Reverse Logistics Models in the Distribution and Transportation Network (Case Study Plastic Waste Management in Indonesia)

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Abstract: Development model of reverse logistics based business activity on plastic waste management, a business activity in the process of determining the distribution network and transportation waste plastic, which is reinforced by literature review regarding the business activity the same in some other countries, such as India and Turkey. In addition, the proven reverse logistics can provide economic value for the multi-actors. Models developed in the determination of reverse logistics network is based on the observation of this with a kind of business activity that occurred in Indonesia, in this case the plastic waste management business activities that can provide economic value for the perpetrators and reinforced with activities similar businesses in other countries. The aim of research to develop models of reverse logistics in the determination of the distribution network and transport-related business activity management of plastic waste.

Keywords: reverse logistics, model development, network, distribution, transportation

1. INTRODUCTION

Uncertainties inherent in the reverse logistics is a challenge Green Supply Chain. For conventional supply chain, demand is uncertain only influenced by the level of inventory, number of production and logistics. Uncertainty factors in the reverse supply chain is very complex compared to the forward supply chain. Part request uncertain on reverse logistics is the value of recovery and landfilling values are difficult to estimate, both very large contribution to the reverse logistics management (Kongar, 2004; Ovidiu, 2007; Salema et al., 2007). In the logistics company, there are some differences between the forward supply chain and reverse supply chain studied by Kongar (2004), shows that there are difficulties in very high levels of uncertainty in the reverse supply chain. Estimates and wrong decisions based on uncertain information, will have an impact on the risk of high losses. This study develops a model Closed-loop logistics for an environmentally friendly company consisting of two parts, namely a forward logistics and reverse logistics. The development of reverse logistics network model based on business activity, especially in plastic waste management. Business activity in the process of plastic waste management in addition to reducing aspects of environmental impact as well as the determination of the network system of reverse logistics in distributing and identifying transportation lines, while the assessment is reinforced by literature review on the activities of the same business in other countries, such as in India (Hess, et al., 2001; Reddy et al., 2003) and Turkey (Nesser, et al., 2008). Corbett, 2001 in his research stating that growing concerns about climate changes, local and regional impacts of air, ground and water pollution from industrial activities have Significantly expanded the interaction between environmental management and operations, leading to the area is termed as "reverse logistics".

Some definitions of reverse logistics if the terms of the process and purpose of its activities, one of which was proposed by Rogers and Tibben-Lembke (1999), reverse logistics as an activity to plan, apply, and control the process in order to achieve efficiency and related to the flow of material, supplies, finished products, and information of consumers return to manufacturing with the aim to regain the economic value of the product or to make the process of proper disposal. Reverse logistics is one of the best alternatives that can be considered to reduce the limited resources of raw materials. In addition, reverse logistics has been shown to provide economic value to multi-actor (Rivera and Ertel, 2008). On the other hand, environmental issues have become one of the strongest motivations for doing reverse logistics (Francas and Minner, 2009; Schultzmann, et al, 2006).

2. CONCEPT AND METHOD

A. *Review literatur*

Over the past decades, reverse logistics has become a very interesting attention from both academic researchers and industry practitioners. Attention serious and persistent environmental aspects of government regulation that has been created as an attempt to motivate research on reverse logistics more (Hamid Pourmohammadi, Maged Dessouky, and Mansour Rahimi, 1990). The Council of Logistics Management, since the beginning of 1990 has published two studies in the field of reverse logistics. First, Stock (1992), applying the reverse logistics in business and society in general. The following year, Kopicki et al. (1993) have elaborated opportunities to reuse and recycle. Then later, some other researchers in the study of reverse logistics has been complementary. Kostecki (1998) have discussed aspects of marketing issues in the reuse and extension of product life cycle engagement. Stock (1998) has been investigated in starting and lifting reverse logistics programs. Rogers and Tibben-Lembke (1999) has demonstrated a collection of reverse logistics business practices by using the comprehensive questionnaire among industries in America.

