ISBN 978-93-5156-328-0

International Conference of Advance Research and Innovation (ICARI-2015)

Decision Making Using AHP under Reverse Supply Chain Environment for EOL Products

Sana Malik *, Aradhana Kumari, Saurabh Agrawal

Department of Mechanical Engineering, Delhi Technological University, New Delhi, India

Article Info

Article history:
Received 9 January 2015
Received in revised form
15 January 2015
Accepted 20 January 2015
Available online 31 January 2015

Keywords

Reverse Supply Chain,
End-of-Life,
Hierarchy,
E-commerce,
Third Party Provider,
Symbiotic Logistics Concept,
Virtual Reverse Logistics

Abstract

The study, characterization and modeling of reverse logistics and its application becomes imperative as the issues related to environment and societies gain more and more importance. With this becoming a necessity, there arises a need to realize the fundamental importance of decision making in a reverse logistics environment. Due to uncertainty involved, the decision making tends to be an arduous and complicated task. In the following paper, an attempt is made to create a model for choosing one out of three alternatives for a reverse supply chain using Analytic Heuristic Process (AHP) along with delineation of the advantages and disadvantages. The three alternatives are a part of a strategic decision which makes it one of the most crucial decisions and a huge determinant in the success of a reverse supply chain.

1. Introduction

Nowadays, with the increasing concern towards environment made it essential for the firm to recover waste product. Several countries have enforced environmental legislation charging producers with responsibility for the whole life cycle of their products. Therefore, managing return product flow is becoming increasingly important to the success of supply chain firms, particularly as the volume of return flow substantially increases [1]. The process of management of return product can be an integral part of a firm's supply chain [2]. Accordingly, returned product disposition should not only happen quickly (Blackburn et al., 2004), but disposition decision-makers must consider a variety of decision parameters to ensure that the chosen disposition policy is the most advantageous for the organization.

However for many manufacturers these recovery and recycling activities are not their mainstream businesses. It would cost very high or even waste for manufacturers to establish complete recovery channel. Therefore, the manufacturer left with only some alternatives to take the responsibility of its product in a cost effective manner. In this paper, three alternatives are taken into account. First is Third Party Provider (TPP). In TPP the manufacturer of the product outsources its responsibility to other people who take the reverse logistics business as its core business and can establish a perfect recovery system which meets the requirements and reduces environmental pollution. Second alternative is Symbiotic Logistics Concept (SLC). Symbiotic relationships have a great importance as the competition becomes more global in the present day environment. A number of factors are important to be considered like the political and legal, competition, and economic concepts. These increase the relevance of symbiotic relationships in reverse logistics. The third alternative is Virtual Reverse Logistics Network (VRL). This relies on e-commerce and www for remote monitoring and benchmarking, instead of physical transportation and distribution. In this a configuration monitoring and benchmarking agent screens the product that is about to enter the end of use stream and register the data in system database. In this framework, the users or agents, consider the possibility of explicitly registering requests or offers for PCs or modules that are matched automatically.

Now, the problems faced by the top management are the evaluation of various alternatives for end-of-life (EOL) products. In this paper, Analytic Hierarchy Process (AHP) based decision model is used to structure the problem related to alternatives in reverse logistics for EOL product and provides a comprehensive and rational framework to structure a decision problem, quantifying its elements, relating elements to overall goals and evaluating alternative solutions.

Corresponding Author,
E-mail address: sm.sanamalik.93@gmail.com

2. Literature Review

Reverse Logistics is related to the operations involved in the movement of an article back from the user to the manufacturer. Reverse Logistics is basically concerned with the return of a product that has either reached its End of Life (EOL) or has been returned by the customer. According to Rogers and Tiben Lembke (1991) [3], the definition of reverse logistics is "operation and the planning along with the implementation of cost effective information and material flow from the point of consumption (of recapturing value) to the point of origin." Work based on and related to reverse logistics was done by Kelle and Silver (1989) [4] who described methods for the forecast of reusable containers. Santibanez-Gonzalez and Diabat (2013) [5] proposed improved Benders decomposition schemes for solving a remanufacturing supply chain design problem (RSCP). Gandhi and Aggarwal (1992) [6] have used di-graph and matrix approach for failure mode and effect analysis. Yadav et al. (2010) [7] used graphs in Graph

Theoretic Approach for the selection of a power plant. Another aspect related to the reverse logistics was taken up when implementation of reverse logistics programs to reuse, recycle and reduce the different wastes generated from distribution and other company processes produces tangible and intangible value was taken up by Kopicki et al., 1993[8]. Veerakamolmal and Gupta (1997) [9] discussed a technique for analyzing the design efficiency to study the effect of end-of-life disassembly and disposal on environment of electronic products. Services related to reverse logistics operations must be driven on the customer perspective.

