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REVERSE LOGISTIC DECISION USING GOAL PROGRAMMING : A REVIEW

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Abstract

Reverse Logistic (RL) has broad areas as recycling, remanufacturing, information technology, warehousing, operations and environment sustainability. Reverse Logistic has been recognized as one of the most important topics in the Supply chain and Examination of RL has become important not only for a business owner, but also a researcher. This paper aims to identify how far the research about RL has explained, especially RL model using Goal Programming. Furthermore, this paper can develop a research agenda for the research gap. This research used a comprehensive literature review which focuses on peer-review journal papers published within the period of 2005-2016. A total of 50 journal have been analyzed in the term of research purpose, method theoretical approach and level of analysis. The review shows there have been many RL papers with many mathematkcal and simulation approaches, including Goal Programming. GP model has been used as mathematical approach for production planning, product design, transport of waste, waste management and supply planning. It identifies some research gaps to apply Goal Programming model in different kinds of production process as the future research direction.

Keywords: Reverse Logistic, Goal Programming, Multi-Objective Model.

1.Introduction

Customer needs are increasing every day, companies as producers always try to fulfill their customer demands. One day, companies will face some problem due to limited resource. Then, those companies will be forced to take actions that can overcome the issue. Companies search for new material, this will also lead to competition over new materials. İn another side, companies faced the massive amount of returned product, but there are limited disposal capatities.

Because of these issues, environmental consiousness among members of society are increasing, waste management has become a majör concern, not only for companies, but also customers and government. Customers want companies to decrease the negative environment impact of their process and product. While governments push the companies to control the waste and give more attention for the product's life-cycle through some regulations.

There are two ways to manage the returned product in waste management. First, disposal of the waste or minimizing the waste. The first option will be hard to apply since limited disposal capacities issue. The possible way is to minimize the waste by recovering some of returned product. Companies found it as new opportunities to new markets that have high environmental awareness. Thus, waste management, as the majör topic of reverse logistic, has become more important as the sustainable strategy.

Another issue is about the complexity of supply chain research especially related to reverse logistic and waste management. The objectives are not only to minimize cost or maximize revebue which can be solved using linear programming. The Goal programming (GP) model is an optimization model which is the development of linear programming. Thus, because of its importance, this paper aims to identify how far the research about RL has explained, especially RL model using Goal Programming. Moreover, this paper used to develop research agenda in reverse logistic decision.

This paper used a comprehensive literatüre review which consist of 4 stages as the research methodology. The first stages is Initial literatüre Review. This stage is used to find the keyword that related to Revese Logistics, then used the keyword to find some paper in Emerald, ProQuest and EBESCO. The next stage is reviewing the material from stage 1. After that, identifing gaps based on the review result in stage 2 can be done. The last stage is to formulate the literatüre review including research map and gaps.

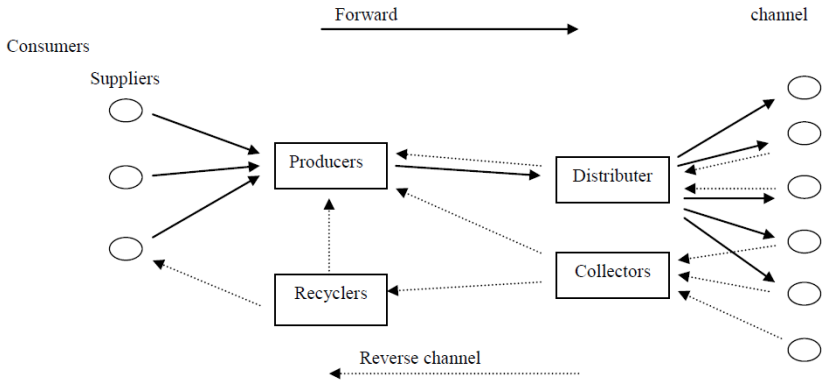
This paper is organized as follows:

Section 2 presents the review result about definition of reverse logistic and some paper about reverse logistics research. Section 3 presents the definition of waste mangement and some paper about waste management research. Section 4 presents the definition and formulation of Goal Programming (GP) model. Section 5 provides the research map which explain about the result of literatüre review about reverse logistic and goal programming model. The last section will provide some conclusion and give some direction for future research.

