METHODOLOGY FOR REVERSE SUPPLY CHAIN DESIGN IN CONSUMER ELECTRONICS INDUSTRY

by

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ABSTRACT

METHODOLOGY FOR REVERSE SUPPLY CHAIN DESIGN IN CONSUMER ELECTRONICS INDUSTRY

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Reverse Logistics (RL), the art and science of moving goods typically from the end consumer towards the upstream end of supply chains, has been the subject of many strategic meetings in organizations today. This is attributed mainly due to the tighter federal environmental legislations on product returns and a hugely untapped potential that has been often overlooked by the managers. Traditionally, enterprises spend most of the improvement initiatives in optimizing its forward supply chain (FSC) performance that aims to delight the end consumer. However, it is not a panacea by itself in the process of continuously satisfying the end customer. Managers are now forced to look at their business processes from a more strategic perceptive than ever

before. This perspective includes a reverse supply chain (RSC) component that complements its FSC counterpart in closing the supply chain / network of an enterprise. Having an "efficient" RSC solves two issues for an organization: (i) it can utilize its resources more effectively than before and (ii) it can project an "environmentally friendly" image in the eyes of the customer. This research is targeted toward designing an efficient RSC with special attention to the consumer electronics industry.

Efficiency of a RSC is defined across three main dimensions that include: the "time taken to recover value", "actual value recovered from returns", and "number of returns that enter the RSC". This research develops a methodology that helps organizations design their RSC systems. Consequentially, the design seeks to reduce the time taken to recover value, increase the value recovered and to reduce the number of returns that enter the RSC respectively.

These three goals of the methodology are done in three stages. In order to achieve the first goal, a "twelve step" algorithm is developed that measures and suggests measures to reduce the time taken to recover value. Next, a "scoring system" is developed to increase the value recovered from product returns. Finally, a "cause and effect" analysis is done for each influential actor in the supply chain to determine the reason(s) for return in order to develop solutions for curbing them in the future.

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CHAPTER 1

INTRODUCTION

1.1 Introduction to Reverse Logistics

Reverse logistics (RL) is the process of planning, implementing, and controlling the flow of raw materials, in process inventory, and finished goods, from a manufacturing, distribution or use point to a point of proper disposal (Rogers and Tibben-Lembke, 1998). More precisely, RL is the process of moving goods from their typical final destination for the purpose of capturing value, or proper disposal (Rogers and Tibben-Lembke, 1998). Different authors use different terms *reverse flow logistics, reverse distribution, reverse logistics, reverse supply chain, closed loop supply chain systems and supply loops* to describe the same activity, or parts of it. The key element in all definitions and discussions of RL is the movement of goods (that includes both products as well as packaging materials) from one location to another after its intended utility is fully or partly consumed.

There are many reasons for products to be returned, either by consumers or by the companies involved in the distribution chain. Retailers may return products because of damage in transit, expired data code, the model being discontinued or replaced, seasonality, excessive inventories, retailer going out of business, etc. On the other hand, consumers can return products for reasons such as quality problems, failure to meet the consumer's needs, for remanufacturing, or for proper disposal (Serrato et. al., 2003). Although these represent some of the major reasons, there are so many other plausible motives for the product to enter the RL network. Typically, the causes for returns are unique to an organization or an industry. Nevertheless, there are some basic RL functions that are valid for most of the industrial segments. A typical RL operation starts with gate-keeping and includes operations like transportation, sorting, storing and Asset Recovery (AR). At the simplest level, the disposition of returned goods consists of junking them or giving them away. But with more sophisticated systems and processes, returned goods can be put back into inventory, sold at liquidation centers, or broken down to component parts (Caldwell, 2001). AR is one of the critical steps in RL that takes cost as well as environmental considerations into account.

RL has two dimensions, viz., the "green" dimension and the "value reclamation" dimension. The "green" dimension controls the environmental impact of the products on the society by imposing stricter product disposition rules. The offshoot of these rules is the latter dimension of "value reclamation" that focuses on the cost / inventory aspects. Due to environmental reasons, governmental legislation on industries is becoming more stringent with their product take back laws. "Product take back" is an international paradigm which requires that firms organize methods to reclaim their products at the end of their useful life (Matthews et. al., 1997). Business sectors throughout the globe are becoming increasingly aware of the possibility that they will be required to comply soon. On the flip side, they are finding economic sense to take the product back. This leads us to the next section that will be targeted towards the importance of reverse logistics on the society as well as industry.

1.2 Importance of Reverse Logistics

"Watching truck after truck, filled with shiny new product, roll out of the distribution center is a sight to warm any executive's heart. It means those orders have been rolling in. But those same executives will do their best to ignore the returned products piled in a heap in the back corner of the distribution center. If the outgoing truck represents success, those mounting piles represent failures" (Meyer, 1999). The importance of RL has increased in the recent years. Guide and Wassenhove (2003) estimated annual sales of $50 million for remanufactured products in the U.S. alone. The Reverse Logistics Executive Council (1999) estimates $35 billion annually for handling, transportation, and processing of returned products. This estimate excludes disposition management, administration time, and the cost of converting unproductive returns into productive assets.

By ignoring this important field of logistics, many organizations may be missing a chance to turn liabilities into assets. Although RL typically represents less than 5% of a company's overall logistics activities, some businesses believe that closely monitoring this operation enhances efficiencies within the entire company. According to one of the high level executives in a third-party logistics provider (1998), the real benefit comes from sharing information with design, production, packaging, and other departments on things like the type, number and source of products coming back (Stock, 1998).

RL may be an area where companies can gain a sizeable advantage over the competitors. In today's highly competitive economy, high-quality and customer service are the tickets to the game. It behooves an organization to differentiate itself from its competitors. In this regard, RL could be one of the significant differentiators that organizations could rely upon (Stock, 1998).

The overall amount of RL activities in the economy is large and still growing (Rogers and Tibben-Lembke, 1998). The Reverse Logistics Executive Council (RLEC, 1998) estimates the cost of RL operations in the U.S. to be between 0.5% and 1% of the total US Gross Domestic Product (GDP). Forrester Research (2002) reports that online U.S. retail sales were around $ 74 billion in 2001. Although it may vary by product and time of the year, the National Retail Federation (2002) reports an average return rate of 5.6% for online retail sales. Bizrate.com (2000) quotes that 12% of the $5 billion worth of products sold online during the two month of Christmas 1999 were returned. Jupiter Research (2000) presents a significant finding: 95% of consumers would rather return a product purchased over the Internet to a physical location; 43% would always use that option if it were available. 37% of online buyers and 54% of online browsers were deterred from purchasing online because of return and exchange processes that were too difficult. Returns Online, Inc. (2001) estimates the cost of processing a return can be 2 – 3% that of an outbound shipment. R.R. Donnelley Logistics (2003) quotes that the returns will cost catalogue and web retailers $3.2 billion in 2001.

Apart from a 10% savings in the total logistics costs, doing a good job in this area translates itself into a competitive advantage by improving the corporate image in the eyes of the customer. Certainly, RL is an integral component of supply chain management systems because of the cost and service dimensions associated with the process. In as much as product returns are a fact of life for manufacturers, traditional retailers, e-tailers, logistics service providers and others, RL will likely increase in importance (Stock, 2001).

1.3 Reverse Logistics across Industries

The magnitude and impact of RL varies by industry and channel position. Within specific industries, RL activities can be critical for the firm. Generally, in firms where the value of the product is largest, or where the return rate is greatest, much more effort has been spent in improving return processes. Table 1 shows the sample return percentages across major industries (Rogers and Tibben-Lembke, 1998).

The magazine publishing industry accounts for the highest percentage of returns. In general, all paper related products (books, greeting cards, magazine) pose a serious threat to handling their reverse logistics functions. Electronics industry is one huge industrial segment that has a multitude of variety of products in it. It encompasses consumer electronics, industrial electronic applications and other auxiliary equipment. The classification scheme for the electronic products is dealt with in detail later. The return percentages of electronic products have soared high due to the advent of electronic methods of conducting business like the e-tailing, e-auction etc. Automobiles and chemical industry returns account for the least percentage of returns. There has been a growing interest in handling the automotive returns in the U.S. and Europe.

