Evaluation and selection of a third-party reverse logistics provider using ANP and IFG-MCDM methodology

Mohsen Zareinejad [1], Habibollah Javanmard [2]

[1.] MSc. Student, Department of Industrial Engineering, Science and Research branch, Islamic Azad University, Arak, Iran
[2.] Assistant Professor, Department of Industrial Engineering, Science and Research branch, Islamic Azad University, Arak, Iran
Mohsen.zareinejad@gmail.com

Abstract: Today, as organizations improve their ability to compete globally, we see that competition innovation and creativity are now shifting to the supply chain. Increased competitive advantage can be achieved only if all supply chain stakeholders are coordinated and integrated with one another. This integration must be created among suppliers, intermediaries, third-party providers, and customers. In addition to the forward supply chain, reverse logistics must also be considered. Amid business complexities, smart organizations are reusing, recycling, and remanufacturing using third-party reverse logistics providers (3PRLP), which affect the performance of the entire organization. The selection and evaluation of reverse logistics providers is important to improving outcomes. Several attributes should be used to select and evaluate 3PRLP. In this paper, an analytic network process (ANP) is used to investigate feedback and relationships among attributes and to identify the most important attributes in the selection and evaluation of 3PRLP. Then a multi-criteria group decision-making is upgraded in uncertainty conditions to guide the process of selecting the best 3PRLP. To deal with uncertainty, intuitionistic fuzzy set (IFS) and grey relation analysis (GRA) will be used.

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1. Introduction

Today, the supply chain is critically important to achieving a coherent integration among different actors in the chain. Competitive advantage can only be achieved if all actors are integrated with one another in the supply chain (Ghazanfari and Fathollah, 2010). To improve efficiency, the supply chain must use modern techniques and approaches, such as JIT purchasing, economic batch sizes, strategic inventory, reverse logistics, and third party logistics (Kannan, Palaniappan, Zhu, and Kannan, 2012).

Logistics is the supply chain integration process. Logistics management includes the completion and integration of planning operations, implementation, the control of efficiency, cost-effective flow, inventory issues, and transformation of products and information in the supply chain to meet customer demand (Bowersox and Clos, 1996). In addition to traditional or forward currents, which are mainly suppliers, manufacturers, retailers, and customers, there is another important current in the supply chain, one which is formed in the reverse direction. In this current, products are returned from lower levels of the supply chain to higher levels. So, along with the forward supply chain, we must also consider the impact of reverse logistics.

Reverse logistics focuses on the reverse distribution of materials, reducing overall cost of logistics and recovery and reducing the amount of material in the forward system (Carter and Ellram, 1998). In general, reverse logistics is defined as 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 of proper disposal (Rogers and Tibben-Lembke, 1999; Meade, et al., 2002). Reverse logistics have become a competitive necessity to meet the needs of customers, process returned goods, or choose to buy a consignment of goods (if the consignment good is not sold, the primary seller retakes the product) (Daugherty, Autry, & Ellinger, 2001). Therefore, reverse logistics allows firms to gain and maintain competitive advantage and ensure maximum customer satisfaction. Buyers should ensure they can return faulty or defective goods. Furthermore, the emergence of stringent environmental implications has led to executives focusing on remanufacturing, recycling, and restoring efficiency in all areas of reverse logistics.

There are some important signs that there is an industry problem in reverse logistics systems. For example: if the arrival rate of returns is higher than the processing and recycling speed, return inventories will build up in warehouses, leading to undetectable returns, lengthy processing times, unknown costs of processing returns, and decreases in customer satisfaction and confidence (Meade, et al., 2002; Schwartz, 2000).

Receiving damaged goods, incorrect shipments, and product recalls and the regulatory requirements associated with recycling are the reasons for the increase in returns (Ritchie, Burnes, Whittle, & Hey, 2000). Each year, U.S. companies spending US$950 billion on logistics. Returned goods cost almost US$43 billion or 4.5% of the total amount (Norek, 2002; Richeya, Chenb, Genchevb, & Daugherty, 2005). In all industries, reverse logistics constitute 3-50 percent of total shipments (Rogers, et al., 1999). The figures are stunning and underscore the importance of addressing the issue.

Proper management of returned goods must include customer service concepts. According to Andel (1997), efficient reverse logistics improve customer satisfaction, reduce the amount of required resources, reduce distribution costs, and streamline storage (Autry, et al., 2000). Most manufacturing companies are unable to handle complex networks due to resource constraints. Therefore, most manufacturers and retailers outsource their reverse logistics to third-party reverse logistics providers (3PRLPs). This helps them remain successful and competitively focused.