2. Reverse Logistics

It has been a long time since Reverse Logistic has been important issue. There have also been many definitions of reverse logistic. Fleischmann and Dekker (1997) defined reverse logistic as the part of logistic that turns the product that has been used to be raw material for new product. Tibben-Lembke and Roger (2002) said that reverse logistic consists of some stage, like planning, implementing, controlling, inventory, product, cost flow, recapturing value or disposal. The Reverse Logistics Association (2009) added that reverse logistics is activities after consumer use the product/service. This action aims to make the product/service more effective in money and environment point of view.

The conventional logistics, that we know, is called forward logistics. The illustration of Forward-Reverse logistics can be seen in figure 1 below.



Source: (Fleischmann, Bloemhof-Ruwarrd, Dekker, Der Lann, Nunen, & Wassenhove, 1997)

Figure 1 : Framework of Forward and Reverse Logistics

The research related reverse logistic increasingly grows. Hu, Sheu, & Huang (2002) examine about reverse logistics for waste management of hazardous waste based on cost minimization. The activities of waste management consist of collection, storage, treatment and distribution (Hu, Sheu & Huang, 2002). While, Ashayeri & Tuzkaya (2011) designed the system of after-sale service that consider the three main o objective, which are cost, customer and asset aspects.

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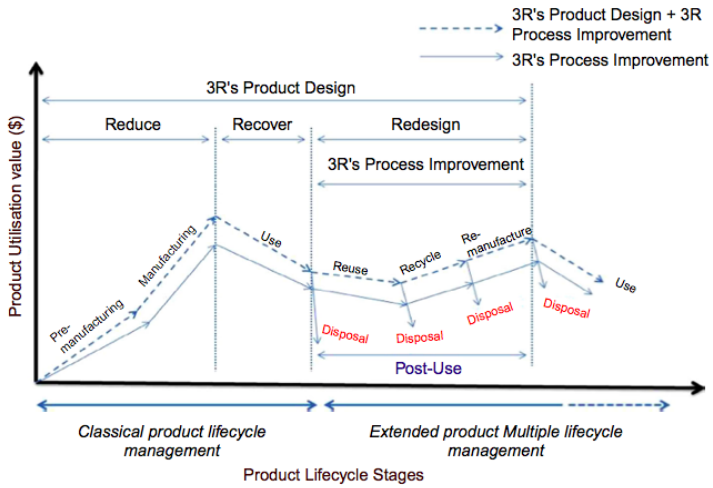
3. Waste Management

The keyword 'waste management' came up because Kuik, Nagalingam and Amer (2011) said that the waste management itself is main treatment in reverse logistics. Kuik, Nagalingam and Amer (2011) explain waste management definition as 6R waste minimization as shown in Figure 2. There are two stages in minimization, 3R's process improvement and 3R's process design development. 3R's process improvement consists of Reuse, Recycle, and Remanufacturing that aims to minimize the waste materials. 3R's product design development consists of Reduce, Recover, and Redesign that's aims to minimize the disposal cost by designing the environmental product (Kuik, Nagalingam & Amer, 2011). Dangwal, Kumar, & Naithani (2013) added that there are two methods to overcome that environment issue, first, disposal the waste or minimize the waste, however space for waste disposal is low and waste minimization is expensive in India.



Source: (Kuik, Nagalingam & Amer, 2011)
Figure 2: Framework of 6R's Waste Minimization

Some research related to the waste management problem has been published. Hao, Hills, & Huang (2007) explained about solid waste management in Hong Kong. Most of solid waste in Hong Kong is caused of Construction and Demolition (C&D) that badly affect to the environment (Hao, Hills, & Huang, 2007). Arif, et al. (2012) added about the importance construction waste management in India due to increasing activities in construction site. There are three kinds of construction material, which are material, labor and machinery that are non-renewable resource (Ekanayake & Ofori, 2000). Arif, et al. (2012) understood the current waste management in India construction site by holding the research in two building where has constructed in the same time. Moczygemba and Smaka-Kincl (2007) held the research about the recycling rate waste management system in the Slovene city of Maribor and the City of Graz, Austria. The waste management system consists of waste collection, separating collection by waste advisors and waste treatment which is recycling system (Moczygemba & Smaka-Kincl, 2007). Varga, Alpar, & Nemeth (2004) also did the research about waste management in Hungary based on the waste management system, especially recycling process in wood industries. (Varga, Alpar & Nemeth, 2004).