Table 1.1 Returns percentage across Industries
(Adapted from Bizrate.com, 2000)

Industry	**Percent**
Magazine Publishing	50
Book Publishers	20-30
Book Distributors	10-20
Greeting Cards	20-30
Catalog retailers	18-35
Electronic Distributors	10-12
Computer Manufacturers	10-20
CD-ROMs	18-25
Printers	4-8
Mail Order Computer manufacturers	2-5
Mass merchandisers	4-45
Auto Industry (Parts)	4-6
Consumer Electronics	4-5
Household Chemicals	2-3

1.4 Problem Definition

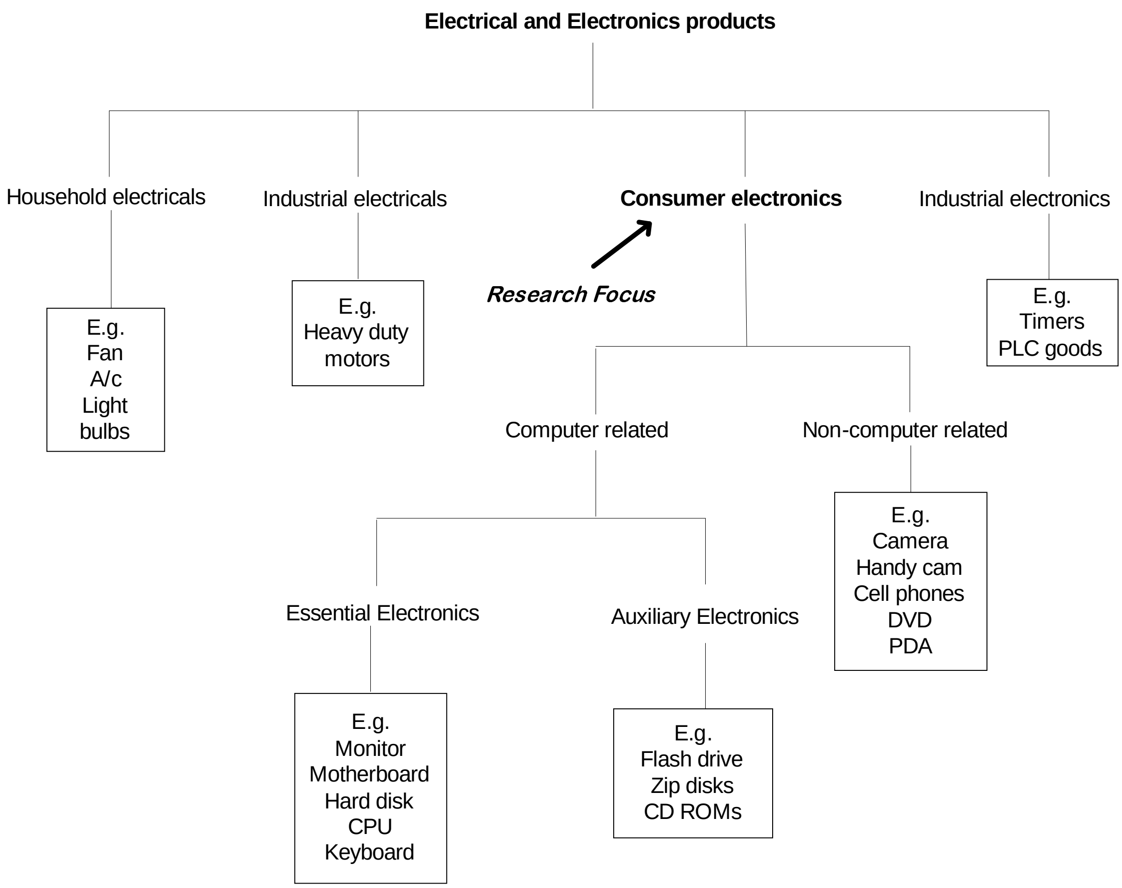

Figure 1.1 Classification scheme
(Rajagopalan and Yellepeddi, 2006)

Figure 1.1 gives the classification scheme for all electrical and electronic products. The four major categories include: “Household electricals”, “Industrial electricals”, “Consumer electronics” and “Industrial electronics”. Electronic items process and display information and possess complex circuitry, circuit boards, or signal processing. Electronic items include televisions, computers, stereo receivers, CD players, tape desks, cameras, and appliances with information display (such as timers).

Electric items use electricity to operate but do not display or process information. Electric items include power tools, blenders, toasters, and coffee makers without timers (Platt and Hyde, 1997). The “consumer electronics” industry can be further classified into “Computer related” and “Non-computer related”. Since the magnitude of computer related products and auxiliaries are very high and will continue to be on the rising side in the future, the whole category of “consumer electronics” can be divided into “Computer related” and “Non-computer related”. Within the sub-group “computer related”, there are two categories namely the “Essential electronics” and “Auxiliary Electronics”. The examples for each category are given in the figure. The research problem will be targeted toward the electronic section of the consumer electronics industry.

The existing literature in RL advocates the need for rapid processing of materials because the longer it takes to retrieve a product, the lower is the likelihood of economically viable reuse options (see Fig. 1.2). It is highly beneficial for an organization to work in tandem with its forward supply chain to reduce the returns. This insures that minimal volumes to be taken care for asset recovery. However, these two strategies are not easy to be implemented.

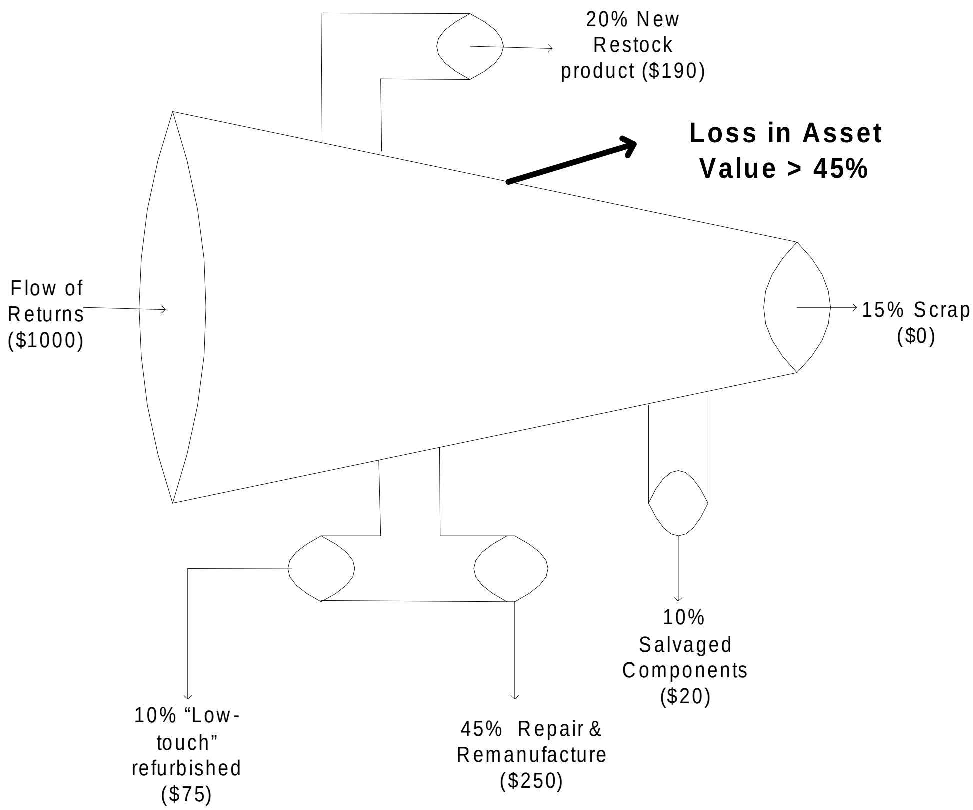

Figure 1.2 The Shrinking Pipeline for Product Returns
(Adapted from Blackburn et. al., 2004)

There are some generic problems associated with any RL management process which includes uncertain timing, quantity and quality of product returns. These issues become more specific and unique depending on the organization and the type of industry in which it operates. These problems are highly acute in the electronics industry that is characterized by an increasing rate of obsolescence and technological outdating. The advent of electronic modes of purchasing has made the purchasing process simpler. This has certainly increased organizations' sales revenue as well as sales volume. However the flip side of it is that there is an increasing rate of returns for the products purchased through the Internet. This had increased the uncertainty variables in the returns management process. As a result, a growing pool of materials enter the reverse supply chain (RSC) waiting for appropriate recovery action.

Electronic products typically have a high Marginal Value of Time (MVT). MVT can be thought of as the change in value of the product if 1 unit of time elapses. Whenever an electronic product enters the reverse supply chain, its value deteriorates rapidly with respect to a given change in time (see Fig. 1.3). Hence, the speedy recovery of those products become imperative compared to any other product type. In addition, as expected with any returns management process, maximum value is be recovered from the items that enter the RL network.