The selection and evaluation of 3PRLP is one of the most important activities that a company can make regarding its resource allocations, affecting overall company performance. There are several different attributes and decision-making models for selecting reverse logistics providers.

In making this selection, improving decision-making models for 3PRLP is important. In this research, interactions among attributes and sub-attributes are examined using an analytic network process. Second, other models of multi-criteria decision-making (MCDM) are used in a state of uncertainty to select and evaluate 3PRLP. Due to increasing complexity of decisions, the uncertainty of the evaluation increases. To deal with this uncertainty, intuitionistic fuzzy set and grey relation analysis are used.

2. Research questions

The objective of the research is to evaluate and select third party reverse logistics providers using a new method of decision-making that combines ANP and IFG-MCDM. The following are the research questions in this study:

- How can we select and evaluate third-party reverse logistics providers by combining two methods of decision-making?
- Can we design an analytic network process and multiple criteria decision-making in combination as a tool for evaluating and selecting 3PRLP in DENASANAAT Company?
- How can the analytic network process help analyze the interdependence among attributes and sub-attributes?
- How can we use intuitionistic fuzzy set and grey relation analysis in a multi-criteria decision making model?
- What are the consequences of implementing the integrated model in an organization?

3. Proposed methodology

3.1. Research design

This research is an applied study. The methodology is descriptive - survey. In this study, the attributes or criteria in selecting and evaluating 3PRLP will be identified by performing a comprehensive review of the literature. While the exact number of values in the evaluation of a complex system can be difficult, complex systems can be divided into several subsystems to determine the value of amounts more easily (Liou, Tzeng, and Chang, 2007).

In this research the analytic network process is used to investigate feedback and interdependence among attributes in the selection of 3PRLPs. Fig. 1 shows the interdependence and feedback of attributes using an ANP model. According to the results of a super matrix, the weight of each criterion is obtained. The super matrix is formed using pair-wise comparisons. The relative importance of each attribute is rated from 1 to 9 in pair-wise comparisons. In that case, (1) indicates the equal importance and of (9) indicates the extreme inequality in the importance (Saaty, 1980). This weighting is entered as values of the super matrix. The relationship between the attributes is reflected in the matrix.

The attributes move to the next stage with the highest degree of importance (maximum of 16) to evaluate 3PRLPs. The next phase of the procedure includes group decision-making using the intuitionistic fuzzy set. The group decision-making occurs through multi-criteria decision-making methods (MCDM). Finally the alternatives are ranked using the GRA approach. Figure 2 shows the conceptual model of research. Note that during the investigation, depending on the new method, restrictions, and improvements to decision making, one of the MCDM methods is used.