Studies reverse logistics can be divided into several categories. Dowlatshahi (2000), have identified into five (5) categories including: global concepts of reverse logistics, quantitative models, logistics (distribution, warehousing, and transportation), company profiles, and applications. More recently, some researchers have been concentrating on the optimization and quantitative models in reverse logistics. Most of the proposed model is the traditional model of facility location models, and mixed integer linear models (Kroon and Vrijens, 1995; Ammons et al., 1997; Spengler et al., 1997; Barros et al., 1998; Marin and Pelegrin, 1998; Jayaraman et al., 1999; Krikke et al., 1999; Fleischmann et al., 2001). Other researchers studying the problems with the single exception of inbound commodity Spengler et al. (1997) and Jayaraman et al. (1999). The main activity of reverse logistics is to collect the product to be renewed, and redistribution of new material generated (de Britto, et al, 2002). Basically stages of activity that occurs in reverse logistics is almost the same as the activity that occurs in traditional logistics, but with some differences. De Britto, et al (2002) describe such a difference include several things, namely:

1. On the reverse logistics supply there are many points where the product can be obtained as well as the collection point products;
2. It takes a good cooperation and voluntary contributions from suppliers of products, in this case is the consumer, to hand over the goods to the point of collection of the product;
3. In traditional logistics, product collected had a low economic value, while the reverse logistics network in various aspects need to be developed.

Furthermore, de Britto, et al (2002) divides the logistics to reverse logistics network into four parts. This distinction is made by the initiator of the activity of reverse logistics. The logistics network includes: logistics network for reusable products, logistics network for remanufacturing, logistics network for community services and environmental regulation by the government and by private logistics network for product renewal.

Logistics network can be specifically distinguished from the standpoint of business principals, include: logistics network designed for Original Equipment Manufacturer (OEM) and logistics network designed to third parties or 3rd Party Company/3PC (Fleischmann, 2002). Logistics network is illustrated by two researchers above, either by de Britto, et al. (2002) and Fleischmann (2002) will be used as the basis in this study.

Some researchers have examined motivation reverse logistics development, the motivation has been studying and researching reverse logistics and conclude various aspects of economic, marketing, and the environment. First, the economic aspect, the recovery is cheaper than building or buying a new product or *'virgin' materials* (Fleischmann, 2001). Recovery options include refurbishing, remanufacturing and recycling, it makes companies/factories can have a return value of product authenticity or value of materials. For example, IBM has recognized the process of dismantling the machines returned an opportunity for significant savings (Fleischmann et al., 2003), reverse logistics management program can provide cost savings in procurement, disposal, handling inventory and transportation.

Flow Reverse logistics is classified into five types (Fleischmann 2001), the endof use returns, commercial returns, warranty returns, production scrap and by-products, and packaging containers like crates, refillable bottles, pallets and reusable boxes, which can often reuse directly without the complicated process, except for cleaning and maintenance simple. In general, the overall activity undertaken in the Returned products include: Direct reuse, Repair, Refurbishing, Remanufacturing, Cannibalization, and Recycling (Thierry et. Al. 1995).

Based on the definition of the Council of Logistics Management are: Reverse logistics 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 origin for the purpose of recapturing value of proper disposal ".

Table 1. Definition of reverse logistics

Author(s)	Definition
Stock (1992)	" the role of logistics in recycling, waste disposal and management of hazardous material; a broad perspective includes all issues relating to logistics activities carried out in source reduction, recycling, substitution, reuse of materials and disposal"
Fleischmann et al (1997)	" a process which encompass the logistics activities all the way from used products no longer required by the user to products again usable in a market"
Krikke (1998)	"the collection, transportation, storage and processing of discarded products"
Dowlatshahi (2000)	"a process in which a manufacturer systematically accepts previously shipped products or parts from the point for consumption for possible recycling, remanufacturing or disposal"
Rogers & Tibben-Lembke (1998)	"the process of planning, implementing, and controlling the efficient, cost effective low of raw materials, in-process inventory, finished good and related information form the point of consumption to the point of origin for the purpose of recapturing value or proper disposal"
Fleischmann et al (2001)	"a process of planning, implementing and controlling the efficient, effective inbound flow and storage of secondary goods and related information opposite to the traditional supply chain directions for the purpose of recovering value and proper disposal"

Source: *Louren and Soto (2002)*

Some definitions of reverse logistics if the terms of the process and purpose of its activities, one of which was proposed by Rogers and Tibben-Lembke (1999), reverse logistics as an activity to plan, apply, and control the process in order to achieve efficiency and related to the flow of material, supplies, finished products, and information of consumers return to manufacturing with the aim to regain the economic value of the product or to make the process of proper disposal. This can be explained by Krunwiede et al, 2002:

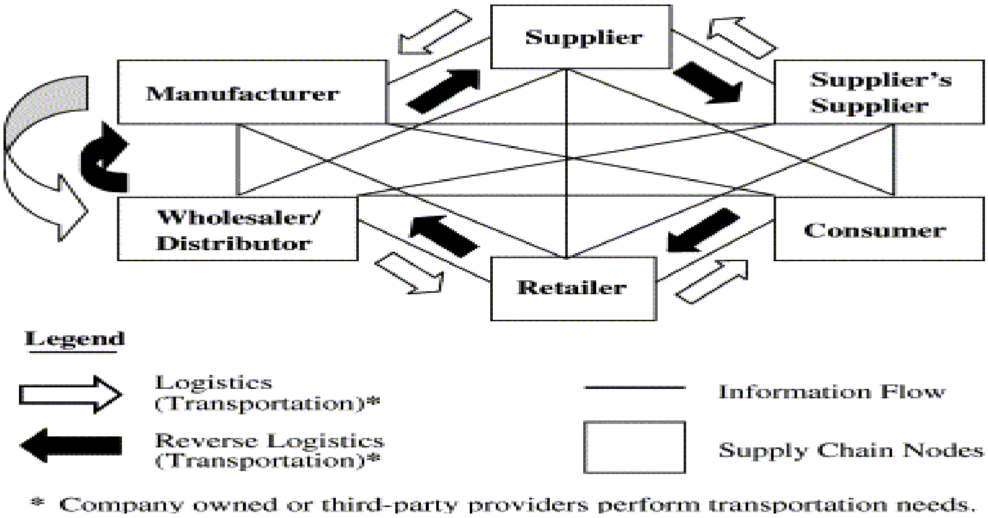

Figure 1. Consumer Supply Chain
Source: Krumwiede et al., 2002

Reverse logistics according to (Rogers, Dale S. and Ronald S. Tibben-Lembke, 2002) can be driven by several reasons, which include cost reduction, regulatory approval and motivations which include legislation concerning disposal, customer satisfaction, value recalamation, and corporate citizenship. Reverse logistics can be something new and also can not something new. If the reverse logistics to say nothing new if about things:

- Supplies products were excessive;
- An error in ordering or delivery, or the cancellation of orders;
- Defective products during the shipping process, defects in packaging are also differences in the price;
- The product warranty.

While reverse logistics is said to be a new thing when it comes to such things as the following:

- Disposed products;
- Technology products are already using;
- EOL (End of Life) products.

Reverse logistics with a new perspective is expected potential value still exists in the product after a period its EOL can be recovered for the purpose of recapturing value of proper disposal. Moreover, after the many issues that brought about reuse, remanufacture and recycle as well as regulations regarding product which leads to a sustainable environment are increasingly demanding their reverse logistics itself. As for the regulation of products that lead to a sustainable environment, which in turn trigger the application of reverse logistics are as follows:

- Extended Producer Responsibility (EPR),
- Integrated Product Policy (IPP),
- Environmentally Superior Products (ESP),
- Sustainable Product and Service Development (SPSD),
- Waste of Electric and Electronic Equipment (WEEE).

Challenges in the reverse logistics of course the application of reverse logistics which has its own challenges in its implementation. Unlike the case with forward logistics, reverse logistics in there are some challenges as follows:

1. Forecasting the return product becomes more difficult because there are no data regarding the exact distribution EOL product for speed product returns are difficult to measure.
2. Transportation is quite difficult because it must collect from many places before it is turned back into the supply chain (many to one transportation), so that in determining the route of products returned will be complex.
3. Determination of the quality of product returns are influenced by many factors such as the condition when the product is returned, who is using and how the product is used.