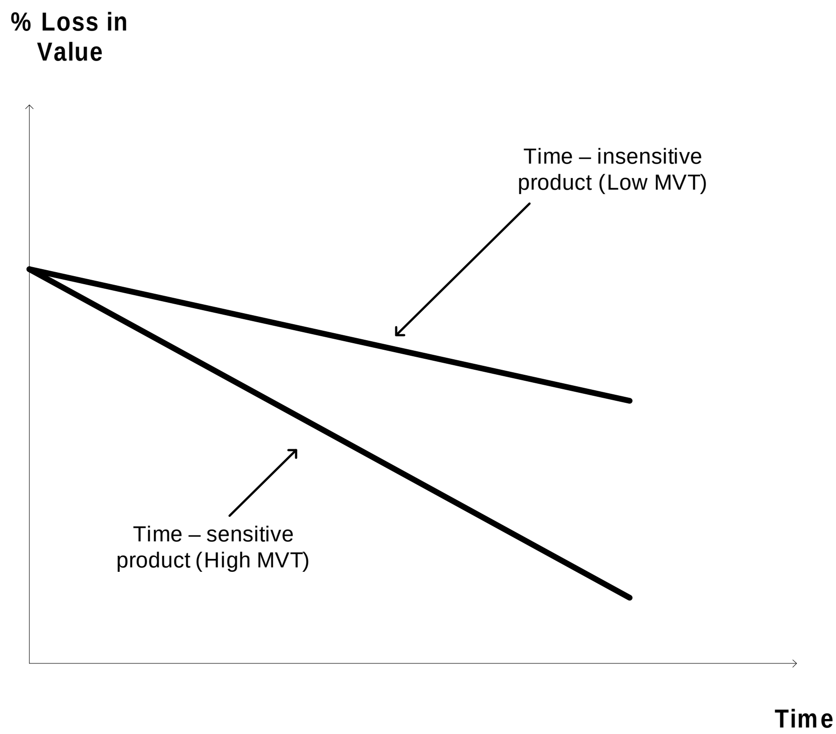

Figure 1.3 Marginal Value of Time (MVT)
(Adapted from Krikke et. al., 2001)

Concisely, the problem of focus is that ***<u>organizations in the consumer electronics industry lack a methodology for designing an efficient reverse supply chain that focuses on the industry's salient features: high "marginal value of time", high "value" and "volume" of returned goods.</u>***

<u>1.5 Problem Justification</u>

The increasing rate of obsolescence for electronic products creates a growing pool of materials that enter the RSC. Every year an electronic trash heap nearly as tall as Mount Everest is tossed into garbage cans, stashed in garages or forgotten in closets. According to the National Safety Council (NSC) report (1999), computers are ranked as the nation's fastest growing category of solid waste by the Environmental Protection Agency (EPA) (Hamilton, 2001). The NSC suggested that the rate of technology change in the computer software and hardware industries will continue to increase the number of obsolete computer products, leveling off by the end of year 2005 at an estimated 60 million PCs annually. The Council also estimates accumulated obsolete PCs from 1997-2007 will total approximately 500 million that equates to 15 million pounds of computers, or 7.5 million tons of potential waste that must be handled by America's businesses and citizens. Such a huge quantity of obsolete, complex material represents a potential problem in the field of waste management, but it also represents a new and challenging opportunity for recycling and economic development of specialists throughout the world (Biddle, 2000). The issues associated with it are that managers in forward chains are confronted with their own problems and may not have time for RL.

Of-late, managers are realizing that it would be economical for the firm as well, to have an efficient RL process.

“Value reclamation”, typically is characterized by a set of RL processes that includes returns forecast, material acquisition, sorting and disposition, recovery, redistribution, and account settlement. There is a great deal of uncertainty in most of these processes that makes it difficult to manage. To further worsen this situation, companies, often overlook this lucrative area since this is neither their priority nor their core-competency. Rogers and Tibben-Lembke (1998) estimates that returns in this industrial sector can lower profits by as much as 25 percent, which makes RL a serious business.

The life cycle of a computer or an electronic product is extremely short when compared to other durable goods. Especially in this industrial segment, managers do face the problem of giving a warranty of 90 days when the product’s life cycle is just 60 days (Rogers and Tibben-Lembke, 1998). This is primarily due to technological outdating.

The consumer electronics industry’s RL systems is one of the most promising sectors for RL improvement efforts due to the sheer volume and value of returned products. However, these types of RL networks represent some of the greatest challenges. This is mainly due to the uncertainty in time and variability in the rate of return. Moreover, these products have a high MVT which means that the value of products deteriorates rapidly. Consumer electronic products typically have short life cycle and high variability in returns that makes management of the reverse logistics systems the “most complex” among all other industrial sectors (Serrato et. al., 2003). However, higher the complexity of a system, broader is the scope for improvement projects. Hence, any system enhancement of the logistics network would definitely be a substantial contribution in the electronic industrial sector.

The existing literature in this field recommends designing an efficient business process design for dealing with the returns. Specifically, the literature suggests that research should be undergone to design the type of RL network and the associated policies that maximize the actors’ profit and minimize the return rate in the long run (Serrato et., al., 2003).

1.6 Objective

The objective of this research was to develop a methodology for designing an efficient reverse supply chain (RSC) system in the consumer electronics industry. The methodology attempts to (1) reduce time needed to recover value (2) increase value from “asset recovery” process for items that have entered the RSC and (3) reduce the number of items that will enter RSC in future.

These are referred to these three as goal 1, goal 2 and goal 3 respectively. Typically, in the literature, efficiency of a RSC is interpreted in terms of recovering maximum value in a minimum time. In addition, a third attribute for an efficient RSC is to have a minimal number of returns entering the RSC. The three goals are discussed in this section.

At this point, it is opportune to introduce the concept of a “closed-loop supply chain” and to explain the differences between a “closed-loop supply chain” and a RSC.

A closed-loop supply chain has two components, namely a forward supply chain (FSC) in which virgin materials flow from raw material supplier to the end customer and a RSC in which all types of materials (finished goods, sub-assemblies, components etc) flow backwards. In this research, we focus on the latter, i.e., RSC.

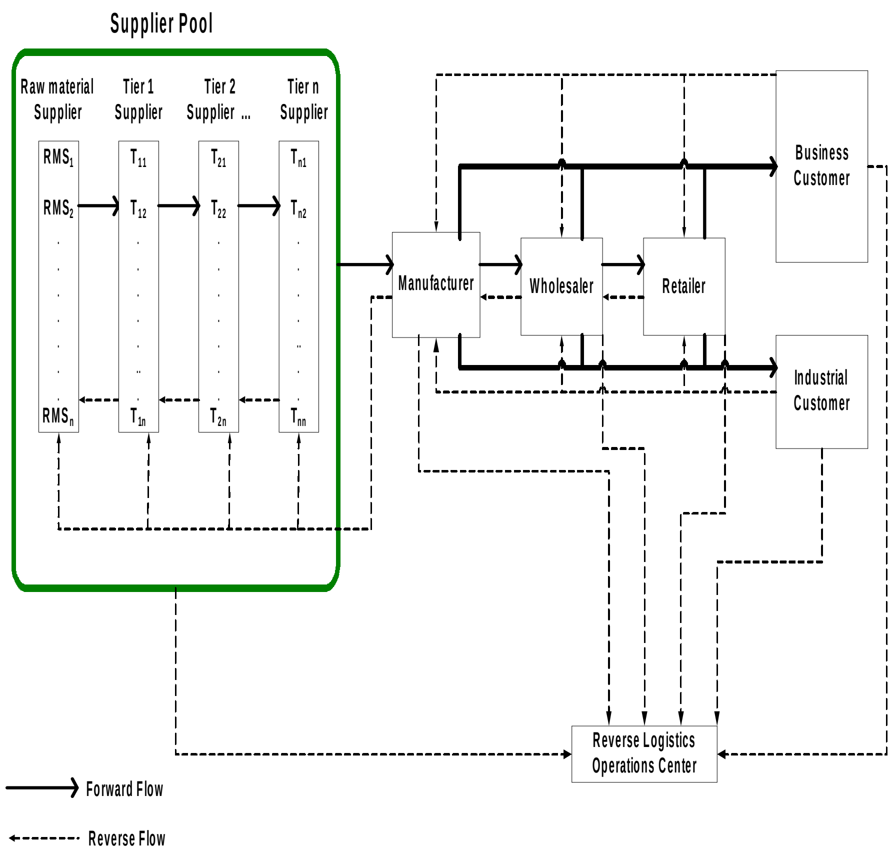

Figure 1.4 Overview of closed-loop supply chain systems
("Supply chain actors" based overview)

The general overview of a typical closed-loop supply chain is given Figure 1.4 and Fig. 1.5. Fig. 1.4 gives an overview of the various actors involved in it and the flow among them. Figure 1.5 shows a typical closed loop supply chain system with the various actors and the associated RL operations involved in it.

In the first step namely the “Gate-keeping (GK)” stage, the products are inspected whether or not to enter the RSC. Typical checking protocols include “warranty” check, “time window for return” check etc. The products that pass the GK stage are collected and transported to the appropriate place. This place can be an array of regional distribution centers from which the products are consolidated into one Centralized Returns Center (CRC). In these distribution centers, typical warehousing activities like “Sorting” and “Storing” happen depending upon the situation.