The Analytic Hierarchy Process (AHP) was developed by T. Saaty. It allows for the assessment of the relative weight of multiple criteria with the help of certain criteria. If the ratings are not available, judges, assessors and people making assessments can still know and realize if one criterion is more important than another. Thus, pairwise comparisons are can be made. AHP helps and eases decision making based on feelings, memories and judgment or other forces that may influence decision making at multilevel hierarchy structures (Bayazit, 2005)[10].

The AHP method may also be successfully employed for supporting decisions concerning the selection and use of technical means of protective equipment and production facilities. Maldonado-Macias et al. (2010) [11] utilised AHP for the determining of the extent to which the criteria of ergonomics and safety of operation are taken into account when equipment has to be selected which is to be purchased. After purchasing, it also has to be installed in advanced manufacturing technology businesses and related enterprises. Caputo et al. (2013)[12] made use of AHP applied this method for giving priorities for the use of several equipment. This would ensure safety when operating machines, such as a fixed guard or a safety light curtain or control system (two hands).

Another field for AHP applications is assessing occupational risk assessment and management. which concerned the development of a new model of occupational risk assessment being adapted to the needs of SMEs (Fera and Machiaroli, 2010)[13] developed a model of occupational risk assessment so as to adapt to the needs of Small and Medium Enterprises (SMEs). A new and novel approach to establish priorities of risk factors in SMEs was illustrated. It can be seen that the pivotal concept of this is to move away from the main types of hazards towards the flexible development of a list of risk factors and this was made possible.

3. Method

3.1 AHP

AHP is a method for ranking decision alternatives and selecting the best one when the decision maker has multiple criteria [14]. The analytic hierarchy process (AHP) is developed at the Wharton School of Business at the University of Pennsylvania [15].

It allows decision makers to model a complex problem in a hierarchical structure containing objectives, and alternatives. Uncertainties and other influencing factors can also be included. AHP also allows the incorporation of both subjective and objective factors in decision problem. During the evaluation of n competing alternatives A1, A2,…, An under a given criterion, it is important to use the framework of pair-wise comparison by n × n square matrix from which a set of preference values for the alternatives is derived.

3.2 Steps

Step: 1. Determine the objective, the evaluation attributes and the alternatives.

Step: 2. Develop a hierarchical structure with goal or objective, attributes and alternatives from top to bottom level respectively in hierarchical structure.

Step: 3.

(i) Determine the relative importance between the attributes and construct a pair-wise comparison matrix using a scale of relative importance. The judgments are entered using the fundamental scale of the analytic hierarchy process [16].

Table: 1. Preference Scale

Preference weights	Definition	Explanation
1	Equally preferred	Two attributes contribute equally
3	Moderately	Experience and judgement slightly favour one activity over another
5	Strongly	Experience and judgement strongly favour one activity over another
7	Very Strongly	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extremely	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values	When compromise is needed
Reciprocals	Reciprocals for inverse comparisons	

If there are M attributes, the pair-wise comparison of attribute i with attribute j yields a square matrix BM x M where aij denotes the comparative importance of attribute i with respect to attribute j. In the matrix, bij = 1 when i = j and bji = 1/bij.

$$
\mathbf{AM\ X\ M} = \begin{bmatrix} 1 & a12 & a13 & - & - & a1m \\ a21 & 1 & a23 & - & - & a2m \\ a22 & a32 & 1 & - & - & a3m \\ - & - & - & - & - & - \\ - & - & - & - & - & - \\ am1 & am2 & am3 & - & - & 1 \end{bmatrix}
$$

(ii) Determine the maximum Eigen value from the equation:

$$A\ X\ W = \lambda \max X\ W$$

Where = λmax is the biggest eigenvalue of matrix A, I = unit matrix.

(iii) Calculate the consistency index CI = (λmax - M) / (M - 1). The smaller the value of CI, the smaller is the deviation from the consistency.

(iv) Obtain the random index (RI) for the number of attributes used in decision making using Table 2.

Table: 2. Average Random Index Values

Attributes	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.39	1.11	1.25	1.35	1.40	1.45	1.49

(v) Calculate the consistency ratio CR = CI/RI. Usually, a CR of 0.1 or less is considered as acceptable, and it reflects an informed judgment attributable to the knowledge of the analyst regarding the problem under study.