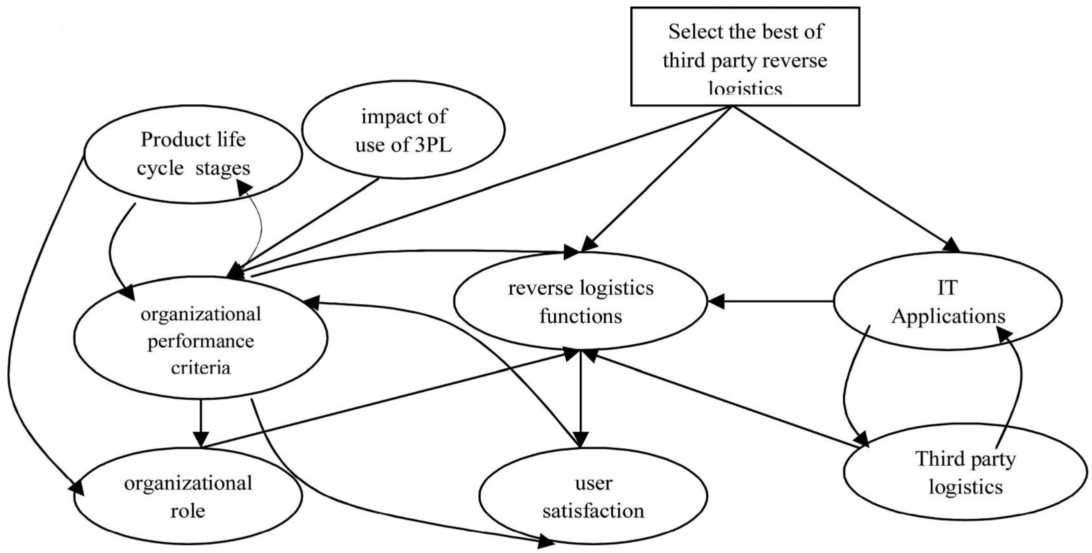

Figure 1. Network analysis model used in the proposed study

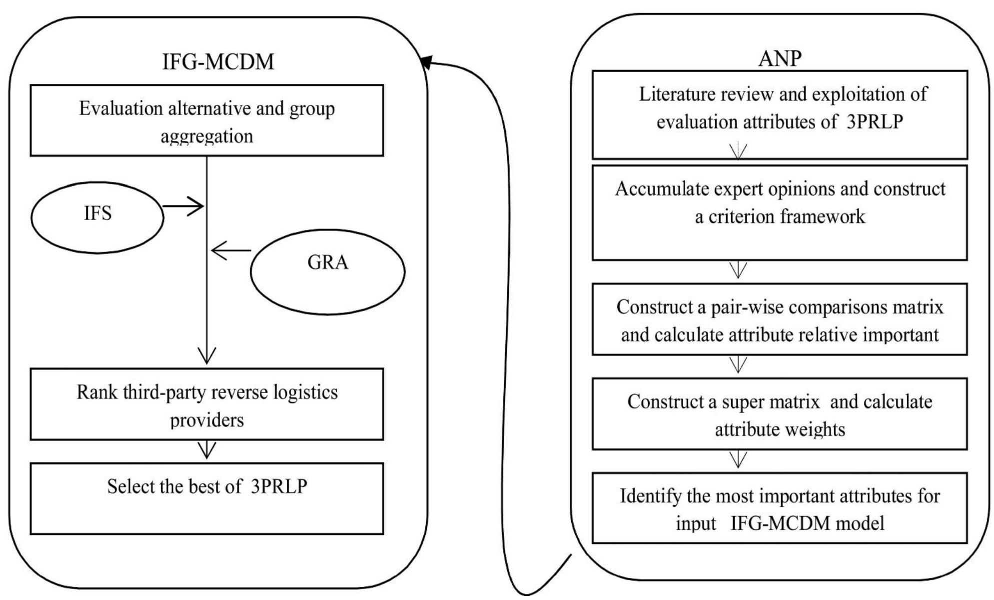

Figure 2. Conceptual model of the proposed research

3.2. Attributes and variables of the research

To evaluate and select 3PRLP, the proposed attributes are regrouped into eight main attributes: third party logistics services (3PLS), reverse logistics functions (RLF), organizational role (OR), user satisfaction (US), impact of use of 3PL (IU3PL), organizational performance criteria (OPC), IT applications (IT), product lifecycle stages (PLC). There are also 38 sub-attributes listed in Table 1.

3.3. Research Instrument and Data analysis

In this study, library and survey methods (including two questionnaires) will be used to collect the required data. The first questionnaire will obtain the dependence and feedback of attributes and criteria. The second questionnaire will examine the importance of attributes. The first questionnaire is sorted based on pair-wise comparisons. The second questionnaire is sorted based on a Likret scale using linguistic terms. Intuitionistic fuzzy numbers are used to change the linguistic terms. The questionnaires will be completed through interviews. To confirm the validity of the questionnaire, experts and specialists' views will be used. Cronbach's alpha and consistency rate (CR) will be used to determine the reliability of the questionnaire.