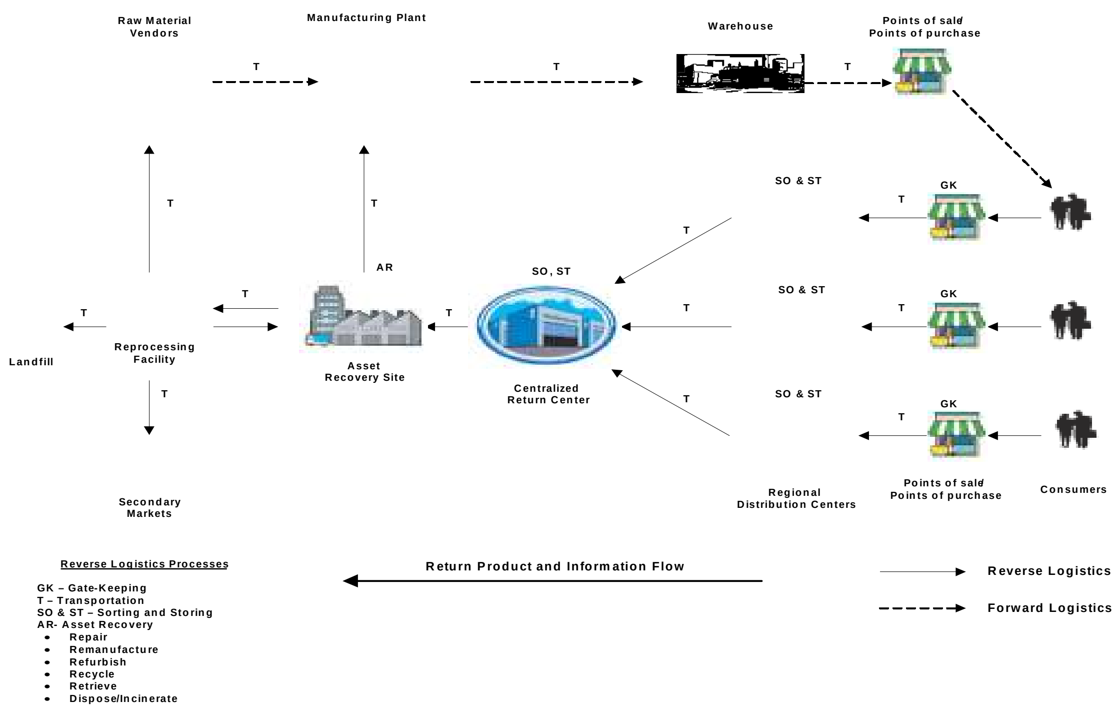

Figure 1.5 Actors and Operations in a Closed-loop Supply Chain

The next process is “Asset Recovery (AR)” where the products are analyzed for proper disposition. The last step is to make sure the product reaches the proper disposal site that could be a landfill or any point in the FSC. The process of classifying the goods into “usable”, “usable with some work”, “usable with lot of work” and “not usable” can be done at any stage. However, the actual / true condition of the product is known better only at the “AR” phase where the products are inspected / tested to find the condition of the product, nature of defect, if any.

In some situations, for certain products, “testing” will be required during the AR stage. This testing process will be crucial for two reasons: (i) It will enable the organization to know the present condition of the product. For example, the organization can know if it is an “End-of-life (EOL)” product or an “End-of-Use (EOU)” product etc and (ii) only after the testing has been done, the organization can figure out the actual item that needs to be recovered and its associated disposition options. The term “item” refers to a finished product or a sub-assembly or any loose component of the product. More generally, a particular item that has some value in it and needs to be recovered is called as the “Returns Tracking Unit (RTU)”.

For some other products, in certain situations, there is no testing required to get the list of disposition options. It might be known during the earlier process of the RL like the gate-keeping stage where the return reasons are mentioned by the gate-keeper. Hence, throughout the context of this research, the term RTU will be used to refer anything – a finished product, a sub-assembly or a component. More about RTU will be discussed in the chapter 4. After AR the RTUs are taken for the concerned destination that is determined by the AR center.

Assumptions: It is important to note certain key assumptions in the network structure depicted in Figure 1.5. This network structure is the starting point of this research and includes some of the typical supply chain actors in a closed loop context. However, this network structure is a more "general" version which means that it is not tailor made to any particular organization. Organizations have to modify this general version according to their own set of actors. The idea in this network is account for the maximum number of supply chain actors in a given closed loop supply chain. In other words, the "maximum node" structure would take into account the worst case scenario where the product and the information have to flow through the maximum number of points in the closed-loop supply chain. For example, products may actually reach the AR center after GK without even passing through the regional distribution centers (RDC) and the centralized return centers (CRC). But the "maximum node" assumption was developed to account for any product and information flow involving the RDCs and the CRCs that may happen anytime in the future. We assume a large Original Equipment Manufacturer (OEM) to be the center of this network and base all our longest node assumptions from its prism. Now with this assumption and the concept of RTU in background, the three goals are described briefly below.

Goal 1: Reducing the time needed to recover value - As mentioned in the problem justification section, this goal is very crucial in the case of electronic products. After an electronic product had entered the closed loop supply chain, the methodology ensures that it takes the least amount of time for the product to traverse through the remaining nodes of the chain. This will enable faster recovery of the valuable resources the product contains.

Goal 2: Increasing value from the asset recovery process – Asset Recovery (AR) is the classification and disposition of returned goods, surplus, obsolete, scrap, waste and excess material products, and other assets, in a way that increases the returns to the owner, while minimizing costs and liabilities associated with dispositions. The objective is to recover as much of the economic and ecological value as reasonably possible, thereby reducing the ultimate quantities of waste (Rogers and Tibben-Lembke, 1998). The methodology ensures that the best possible disposition option is chosen for a given RTU.

Goal 3: Reducing the items entering the reverse supply chain - GK is an activity that decides which products are eligible to go through the RSC. The more the number of products that enter the RSC via GK, the more the time and resources consumed in the value recovery of returns. Also high is the uncertainty associated with the value recovered from the RTUs. Hence the number of RTUs that enter the RSC should be very minimal. Consequently, the methodology reduces the number of items that proceed to the collection stage of the reverse logistics process.

Figure 1.6 captures the overall picture of the methodology from a strategic perspective.

