n}\sum_{w=1}^{n} \beta R_{vw} I_{vw}\}$$

The constraints are,
N = Input quantities near facilities,

$$\sum_{v=1}^{n}\sum_{w=1}^{n} I_{uv} = \sum_{v=1}^{n}\sum_{w=1}^{n} \hat{I_{vw}} :$$

Yv = (0,1) for all the values of u and v,
Iuv>= 0; and Ivw = 0; for all u,v,w.

Assumptions: It is assumed that the used products are returned. The collection center’s capacity should be less than or equal to that of remanufacturing markets and the plants. The rate of reproduction should be equal to the corresponding demand at that time. Transportation time is not considered.

Steps to carry out Genetic Algorithm

1. The collection, remanufacturing and markets exact number is entered, various capacities are defined.
2. After initialization, we obtain the values of the objective functions.
3. The roulette wheel concept is applied based on cumulative values and probabilities.
4. The mated pairs and children are obtained.
5. The process is continued till the condition is satisfied and we obtain the optimum value.

- Initialization: Based on the random numbers in the criteria, initialization is done. Then the entry in its binary format is encoded. Binary strings are found in each strings, every bit containing some of the characteristics.
- Selection: The best chromosomes are selected to obtain the best off springs. For this the roulette wheel concept is used. The chromosomes are drafted according to their normalized fitness values on a pie chart following which a random number is generated to select a chromosome. Chromosomes with higher fitness values are selected and they occupy more space on pie.
- Crossover: Crossover combines characteristics of parents to produce off-springs. It also provides a momentum for improvement.
- Mutation: Mutation makes small local challenges of feasible solutions to provide diversity of population for wider search of feasible solutions.

6. Results And Interpretation

Considering a company, the study says 600,000 tons of products it produces are disposed off. These products are returned to various remanufacturing plants for remanufacturing to reduce effects on environment as well as increase profits of company. The reverse supply chain with 3 collection centres and 3 re-manufacturing plants and 3 secondary markets is taken into consideration after analysis. This example problem is optimized by genetic algorithm by random generation of initial solution and then optimizing total cost taken. Operational method is encoded and executed using MATLAB. The program is tested with various randomly generated problems. The results were compared to those from literature.

7. Conclusion and Future Scope

A network model for single product multi level scenario in reverse logistics has been developed using Genetic Algorithm considering various values from literature. This network is an attempt to correct shortcomings in an industry with single product in multi level scenario. It is aimed at reducing various costs incurred during reverse supply chain system starting from collection centres to remanufacturing plant, remanufacturing processes and finally transportation to secondary markets. The proposed genetic algorithm has been used to optimize solution using MATLAB software consuming less computation time. The results have shown that this optimized network has sufficiently reduced costs and saves time.

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