4. Goal Programming

Sen and Nandi (2012) explained about the complexity of organization objectives because of regulatory, environment issue, etc. Thus, the firm need to set multiple goal to overcome the complexity. Goal programming (GP) is the extended of linear programming. Sen and Nandi (2012) said that if the goal is only one, whether minimize or maximize, the system can used Linear Programming (LP). Therefore, Goal Programming is needed to optimize the multiple goals (Sen & Nandi, 2012).

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In addition, the reason GP can satisfy the decision makers with the multiple goals is the satisfaction level which can measure the best solution based on the priority order (Liner, 1996). Liner (1996) continued that the higher level goals need to be satisfied first before the lower level goals. Goal Programming can be used to solve the problem that provide the goals ranking based on the contribution and importance and also the all constrain must be linear (Liner, 1996). Chowdary and Slomp (2002) continued that to overcome the recent problem with multi goals when decision maker also need to find fit decision analysis to the environment constrain, GP approach can be the suitable decision analysis. GP does not give the solution directly to maximize or minimize goal, but it gives minimum deviation between the actual result and the goal based on the priority level (Chowdary & Slomp, 2002).

Turban and Meredith (1991) mentioned that there are 3 important concepts in Goal Programming :

1. Deviation
2. Prioritizing Goals
3. Dimensions of the goals
   There are also 4 elements that build Goal Programming model, which are (Turban and Meredith, 1991) :
1. Decision Variables
2. System Constraints is a restriction not to allow deviation in the GP model.
3. Goal Constraints is a target to be achieved in GP model than allow deviation.
4. Objective Function is formulated to minimize undesirable deviations.
5.

Kwak, Schnierderjans, & Warkentin (1991) showed the basic GP equation as below :

Minimize $Z = \sum_i w_i P_i (d_i^+ + d_i^-)$

P_i = Priority level for each goal (I.e. $P_1 > P_2 > \cdots P_n$),

d_i^- and d_i^- = Deviational variables,

w_i = Relative weight that is set to the priority level to the deviational variables,

a_{ij} = Coefficient of Decision Variables

5. Research Gaps

Based on Simchi-Levi, Kaminsky, & Simchi-Levi (2008), there are two techniques to complete the logistics problem, which are Mathematical model and Simulation model techniques. Simulation model is providing the design alternative to be evaluated the problem (Simchi-Levi, Kaminsky & Simchi-Levi, 2008). Problem solving with simulation can be seen in the Solid waste management that has been researched by Hao, Hills, & Huang (2007) by using simulation model in STELLA software. The simulation is built to plan the construction and demolition waste management using the relation among real world activities in C&D waste management (Hao, Hills & Huang, 2007).

The second technique is using the mathematical model that consists of two algorithms, Heuristic Algorithms and Exact Algorithms. Heuristic Algorithms are not finding the optimum solution, but the good one (Simchi-Levi, Kaminsky & Simchi-Levi, 2008). Exact Algorithms are finding the best solution of the problem (Simchi-Levi, Kaminsky & Simchi-Levi, 2008). The Goal Programming model in this research is classified as Exact Algorithms.
The research about production in multi-objectives has been established over decades. Olson (1990) used the Multi-objective model to accomplish the problem about product design. The research wants to get good quality product with good cost too. The multi-objective model is used to get the best product and efficient process design that can fit with the objectives, maximize quality and minimize cost. Olson (1990) used 3 steps, the first of which is regression to know the relation between the input design and output. Stage 2 is designing the

structure model using multi-objectives model by defining variables, constrains and objectives. The last stage is analyzing the multi-objective model.

Jayaraman (1999) explain that Multi-Objectives analysis has more advantages than Single-objective analysis, for example, the capability of Multi-objectives to evaluate some objectives in one measurement. Jayaraman (1999) continued the research by building mathematical model of Mixed-Integer Goal Programming that solved service facility location problem. The objectives are minimizing fixed cost, variable operating cost and response time (Jayaraman, 1999).