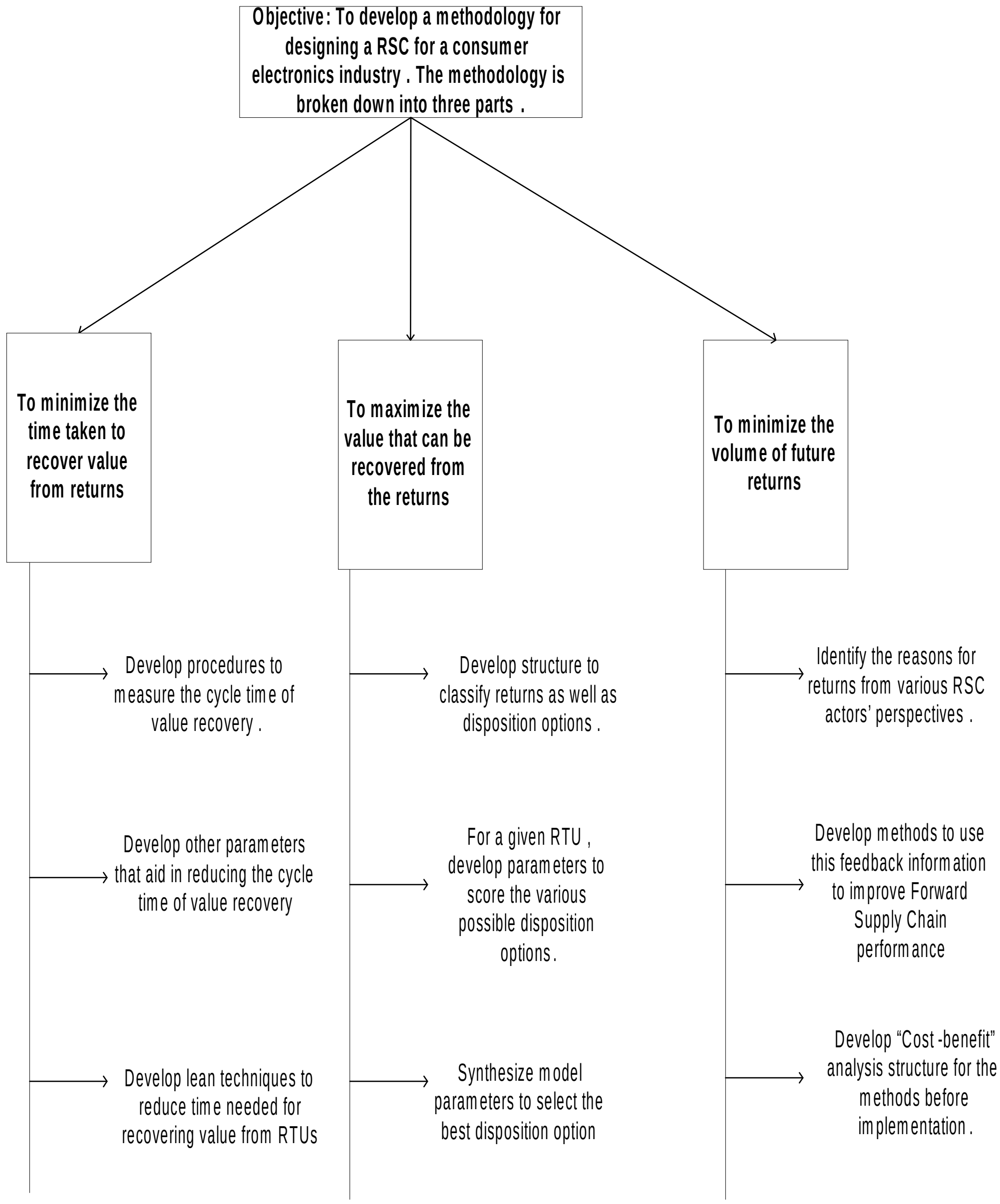

Figure 1.6 Overall strategic perspective of the methodology

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Reverse Supply Chain

Logistics has been defined as that part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point-of-origin to the point-of-consumption in order to meet customers' requirements (CLM, 1999). RL is defined as the logistics management skills and activities involved in reducing, managing, and disposing of hazardous waste from packaging and products. It includes reverse distribution, which causes goods and information to flow in the opposite direction from the normal logistic activities (Kroons and Vrijens, 1995 and Pohlen and Farris, 1992). While RL is associated with the logistics activities within the boundaries of a firm, authors use the term reverse supply chain (RSC) to refer to the chain on linkage of many independent firms that serve as a member in the reverse flow of product and information across multiple channels. A forward supply chain (FSC) and an RSC constitutes the two dimensions of a "closed – loop" supply chain (Krikke et al., 2004).

Though the idea of RL dates from long ago, the naming is difficult to trace with exactness. Though systematically related with recycling, terms like "Reverse Channels" or "Reverse Flow" already emerge in scientific literature of the seventies (Guiltinan and

Nwokoye, 1974; Ginter and Starling, 1978). During the eighties, the definition was inspired by the movement of flows in the supply chain, or "going the wrong way" (Lambert and Stock, 1981, Murphy, 1986, Murphy and Poist, 1989). In the early nineties, a formal definition of RL was put together by the Council of Logistics Management (CLM), stressing the recovery aspects of RL: " the term often used to refer to the role of logistics in recycling, waste disposal, and management of hazardous materials; a broader perspective includes all issues relating to logistics activities to be carried out in source reduction, recycling, substitution, reuse of materials and disposal". Pohlen and Farris (1992) define RL giving again notice of a direction in a distribution channel: the movement of goods from a consumer towards a producer in a channel of distribution. Carter and Ellram (1998) define it as the process whereby companies can become environmentally efficient through recycling, reusing, and reducing the amount of materials used". Rogers and Tibben-Lembke (1998) define it as the process of planning, implementing and controlling the efficient, cost-effective flow or 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.

Some of the key dimensions of RL in all these definitions were issues related to logistics, environmental, and inventory management. For the context of this research, I use the following definition: RL is defined as "the movement of goods (that includes both finished products as well as packaging materials) from one location to another after its intended utility is fully or partly consumed".

2.2 Drivers of Reverse Logistics

Economic benefits, legislation, corporate citizenship (de Brito & Dekker, 2003) and customer service initiatives (Rogers & Tibben-Lembke, 1998) are the four main drivers or determinants of RL. As shown in figure 2.1, legislation and customer service initiatives represent the conventional operational drivers, whereas corporate citizenship and economic benefits have major bottom line benefits and can transform returns management to a strategic asset. These four perspectives are briefly described below.

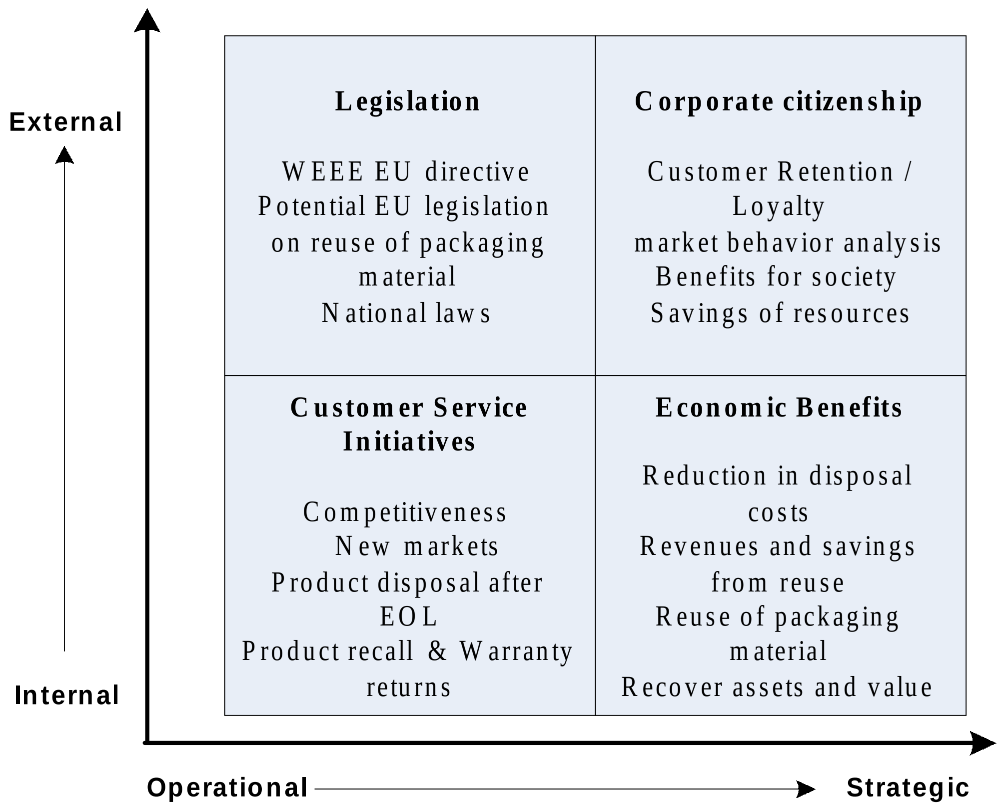

Figure 2.1 Drivers of returns management in Reverse Logistics
(Source: Infosys, Viewpoint)

2.2.1 Economics

Economics is seen as the driving force to RL relating to all the recovery options, where the company receives both direct as well as indirect economic benefits. It is seen that companies continually strive for achieving cost savings in their production processes. The economic drivers of RL lead to direct gains in input materials, cost reduction, value added recovery and also in indirect gains by impeding legislation, market protection by companies, green image for companies and for improvement in customer / supplier relations. RL is now perceived by the organizations as an 'investment recovery' as opposed to simply minimizing the cost of waste management (Saccomano, 1997).

2.2.2 Corporate Citizenship

Another driver for the RL is good corporate citizenship, which concerns a set of values or principles that impels a company or an organization to become responsibly engaged with RL activities. RL activities can lead to increase of corporate image (Carter & Ellram, 1998). Nike, the shoe manufacturer encourages consumers to bring their used shoes to the store where they had purchased them after their usage. They ship these back to Nike plant where these are shredded and made into basketball courts and running tracks. Nike also donates the material to the basketball courts and donates fund for building and maintaining these courts, thus enhancing the value of brand (Rogers & Tibben-Lembke, 1998).

2.2.3 Legislation

Legislation refers to any jurisdiction that makes it mandatory for the companies to recover its products or accept these back after the end-of-life of the product. These may include collection and reuse of products at the end of the product life cycle, shift waste management costs to producers, reduce volume of waste generated, and the use of increased recycled materials (Ravi et. al, 2005). There has also been a restriction on the use of hazardous substances in the production processes, which facilitates the dismantling, and recycling of waste electronics. A RL decision should ensure that the end-of-life electronic products are retired in a way that is compliant with existing legislation.