Step 4: The next step is to compare the alternatives pair-wise with respect to how much better (i.e., more dominant) they are in satisfying each of the attributes. If there is N number of alternatives, then there is M number of N x N matrices of judgments, since there are M attributes. Construct pair-wise comparison matrices using a scale of relative importance. Using the fundamental scale of AHP method judgments are entered [15, 16]. The steps are the same as those suggested under main step 3.

Step 5: The last step is to obtain the overall or composite performance scores for the alternatives by multiplying the relative normalized weight (wj) of each attribute (obtained in step 3) with its corresponding normalized weight value for each alternative (obtained in step 4), and summing over the attributes for each alternative.

The overall or composite performance scores can be calculated for each and every alternative. These scores are indicative of which alternative is the more viable solution out of those present. Hence, the one with the highest value is chosen as the best and the suitable solution.

4. Conclusion

AHP is thus realized to be an important method that can be used to find out the most viable out of the three alternatives. It can be seen that AHP decreases the bias or prejudice in the decision-making process. The significance of each and every criterion becomes clear. AHP is more flexible when compared with other multi-criteria decision making methods. While using AHP, a quantitative as well as qualitative role, that is, the role of both objective as well as subjective measures can be identified. A method to check the consistency also exists, hence increasing the reliability of the overall value or answer. Finding a viable solution or the most feasible solution, as we may put it, is of strategic importance. It is very important that we realize the importance of selecting the most feasible solution as it determines the success of the supply chain. By applying the model given above (AHP), it can be seen that AHP can be used to satisfactorily model the problem of reverse logistics described in the paper. However, AHP lags in a few respects. If the numbers of factors are more, the number of pair wise comparisons can become very large, thus, making the problem and its solving a bit more complicated. Another disadvantage is the use of the scale containing values in the form of numbers from 1 to 9. It might become difficult for the decision maker to ascertain a certain number for the given elements. However, for the problem given above, AHP is able to model the problem quite satisfactorily.

References

[1] D. R. Guide Jr, G. C. Souza, L. N. J. Van Wassenhove, D. Blackburn, Time value of commercial product returns, Management Science, 52(8), 2006, 1200-1214

[2] D. S. Rogers, D. Lambert, K. Croxton, S. J. Garcia-Dastugue, The returns management process, International Journal of Logistics Management, 13(2), 2002, 1-18

[3] Tibben-Lembke, S. Ronald, Rogers, S. Dale, Differences between forward and reverse logistics in a retail environment, Supply Chain Management: An International Journal, 7(5), 2002, 271 – 282

[4] P. Kelle, E. A. Silver, Forecasting the Returns of Reusable Containers, Journal of Operations Management, 8(1), 1989a, 17-35

[5] E. D. R. Santibanez-Gonzalez, A. Diabat, Computers & Industrial Engineering, 66(4), 889-898

[6] O. P. Gandhi, V. P. Agrawal, FMEA-A digraph and matrix approach, Journal of Reliability Engineering and System Safety, 35, 1992, 47-158

[7] N. Yadav, I. A. Khan, S. Grover, Operational-based economics evaluation and selection of a power plant using graph theoretic approach, world academy of science, Engineering and Technology, 63, 2010, 426-436

[8] R. Kopicki, M. Berg, L. Legg, V. Dasappa, C. Maggioni, Reuse and recycling: Reverse logistics, opportunities Council of Logistics Management, Oak Brook, 1993

[9] P. Veerakamolmal, S. M. Gupta, Analysis of design efficiency for the disassembly of modular electronic products, Journal of Electronics Manufacturing, 9(1), 1997, 79–95

[10] O. Bayazit, Use of AHP in decision-making for flexible manufacturing systems, Journal of Manufacturing Technology Management, 167, 2005, 808–819

[11] A. Maldonado-Macías, A. Realyvásquez, E. Martínez, J. Sánchez, Importance of Ergonomic Compatibility Attributes on the Selection of Advanced Manufacturing Technology – AMT. In: Johnson, A., Miller, J. (Eds.), Proceedings of the 2010 Industrial Engineering Research Conference, 2010, Cancun, Mexico

[12] A. C. Caputo, P. M. Pelagagge, P. Salini, AHP-based methodology for selecting safety devices of industrial machinery, Saf. Sci., 53, 2013, 202–218

[13] M. Fera, R. Macchiaroli, Appraisal of a new risk assessment model for SME, Saf. Sci., 48(10), 2010, 1361–1368

[14] B. W. Taylor, Introduction to Management Science, Pearson Education Inc., New Jersey, 2004

[15] T. L. Saaty, The Analytic Hierarchy Process, McGraw Hill, New York, 1980

[16] T. L. Saaty, Fundamentals of decision making and Priority Theory. 2nd ed. Pittsburgh PA: RWS Publications, 2000