Research about Goal Programming and its relation to environment has started in the early 1990s. Alidi (1992) used Integer Goal Programming to overcome hazardous waste during manufacture processes since there are some objectives need to be achieved by the organization. There are 10 objectives related to the environment that need to be minimized, which are allocated budget, hazardous waste supplies, treatment capacity, landfill capacities, combustion plant capacities, Market capacities, waste transportation, treated waste transportation to landfill, treated waste transportation to the combustion plant and recycled material transportation (Alidi, 1992). Those objectives are counted based on the decision maker's priority.

The increasing amount of customer goods leads to increasing usage of discarded products (Konga & Gupta, 2000) which is not good for environment. Kongar and Gupta (2000) focused on disassembly used or discarded product to remove the useful material. Goal Programming gave some choices for Decision Makers to choose the decision based on their objectives. The objectives are to fulfill the disassembly product demand by considering inventory and to minimize cost (Kongar & Gupta, 2000).

Ashayeri & Tuzkaya (2011) applied the uncertain variable, which are number and quality of returned product into the Goal Programming model. Thus, Goal Programming is combined with the Fuzzy model to overcome the uncertainties. The proposed model is constructed with some strategic decision based on the objectives and decision channel of reverse logistic network. Ashayeri & Tuzkaya (2011) aim to minimize cost, maximize weight assignment to Repaired Center, minimize retardation in customer service and maximize capacity utilization level.

The increasing of product can lead to the increasing of its waste. Sharma & Hada (2012) explain about the milk waste minimization in India due to the increasing of its demand using Goal Programming model. Dairy waste material consists of various chemical and salt that can be harmful to people (Sharma & Hada, 2012). The main objective is to minimize waste that are defined as production requirement, raw milk utilization, salt utilization, electricity utilization, steam consumption, oil expenditure, recycling cost, reused of recycled water and cleaning cost (Sharma & Hada, 2012).

Dangwal, Kumar and Naithaini (2013) held the research in India where there is limited waste treatment plant. They used goal programming to optimize transportation of waste and waste treatment. The main objectives are to maximize the capacity of waste transportation, maximize the amount of waste to be treated and minimize waiting time and cost (Dangwal, Kumar & Naithani, 2013). To get the optimal solution for those objectives, Dangwal, Kumar, and Naithani (2013) used the combination of GP and Simulation to help the Decision Makers to overcome problem that might occur during the waste treatment process into real condition. The data can be input in simulation model and GP to analyze the tradeoff among objectives based on its weights.

Some literature about Goal Programming have been reviewed as shown in table 2 to learn about this method easily. Then, this section also show the research gaps based on previous literature related to reverse logistics, waste management and goal programming in table 1

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below. Overall, reverse logistics and waste management are the part of supply chain management research.

Table 1 : Research Gaps about Reverse Logistic and Goal Programming

No.	Previous Research	Environmental concert	waste management	Production Planning	Production Cost	Product quantity	Inventory Management	Sales revenue	Transportation	Goal Programming	Simulation
1	Olson (1990)				V					V	
2	Alidi (1992)	V	V	V	V	V			V	V	
3	Liner (1996)	V		V	V			V			
4	Strom (1998)	V	V	V	V			V	V		V
5	Jayaraman (1999)			V	V	V	V		V	V	
6	Kongar and Gupta (2000)	V	V		V		V			V	
7	Chowdary and Slomp (2002)	V		V		V	V	V		V	
8	Hu, Sheu, & Huang (2002)	V	V	V	V		V		V		
9	Kongar, Gupta & Al-Turki (2002)	V	V	V	V	V		V	V	V	
10	Hao, Hills, & Huang (2007)	V	V	V							V
11	Rahmatian (2008)	V	V	V	V	V			V	V	
11	Selim & Ozkarahan (2008)			V	V		V		V	V	
12	Ashayeri & Tuzkaya (2011)	V	V	V	V		V	V	V	V	
13	Sharma & Hada (2012)	V	V	V	V	V				V	
14	Dangwal, Kumar, and Naithani (2013)	V	V	V	V				V	V	V

Conclusion

This paper can answer the objective to identify how far the research about Reverse Logistic has been explained so far, especially Reverse logistics using Goal Programming. Surprisingly, the research that applied multi-objectives has known since early 1990s. Moreover, the research that combined Goal programming and reverse logistics have been established over decades.