2.2.4 Customer Service Initiatives

The voice of the customer is the most important driver of RSC. RL has led to competitive advantage for companies which proactively incorporate environmental goals into their business practices and strategic plans to gain customer loyalty. The environmental management has gained increasing interest in the field of supply chain management. Murphy, Poist, and Braunschweig (1995) have found that 60% in a group of 133 managers surveyed considered the issue of the environment to be a very important factor and 82% of them expected that the importance would increase in the years to come. A 'green' image of producing environmentally friendly products has become an important marketing element, which has stimulated a number of companies to explore options for take-back and recovery of their products (Thierry, 1997).

2.3 Reverse Supply Chain Design

The three attributes of an RSC are discussed in the following sections.

2.3.1 Time

While global environmental concerns have been the motivation for initiating the field of RL, businesses have discovered that valuable commercial opportunities are embedded in it (Amini and Retzalf – Roberts, 1999). An increasing number of companies have started to realize that RL may be the last frontier of competitive advantage. RL accounts for more than 4.5 percent of total logistics costs, so inefficiency can severely affect a company's bottom line. On the flip side, it can significantly impact a company’s bottom line by recapturing value (Andel, 1997, Clendenin, 1997, South, 1998).Cutting the number of returns on the 20 percent of product coming back is equivalent to adding more than 25 percent in profits for a company getting 10 percent margins (Montgomery, 2004).

The world is changing rapidly, and companies, in cooperation with academics, must quickly develop supply chains that can handle coordinated forward and reverse flows of channels (Guide et al., 2003). While the existing literature in logistics and supply chain management has been inundated with FSC models, the number of RSC works is relatively less. Unlike FSC, the design strategies for RSC are relatively unexplored and underdeveloped (Blackburn et al., 2004). This research focuses on designing an efficient RSC chain. The main attributes of an efficient RSC includes increasing the asset recovery value, reducing the time taken to recover value and

Reducing the number of future returns. This research focuses on the second attribute to develop methodology for reducing the cycle time of value recovery.

The tremendous growth in returns has stimulated new interest in RL as firms attempt to meet the challenge (Autry et al., 2001). Typically, the higher the level of challenge greater is the opportunity for improvement. This is especially true in the case of RL management. Engineering a RL / RSC network is fraught with daunting challenges due to the sheer uncertainty that surrounds returns quality, quantity and time. Transporting returned goods is usually difficult and a cumbersome process. Statistically, there are up to 12 times the number of transactions involved in the returns process than to sell the product in the first place, and more require human intervention. For example, an outbound shipment of goods only involves one or two transactions (picking up the goods from a warehouse and delivering them to a small number of locations, or even just one location). However, the process of returning just ten items could mean supply from many locations, plus a different problem resolution per item, and at different times (Montgomery, 2004).

Blackburn et al opine that for FSCs a “responsive” supply chain may be appropriate for high demand uncertain products and an “efficient” supply chain for low demand uncertainty products. Their research indicates that the most influential product characteristic for supply chain design is the marginal value of time (MVT) that can be viewed as a clock speed. Responsive RSCs are appropriate for products with high MVT, whereas efficient RSCs are appropriate for products with low MVT. (Blackburn et al, 2004). As mentioned above, quantity, quality and time three are the essential attributes in a RSC. The degree of importance varies across industries and across product categories. In the case of electronic industries, timing is of prime importance because of the volatility in the product technology. The time taken to retrieve a product is directly proportional to the number of economically viable reuse options.

The motivation for this research is taken from the electronic products that typically have a high MVT, meaning that for a given elapse in time, the drop in value of the returned items are very high. Fast disposition analysis is the likely to be one of the alternatives that companies need to do today. Hence, it is extremely important in case of electronic industries to design their RSC that takes into account the crucial variable of time. Consequently, we develop a methodology that helps the organization to systematically measure the time take for value recovery. Later, we develop some process improvement techniques that identifies the non-value added time in the RSC operations and strives to cut on them. It is important to note that the source of inspiration for the development of the methodology is electronic industry. However, the methodology can be equally applied to any industry.

2.3.2 Value

Practically all businesses must handle returns (Richley et al., 1994). Research related to model development in returns management has been conducted over the past eight years. Recently researchers have focused on supply-chain management and RL, trying to modify supply chains to form closed-loop supply chains (Van Hillesgersberg et al., 2001, Guide and Van Wassenhove, 2003, Krikke et al., 2003). We briefly review some of the modeling works done in RL.

Koepfer (1993) focused on re-manufacturing and examined the three options of re-building, re-manufacturing and retrofitting in a machine tool industry, analyzing the choices among these options regarding machine-tool life cycles. Matthews et al (1997) developed quantitative models for end-of-life personal computers disposition. Fleischmann et al (1997) and Fleischmann (2001) have conducted a detailed survey of logistic network designs for recovering spent products from different sectors and quantitative models to support the design of RL networks. Carter and Ellram (1998) conducted an extensive overview of the RL literature. They integrated it with a framework for comparative analysis established in the marketing literature to develop a model of external factors affecting RL. Kneymer et al (2002) combined Carter and Ellram's model with the material developed by Dowlatshahi (2000), to develop a conceptual model for examining RL issues in EOL computers. Krikke et al (1999) researched extensively on dynamic, stochastic model development with respect to recovery strategies for monitors. Louwers et al (1999) presented a facility location – allocation model for the collection, preprocessing and redistribution of carpet waste.

Klausner and Hendrickson (2000) developed a model to determine the optimal amount to spend on buy-back and the optimal unit cost of reverse logistics. They use the latter to select a suitable RL system for end-of-life products. Ferguson and Browne (2001) came up with models related to issues in end-of-life product recovery. They illustrated the specific information flow between the key players within the automotive industry. Flapper et al. (2002) and Guide (2000) described rework and remanufacturing strategies. Schultmann et al (2003) modified their work and developed a hybrid approach to establish a closed-loop supply chain for spent batteries. This approach combines an optimization model for planning a reverse – supply network and a flow-sheeting process model that enables a simulation tailored to potential recycling options for spent batteries in the steelmaking industry. Krumwiede and Sheu (2002) developed an implementation model for strategic RL decision-making to help companies who would like to pursue RL as a potential new market to enter. Inderfurth (2005) developed a stochastic remanufacturing model that reveals how product recovery behavior is affected by stochastic and non-stochastic models inputs under qualitative and quantitative aspects

Tibben – Lembke asserts that more research is needed into how companies should process, store and dispose of returned goods. Much more research is needed in understanding secondary markets, and how companies should best sell unwanted product (Tibben-Lembke, 2002). Rogers and Tibben-Lembke (1998) have established various recovery options for products entering the RL. They have classified the returns based on some set of criteria. These criteria are discussed later in the classification of returns section. De Brito and Dekker (2002) have classified the asset recovery options. We note in the literature that there has not been any research done on selecting the best disposition option given a set of plausible options. We combine the insights gained from Rogers and Tibben-Lembke and de Brito and Dekker to serve as our foundations for this research. Consequently, we develop a model that prioritizes the disposition options for a given returned product based on some parameters of the RL process.

2.3.3 Volume

Returns play a strategic role in the organization. A survey in 2001indicated that the strategic role of returns in the following ways: competitive reasons (ii) clean channel (iii) legal disposal issues (iv) recapture value and (v) recover assets. A new dimension is been added to this list by extrapolating the roles of returns. I examine the possibility of extracting useful information from product returns to figure out ways to improve the performance. Typically returns happen because something is wrong somewhere in the long supply chain pipeline. It is also to be noted that returns also happen even when everything is perfect. The focus of this research would be to tap the former and analyze the reasons for returns from various supply chain actors point of view. After zeroing on the return reason for each actor, this research methodology strives to use this feedback information for future purposes so that the number of returns is reduced in the future. In other words, we link the returns to the FSC performance. We recommend various suggestions from a strategic and a tactical perspective for two reasons: (i) it can be applied to a wide gamut of industries and (ii) the operational managers can tailor these remedial procedures to suit their RL climate within the organization (Yellepeddi, Rajagopalan, and Rogers, 2006).

Dowlatshahi (2002) remarks that the successful design and implementation of an RL system should consider the strategic factors from the customer and from a business standpoint. The strategic factors provide the critical factors that must be considered before other detailed or operational factors are considered. It serves no purpose to proceed to operational factors if RL system does not meet the strategic factors or values of a firm. The strategic factors are an impetus for the operational factors. Once strategic factors are considered and satisfied, operational factors could be considered and evaluated (Dowlatshahi, 2002). Thus, we develop strategic level suggestions based on the reason for returns for the following supply chain actors namely producer, transporter, seller and the consumer.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Development of Initial Methodology

The major tasks in the dissertation work plan are as follows: Development of initial methodology, validation of methodology, revision of methodology and finally the development of implementation guidelines. These are discussed briefly in the following sections.

The objective of this research is to develop a methodology for designing an efficient reverse supply chain (RSC) system in the consumer electronics industry. The methodology had attempted to (i) reduce time needed to recover value (ii) increase value from "asset recovery" process for items that have entered RSC and (iii) reduce the number of items that will enter RSC in future.