Table 1. Attributes and Sub-attributes

Attributes	***Sub-attributes***	***References***
Third Party Logistics Services (3PLS)	Inventory Replenishment (3PLS1), Warehouse Management (3PLS2), Shipment Consolidation (3PLS3), Carrier Selection (3PLS4), and Direct Transportation Services (3PLS5)	Dowlatshahi (2000), Van and Zijm (1999), Kleinsorge et al. (1991), Gunasekaran et al. (2001), Davis and Gaither (1985), Gupta and Bagchi (1987), Khoo and Mitsuru (2006), and Holguin Veras (2002), and Kannan, Palaniappan, Zhu and Kannan (2012)
Organizational Role (OR)	Reclaim (OR1), Recycle (OR2), Remanufacture (OR3), Reuse (OR4), and Disposal (OR5)	Meade and Sarkis (2002), Dowlatshahi (2000), Demir and Orhan (2003), Schwartz (2000), and Kannan et al. (2012)
Product Life Cycle stages(PLC)	Introduction (PLC1), Growth (PLC2), Maturity (PLC3), and Decline (PLC4)	Mead and Sarkis (2002)
Reverse Logistics Functions (RLF)	Collection (RLF1), Packing (RLF2), Storage (RLF3), Sorting (RLF4), Transitional Processing (RLF5), and Delivery (RLF6)	Schwartz (2000), Dowlatshahi (2000), Jeffery and Ramanujam (2006), Kaliampakos et al. (2002), Van Dijck (1990), and Kannan et al. (2012)
Impact of use of 3PL (IU3PL)	Customer Satisfaction (IU3PL1), Frequent Updating (IU3PL2), Profitability (IU3PL3), and Employee Morale (IU3PL4)	Hendrik et al. (2006), Lynch (2000), Boyson et al. (1999), and Kannan et al. (2012)
Organizational Performance Criteria (OPC)	Quality (OPC1), Cost (OPC2), Time (OPC3), Flexibility (OPC4), Customer Satisfaction (OPC5), and Service (OPC6)	Kim et al. (2004), Kwang et al. (2007), Andersson and Norrman (2002), Lynch (2000), Boyson et al. (1999), Stock et al. (1998), and Kannan et al. (2012)
IT Applications (IT)	Warehouse Management (IT1), Order Management (IT2), Supply chain planning (IT3), Shipment and Tracking (IT4), and Freight Payment (IT5)	Dowlatshahi (2000), Van and Zijm (1999), Jing et al. (2006), Khoo and Mitsuru (2006), Holguin Veras (2002), and Kannan et al. (2012)
User Satisfaction (US)	Effective Communication (US1), Service Improvement (US2), Cost Saving (US3), and Overall Working Relations (US4)	Mohr and Spekman (1994), Lynch (2000), Andersson and Norrman (2002), Boyson et al. (1999), and Kannan et al. (2012)

All questionnaires will be completed by experts in the field of logistics and supply chain who work in DENASANAAT Company (Yasuj City, Iran). Reza and Vassilis (1988) suggest that the number of experts interviewed (paired comparisons questionnaire) should not be large – five to 15 experts would be enough. The first questionnaire related to the interdependence among attributes and sub-attributes will be given to 15 experts, including consultants, executives, IT personnel, and logistics experts. The second questionnaire is set in four versions, which will be completed by experts as the main decision makers. The evaluated attributes in this study will be extracted from the research in reverse logistics and other resources. In this study, important decision-making models are integrated into a conceptual model. The tools that in this study include analytic network process (ANP), for analyzing the relations of attributes and obtaining their weights, and multi-criteria decision making (MCDM), to rank 3PRLP. Super Decisions ANP software (version 2.2.0 2012) will be used to analyze the feedback and relationships among attributes and sub-attributes. Microsoft Excel will be used to analyze the fuzzy group decision-making and MCDM model.

4. Excepted results and outcome

In this study, we seek to find the best of third-party reverse logistics provider. It is logical that a provider offering better performance in reverse logistics should be chosen for this service. Finally, the best reverse logistics services are represented. Reverse logistics outsourcing can lead to lower costs for facilities, information technology resources, and labor. Consequently, the efficiency and effectiveness of the company can improve. Other benefits of this research to increase reverse logistics service efficiency include lower costs of goods, improved supply chain management, stronger customer service, better supply chain integration, easier access to global markets, improved transportation capacity, and reduced environmental impact.

Decision-making models are considered as one of the management sciences. Expanding and improving decision-making models for evaluating and selecting appropriate 3PRLP will significantly help policymakers and industry leaders. The proposed method can be viewed as an extension of traditional MCDM methods. This method provides a convenient and practical tool for dealing with real-world problems in a state of uncertainty and linguistic decision-making information. The features of this decision-making method are using intuitionistic fuzzy sets for group aggregation and decision analysis in the decision-making method. Also the use of grey relation analysis can account for incomplete data, lack of data, and executive inexperience. The unique ability of ANP to analyze the relationships and feedback of attributes should not be ignored. Combining these two models can deliver better results. The better results of integrated models have not been proven conclusively.

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Corresponding Author:
Mohsen Zareinejad,
Department of Industrial Engineering, Science and Research branch, Islamic Azad University, Arak, Iran
Tel: +98.9364365775
Fax: +98.2189786792
E-mail: Mohsen.zareinejad@gmail.com

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