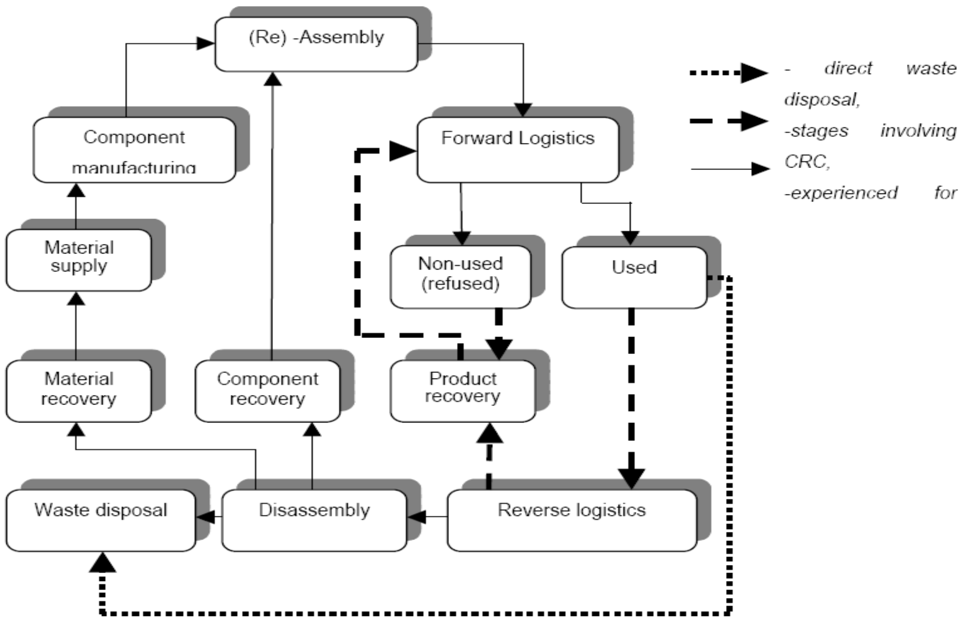

Figure 2. Direct and Reverse Logistics Chain
Source: Ferrer, 1997

B. *Methodology*

Reverse logistics system conditions plastic waste that occurs in most of the recycling industry is a framework in this study. The existence of an integrated supply chain system in plastic waste management is expected to provide optimal benefits to the parties related either economically, socially, and environmentally. This research case study supply chain management system on an industrial plastic waste recycling plastic waste. Because of the lack of an integrated system for waste management, researchers are trying to model the entities associated with the network of supply chain management of plastic waste and identify the capacity of plastic waste, the costs incurred in each entity, as well as multi-actors in the supply chain network. Then with engineering models created can be prepared a plan pattern of the plastic waste collection centers as collection and distribution planning recycled to the distributor. So from the results proposed models created are expected to give an overview of plastic waste for its stakeholders.

This research is expected to develop the engineering model of the system or the reverse logistics supply chain in plastic waste management case studies in industrial plastic waste recycling. Supply chain management system is a plastic trash can involve a lot of integrated components that interact with each other in achieving certain goals. In achieving a system of supply chain/logistics integrated reverse takes several approaches, which include the conceptual approach and mathematical approach.

The conceptual approach in this study is needed is a systems approach (system of thinking) to see how the elements in the system as an integrated whole. In addition to the systems approach is also required integrated concepts, including concepts such as Design for Environment (DFE), the concept of Green Supply Chain Management, Reverse Logistics concept, and the concept of system design. Based on the simplification of the issues discussed and to facilitate understanding, the engineering plastic waste management will be modeled in the form of a mathematical model. Results are expected in this study was the presence of network planning collecting plastic waste from the consumer, is expected to provide an overview and information on the model of reverse logistics system integrated plastic waste management for the parties concerned in the network system of the plastic waste management. In addition, also is expected to propose the policy-making tools that are useful economically, socially and environmentally for the elements associated with the system as well as a reference system of distribution and transportation network decision plastic waste in general.

Description of appropriate systems can be designed and manufactured based on the scope of transformation in the system, system constraints, components, subsystems and system structure, input and output systems. Researchers used a process approach in explaining the corresponding system because there are not yet integrated recycle system on conditions to be described. Observation and understanding of the process, as well as the relationship is to find the right structure and configuration. The process and structure of the reverse logistics management of plastic waste is planned referring to the network model (Fleischmann, 2000).

The design of the model is done because this research has not been done before or because previous research has not addressed the issues discussed. Based on preliminary studies have identified problems encountered and the possibility to do the design of a model. In previous studies has been much discussed issue of reverse logistics began the study of theory, on the model, as well as case studies and applications. The study mostly discusses the minimization of logistic and environmental costs on logistics networks such as the return of electronic products, paper, and waste management. Model design is the stage to make the design of decision models in research based on the reference model used. The design of the model conducted in this study can be illustrated in Figure 3 below.