These three goals are referred to as goal 1, goal 2 and goal 3 respectively. Typically, in the literature, efficiency of a RSC is interpreted in terms of recovering maximum value in a minimum time. In addition to it, a third attribute for an efficient RSC was added that is associated with having a minimal number of returns entering the RSC.

As discussed in Chapter 1, the first two goals (goal 1 and goal 2) are associated with operations after the products had entered the RSC. Reiterating them, the methodology reduces the time required to recover value in RL pipeline and increases the value from AR process. These are the first and second goals respectively. The third goal concerns the entry of products into the reverse stream. The task is to reduce the number of returns that enter the RSC in future. In other words, the methodology ensures that the number of products entering the RSC will be minimal in the future.

To come up with the initial methodology, the following activities were undertaken. They are as follows:

(i) Performed a thorough literature search about RL and RSC.

(ii) Identified the specific problem.

(iii) Justified the problem in terms of scope, practicality and use in industry.

(iv) Developed the problem statement of the research.

(v) Decomposed the objective of research problem into three distinct areas with three goals each.

(vi) For each of the goals, developed the following:

  a. Steps in envisioned methodology
  b. Work plan for the corresponding step in the envisioned methodology and
  c. The associated deliverable.

3.2 Validation / Demonstration of Methodology

The next main task in the dissertation work plan dissertation was to validate the developed initial / envisioned methodology using real time information. This was done by collecting data from a couple of companies in the electronics industry in and around the Dallas Fort Worth (DFW) metroplex.

The method of data collection was by means of in-depth interviews (IDI) with organization personnel. The interview process consisted of a single session with the Logistics Manager of the company. The interview was guided by a questionnaire that is attached in appendices A, B and C. The questionnaire was developed in such a way that all the key technical terms are defined clearly before proceeding to another topic. The same questionnaire was used for both the companies to ensure consistency in the data to be collected.

To be specific, for each of the three goals of the objective, the following information was garnered. The related topics in each of the three goals are given below:

Topic areas in Goal 1:

(i) Identification of the list of relevant supply chain actors in the company.

(ii) Identification of the product flows.

(iii) Determination of the entry and exit points of RSC.

(iv) Determination of the operations between RSC_{entry} and RSC_{exit}.

(v) Determination of standard times for tasks.

(vi) Development and determination of RSC parameters.

(vii) Development of process improvement techniques.

Topic areas in Goal 2:

(i) Identification of the type of returns.

(ii) Identification of the type of disposition options

(iii) Definition of Returns Tracking Unit (RTU)

(iv) Determination of drivers for "Value of RTU (RTU)".

(v) Determination of drivers for "Total Expected Value of Recovery".

(vi) Determination of drivers for "Total expected cost of implementing the disposition option".

Topic areas in Goal 3:

(i) Determination of the possible primary, secondary and the associate tertiary return reasons, if any.

(ii) Development of fool-proof methods to avoid the return

(iii) Determination of costs and benefits of methods.

3.3 Revision of Methodology

The next dissertation step was to revise the initial methodology based on the inputs and insights from the organization visits. The purpose of revising the methodology was to make sure that the final methodology is consistent with most of the real time scenarios. If some of the steps in the envisioned methodology are not consistent with the real time scenarios, or if some additional steps need to be added in the envisioned methodology, it was added in this step of the dissertation work plan.

The purpose of revising the methodology is to refine / fine-tune it so that the methodology is more accurate and useful. In addition to the regular interview sessions with the Logistics Manger, there was a time window of 2 hrs available with the organization personnel to clarify any issues. However, this time window was not used as there was not real need for any further clarification on any issues. This revision step ensured that the salient features are not missed out in the development of methodology.

3.4 Development of Implementation Guidelines

After the “revision” step was completed, the methodology was ready to be used in the company. However, before it could be done, it behooves to develop a set of “implementation guidelines”. Consequently, the implementation guideline was developed after collecting feedbacks about the initial methodology.

The implementation guideline allows the concerned personnel to implement the final version of the methodology in the organization. It explains the process of following each step in the methodology in a detailed manner. The implementation guideline is discussed later in Chapter 5 and is also given in Appendix D.

CHAPTER 4

DEVELOPMENT OF INITIAL METHODOLOGY

4.1 Goal 1

As discussed in Chapter 1, this research has three goals. Goal 1 seeks to reduce the time taken to recover value. Goal 2 seeks to increase the value recovered from the “asset recovery” process. Goal 3 seeks to reduce the future returns into the reverse supply chain. The methodologies for achieving these are discussed in this chapter. Accordingly, this chapter is broken down in to three main sections. These are explained in detail in the following sections.

4.1.1 Methodology

The methodology for reducing the time taken to recover value starts from developing a methodology to measure. Hence the first task is to define the time taken for value recovery is to develop procedures to measure and reduce it. Once a proper measurement system is in place, then all the ensuing initiatives for reducing them would be much simpler. Consequently, this section is broken down into two sub – sections. The first one discusses about measurement and the second one about the improvement techniques.

4.1.1.1 Measurement

"Cycle time of value recovery (CTVR)" is the parameter that serves as the cynosure of goal 1. The methodology developed here identifies methods to measure / calculate the cycle time of value recovery which is nothing but the time taken by a RTU to traverse the RSC. In the process of measuring it, some key parameters are developed that serve as insights for lean improvement techniques. However, in order to reduce the cycle time of value recovery, there needs to be proper measurement system in place. Hence, the first step in this research methodology is to measure it.

Step 1: Identify the relevant supply chain actors in "closed-loop" that includes both FSC and RSC: The actors in the closed-loop chain are segregated into three based upon their functionalities. Firstly, there are the "traditional" FSC actors that include but not limited the following: raw material suppliers, wholesaler, retailer and customer. The second category includes "facilitators" whose function is to facilitate an aspect of the supply chain. Typical examples of them include "third party service providers" that specialize in activities like warehousing, transportation, inventory management, accounting, customs brokerage, freight forwarding, export packaging, export and import management etc. The third category includes all actors that specialize in RSC activities. Some examples include secondary markets, liquidators, actors who specialize in remanufacturing, repair, refurbishing, recycling, land-filling so on and so forth. The task here is to identify all the possible supply chain actors in each category that an organization has to deal with.

Step 2: Form the "closed-loop" network structure (similar to Figure 4.1) that takes the worst-case scenario of the product and information flow: In the previous step, some of the typical supply chain actors were suggested. In this step, it is suggested that the organization need to map out those actors with the product and information flow between then. A typical figure is illustrated in Figure. 4.1. However, the organizations will have to modify it to suit their list of actors and the associated product and information flow among them. Any new update in the RSC actors should be updated in the network structure.

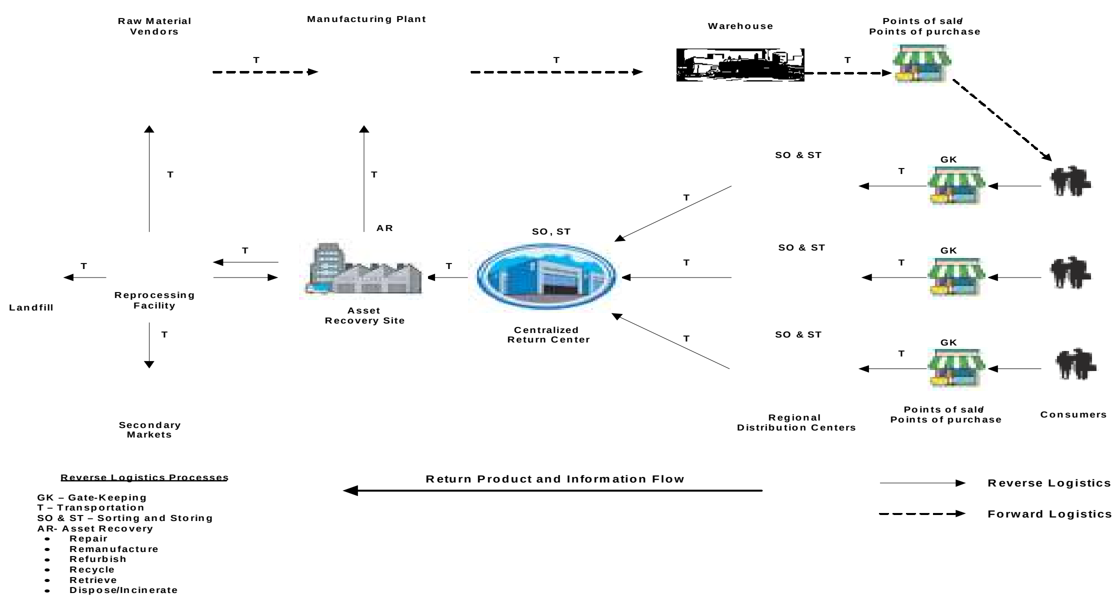

Figure 4.1 Supply Chain Actors

Step 3: Define the $\mathbf{RSC_{entry}}$ and $\mathbf{RSC_{exit}}$ points: This step is to identify where the RSC operations begin (RSC_{entry}) and end (RSC_{exit}). RSC operations typically begin at gate-keeping and end at different places depending upon the action chosen by the AR stage (refer Figure 4.1). However, it is recommended to identify the earliest RSC entry node and the latest RSC exit points that will be consistent with the longest node assumption. To restate the assumptions, the idea in this network is account for the maximum number of supply chain actors in a given closed loop supply chain. In other words, this "maximum node" structure would take into account the worst case scenario where the product and the information have to flow through the maximum number of points in the closed-loop supply chain. For example, products may actually reach the AR center after GK without even passing through the regional distribution centers (RDC) and the centralized return centers (CRC). But the "maximum node" assumption was developed to account for any product and information flow involving the RDCs and the CRCs that may happen anytime in the future.