The second objective, to develop research agenda in reverse logistics, has been achieved. In the future, using the goal Programming model in reverse logistic problem will face some uncertainties about the returned product, such as Quantity and Quality. Reality condition sometimes are unstable, the uncertainties amount of returned product may affect the companies capabilities to fulfil the demand. The uncertainties quality of returned product also need to be considered. Each country has different quality standard of the returned product. So, if the future research wants to consider quality, they need to understand the quality standard where the research being held. In addition, combine Goal Programming and Simulation model can give more detail solution because the simulation model gives the almost real pictures of the problem.

Table 2 : Summary of Literature Review

No	Previous Research	Problem statement	Decision Variable	Objective Function	Constraint	Method
1	Kongar and Gupta (2000)	Inventory in remanufacturing supply chain for Consumer goods	1. the variety of product in inventory 2. Demand product	2 main objectives : 1.Cost and revenue function 2. Environmental function	1. number product to be dissambly 2. number and type of resold, recycled component 3. Demand of each component 4. Recycled components 5. Number of inventory items	Goal Programming
2	Kongar, Gupta & Al-Turki (2002)	Disassembly-to-order system to meet the product demand	1.Revenue 2.Cost 3.Total profit	4 objectives : 1. Total profit value (TPR) must be greater than aspiration level for TPR 2.Recycled components (NRC) must be greater than aspiration level for NRC 3.Disposal cost (CDI) must be less than aspiration level for CDI 4.Disposed+stored components should be less than its aspiration level	1.Recycle component 2.Reuse component 3.Retrieve component 4.Occupied total space 5. All the variable must be non-negative integers	Fuzzy-goal Programming
3	Wongthatsanekorn (2009)	Plastic recycling planning in Thailand	1.Site opening and closing 2.number of transportation 3.Number of machine 4.Number of material	3 objectives : 1. Minimize total cost 2. Maximize recycled plastic target 3. Maximize desired plastic waste at collection site	1. Slack variable 2.Flow-in=Flo-out 3.Transportation and capacity constraints 4.Operating capacity of each site 5.Materials have to be processed 6.lanfill capacity need to be closed at later time periods 7.Binary variables represent opening and closing site action 8.Logical, Binary, and non-negativity constraints 9. All objectives have to be zero	Mixed-Integer Goal Programming (MIGP)

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4	Ashayeri & Tuzkaya (2011)	Designing after-sale service for High-tech product	1.Renting Decision in CC 2.Establishment decision in RC 3.Assignment decision fron CC to RC 4.Total return volume from customer to CC 5.Total return volume from CC to RC	4 objectives : 1.Minimize cost 2.Maximize weight assignment to RC 3.Minimize retardation in customer service 4.Maximize capacity utilization level	1.All customer's demand 2.If CC is opened, Customer can collected product in this CC 3.If customer is collected product in CC, permition only for flow volume to CC 4.Incoming product volume in CC 5.If RC is not opened, CC cannot send the product to RC 6.assignment product volume does not happen if a CC is not opened fora RC 7.Each customer is sent product to a CC, a CC is opened to only one RC 8.Capacity constraints in CC and RC 9.Non-negativity constraints and binary variable	Fuzzy-goal Programming
5	Sharma & Hada (2012)	Waste minimazation for dairy production	11 Dairy products :	9 objectives : Minimize 1.Production requirement 2.Raw milk utilization 3.Salt utilization 4.Electricity utilization 5.Steam consumption 6.Oil expenditure 7.Recycling cost 8.Reused of recycled water 9.Cleaning cost	1. Refrigeration Capacity 2. Man Power Requirement	Goal Programming
6	Dangwal, Kumar, and Naithani (2013)	Waste treatment and transportation planning in India	1. Transportation Unit 2.Transportation cost 3.Treatment cost 4.Amount of waste treatment	4 objectives : 1. Minimize Waste transportation 2. Maximize the volume of waste to be recycled 3. Minimize waiting time and cost 4. Minimize production cost	1.Aspiration level x1 (transportation unit) 2.Aspiration level x2 (transportation cost) 3.Aspiration level x3 (waiting time) 4.Aspiration level x4 (amount of waste to be treated) 5.Aspiration level x5 (waste treatment time) 6.Aspiration level x6 (waste treatment cost)	Goal Programming

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