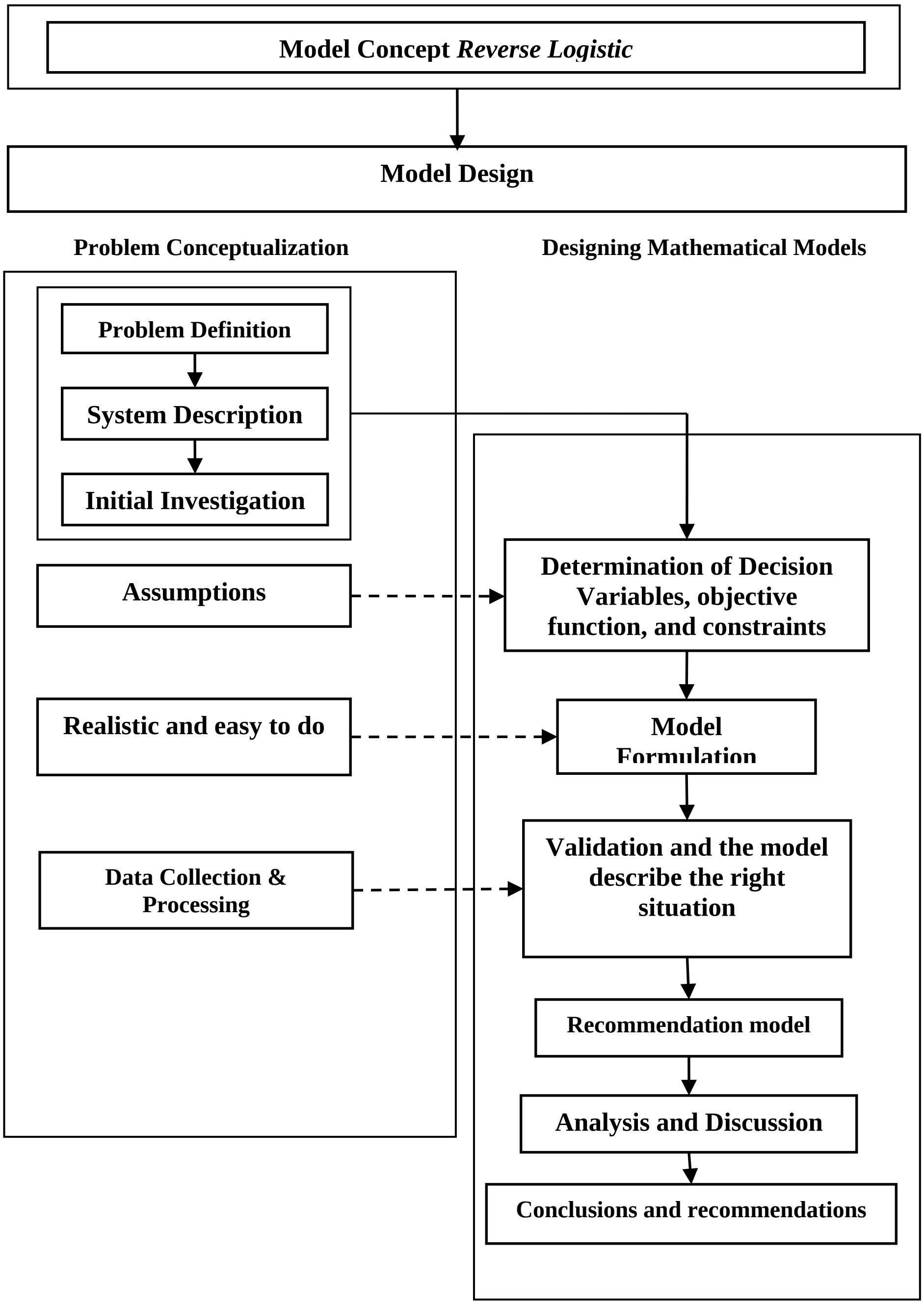

Figure 3. Model Design Reverse Logistic
Source: Researchers' Analysis, 2016

Formulations model developed should be realistic in accordance with the conditions and needs of the construction of the system. Formulations model developed should also be easy to do so as to provide optimal results. Formulations model developed should be solved by using the approach of the methods that correspond to the expected decision variables. In this case formulation approach to resolve the models developed method approach 'optimization'.

Reverse logistic network system in the flow and process of plastic waste that occurs in the final consumer (k = 1), scavenger (k = 2), garbage bank (k = 3), collector (k = 4), agent (k = 5) Recycling plant (k = 6), and Consumer economical product (k = 7) are illustrated in Figure 4 below.

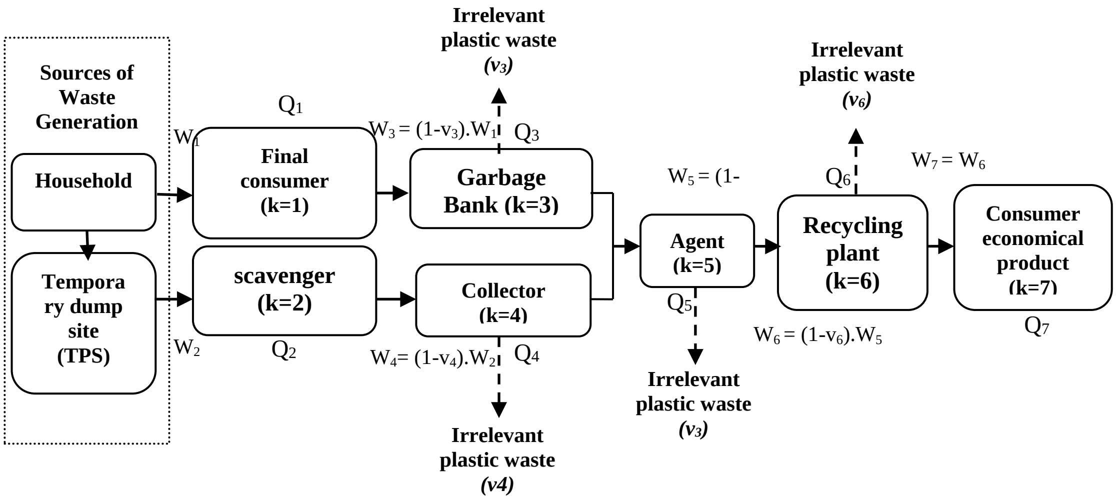

Figure 4. Flow and Process of Reverese Logistic of Plastic Waste on Each Entity.

Source: Researchers' Analysis, 2016

Entities reverse logistic system of recycling plastic waste generated by this research model development including identification of some of the costs to be incurred in any such entity. The objective function of the model developed in this research is to minimize the total cost of reverse logistics system of recycling plastic waste management. Then in getting the best model solutions are used by groups of optimization models. It is analogous with ten types of costs incurred in the system of reverse logistics recycling (Rupesh Kumar Pati, at al, 2006), Total System Cost (TC) = Total Cost of Transportation (TCT) + Total Cost of Shortridge (TCS) + Total Cost of Disposal (TCD) + Total Cost of Manufacturing or Processing (TCP).

Based on the results of analysis and inventory of reverse logistic model parameters of plastic waste recycling, then obtained the mathematical model of the system as follows:

Minimum TC = TCT + TCS + TCD + TCP

Minimum TC = $\sum_{k=5}^{6}[CT_k.d_k.W_k]$ + $\sum_{k=3}^{6} CS_k.W_k$ + $\sum_{k=3}^{6} CD_k.v_k.W_k$ +

$$\sum_{k=6}[(CB_k + CE_k + CL_k).W_k]$$

The decision variables in this research is the amount of material that exist in each entity model of reverse logistics recycling of plastic waste which will provide a minimum total cost of the system.

Functions constraints in the model of this study are as follows: constrained demand, storage capacity, the production capacity, the type of waste that is not relevant, as well as non-negative variables. Constrain the demand for this model to ensure that the request is fulfilled at each entity. Storage capacity constraints are meant to ensure that the material is stored on each entity does not exceed the storage capacity. Production capacity constraint is intended to appear on the entity plant raw materials is constrained maximum processing capacity of raw material of plastic waste. Constraint types of waste that are not relevant for the purpose of ensuring that the percentage of plastic waste disposal that will be done will not be relevant to be used as raw material and the amount of plastic waste would be relatively small compared to the amount of material that goes to each entity. Then the last is constrained non-negative variable is intended to ensure that all decision variables in the model can be qualified as an optimal solution.

3. DISCUSSION

Implications of the model approach can be done by using a simulation model approach or mathematical models. Reverse logistics system of recycling plastic waste is a system that was built for the benefit of the company's business activities waste recycling plastic that provides profit and also as a form of environmental responsibility. Demand for the reverse logistics recycling of waste plastic at the industrial recycling plastic waste which is processed into products value. Demand for the reverse logistics recycling of plastic waste created by plastic waste recycling company that is processed into a product that has economic value of the product. In a system has been established for the market mechanism of demand and supply plastic waste recycling system as well as other materials such as recycled paper and metal. Therefore, the business activity of recycling plastic waste that exists today, the price of plastic waste materials have also been formed from the interaction of the market.

4. CONCLUSION

In optimizing the system performance of reverse logistics recycling of plastic waste established mathematical model in the form of linear programming with function in order to minimize the total cost of reverse logistics system with decision variables including the amount of material falling into each entity. As for the cost components included in the total cost of reverse logistics system are: collection costs, transportation costs, ordering costs, segregation cost, disposal costs, inventory costs, shortage costs, manufacturing costs, quality costs, and environmental costs.

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