Step 4: Identify the activities involved for each operation between RSC_{entry} and RSC_{exit}: Firstly, the organization should identify the various operations between an RSC_{entry} *and* RSC_{exit}. After identifying the operations between RSC_{entry} *and* RSC_{exit}, for each RSC operation, the organization will have to identify the list of activities that typically happen in it. The list of activity might differ depending upon on the RTU. But for this purpose, it is suggested to include all possible activities within a given RSC operation.

Step 5: For a given RTU and for the first RSC operation, perform the following*:* Develop a "Process Flow Chart" to classify the activities involved in it into "operations", "storage", "inspection", "transportation", "decision", "delay" and "value recovery": The first five categories are typical of a process flow chart. In addition to it, a new category is introduced called the "Value Recovery". The "Value Recovery" category is different from the “operation” category. While the essence of all “value recovery” activities would be to recover as much value as possible for a given RTU, the latter is just any other activity that is needed to complete the RSC operation. The motive behind “Value Recovery” category is to figure out the number of actual “value recovery” activities and the associated time taken. This piece of information will be useful in developing methods to reduce “cycle time of value recovery”.

The task now is to document the “Observed time (OT)” for performing a particular activity. After this, the “standard time (ST)” should be figure out based on the OT. Refer to “Process flow chart” in Table 1. While the OT is the actual time taken to perform a task in a given instance it does not take into account the operator allowances etc. Hence, we recommend calculating the ST from the OT.

Step 6: Identify the list of possible activities that can be classified in the “Value Recovery” category: For a given RTU and a given RSC operation, there might be a number of activities. However, there are only a few that can be classified as a “Value Recovery” activity. These “Value Recovery” activities typically include all asset recovery activities. We posit that only the “asset recovery” activity adds value to the process. The rest of the activities could ideally be eliminated. This is in a way analogous to the differentiation between “Value Added Time (VAT) activity” and “Non-value added activity in the FSC. Value added activity is one for which the customer pays while for all the other activities (non-value added), the customer is not willing to pay. On a similar note, the reasoning is that only the asset recovery operation is the operation which is instrumental in recovering value from the RTU. Though all the other operations are still needed for the successful asset recovery, we consider those to be supporting operations and consequently non-value added. Hence, there is a great deal of potential in saving time in those operations.

Step 7: Calculate the ST of various process categories in the process flow chart: In this step, excluding the "value recovery" category, the task here is to sum the STs of all the process categories. This will give the ST of the particular RSC operation. Label them as ST_{RSC1}. Sum the STs of "value recovery" activities to get the standard time of value recovery. Label it as $STVR_{RSC1}$.

Step 8: Calculate ST for the rest of RSC operations: For the same RTU, repeat step 5 thro 7 for the rest of RSC operations between RSC_{entry} and RSC_{exit}. Doing this will yield ST_{RSC1}, ST_{RSC2} … ST_{RSCn} and $STVR_{RSC1}$, $STVR_{RSC2}$ … $STVR_{RSCn}$.

Step 9: Calculate the "initial" time parameters: There are certain parameters related to time that are introduced in this research. They are used to calculate the final time parameters that are discussed later discussed below.

i) Total time taken by RTU_1 to traverse the RSC: This is labeled as $\mathbf{TT_{RTU1}}$ and is calculated using the following equation.

$TT_{RTU1} = \sum (ST_{RSC1} + ST_{RSC2} + \ldots ST_{RSCn} + STVR_{RSC1} + STVR_{RSC2} + \ldots STVR_{RSCn})$.. *Eq. 4.1.*

ii) Value Recovery Time of RTU_1: This is labeled as $\mathbf{VRT_{RTU1}}$ and is calculated using the following equation.

$VRT_{RTU1} = \sum (STVR_{RSC1} + STVR_{RSC2} + \ldots STVR_{RSCn})$............................. *Eq.4.2.*

Similarly calculate VRT_{RTU2} VRT_{RTU3} VRT_{RTU4} ……… VRT_{RTUn}.

Step 10: Perform 5 through 9 for all RTUs for a significant period of time: The word "significant" is used in a subjective way. Typically, it is recommended to use anywhere from month to 3 months to gain a good "profile" of the various process categories. The idea is to use a time frame that captures the steady state condition rather than the anomalies.

Step 11: Calculate the following "final" time parameters:

(i) Average Total Time (Avg. TT): This is the average of TT of all RTUs for the given time period under consideration.

(ii) Average Value Recovery Time (Avg. VRT): This is the average of the VRTs of the various RTUs in the same time period.

(iii) Time Efficiency (T.E): This parameter is similar to the concept of Lean ratio in the FSC that is given by dividing VAT by the total time taken. This is given by the following formula

T.E = Avg. VRT / Avg. TT.. *Eq.4.3.*

(iv) Non-Value Recovery Time (NVRT): This is the total time that is spent on all activities excluding the VRT. Hence it is given by the following equation.

NVRT = Avg. TT – Avg. VRT... *Eq.4.4.*

(v)Average Standard Time of process categories (Avg. ST_i): For each of the various process categories listed in the process flow chart, we calculate the average standard time using the following equation

Avg. ST of a given process category i =

Total ST of the process category i / # of RTUs under consideration in the given time period.. *Eq.4.5.*

Table 4.1 Process Flow Chart

RSC OPERATION: Gate keeping
RTU: ABC123

DATE: April 4, 2006
TIME: 11:31:05 PM

Process Categories →	**Operation**		**Storage**		**Decision**		**Inspect**		**Delay**		**Transport**		**Value Recovery**	
Activity ↓	*OT*	*ST*	*OT*	*ST*	*OT*	*ST*	*OT*	*ST*	OT	ST	OT	ST	OT	ST
Inspect documents														
Check for completeness														
Return to customer if not complete														
Check for warranty														
Return to customer if not ok														
Check for product characteristics														
Return to customer if not ok														
Credit customer														
Sort RTU's														
Pack the products														
Move to store location														
Store														
Issue RMA														
ST_i	5		10		6		7		8		9		2	

The calculations are shown in the following page.

Step 8: $ST_{RSC1} = \sum ST_i$ (i = "Operation" to "Transport". Value recovery is not to be included)

Step 8: $STVR_{RSC1} = \sum$ ST of all activities in "Value Recovery" category

Step 8: Similarly find ST_{RSC2}, $ST_{RSC3} \ldots ST_{RSCn}$ and $STVR_{RSC2}$, $STVR_{RSC3} \ldots STVR_{RSCn}$

Step 9: $TT_{RTU1} = \sum (STR_{RSC1} + ST_{RSC2,} + \ldots + ST_{RSCn} + STVR_{RSC1} + STVR_{RSC2} + STVR_{RSCn})$

Step 9: $VRT_{RTU1} = \sum (STVR_{RSC1} + STVR_{RSC2} + STVR_{RSCn})$

Step 11: Avg. TT = Avg. $(RTU_1, RTU_2 \ldots RTU_n)$

Step 11: Avg. VRT = Avg. $(VRT_{RTU1}, VRT_{RTU2} \ldots VRT_{RTUn})$

Step 11: T.E = Avg. VRT / Avg. TT

Step 11: NVRT = Avg. TT – Avg. VRT.

4.1.1.2 Improvement

The previous section described how to measure the cycle time of value recovery. We also developed some new parameters that can be utilized effectively. Now, with these parameters, we suggest some analysis that would throw light on the various process parameters. This will be insightful as to where the bottlenecks are in the system. Based on this information, the organization can device further lean improvement techniques based on the specific cases.

(i) Analyze the process parameters

It is recommended to perform the following analysis of the various parameters. The following graphs are examples and do not represent any real time data.

Average Standard Time of RSC operations

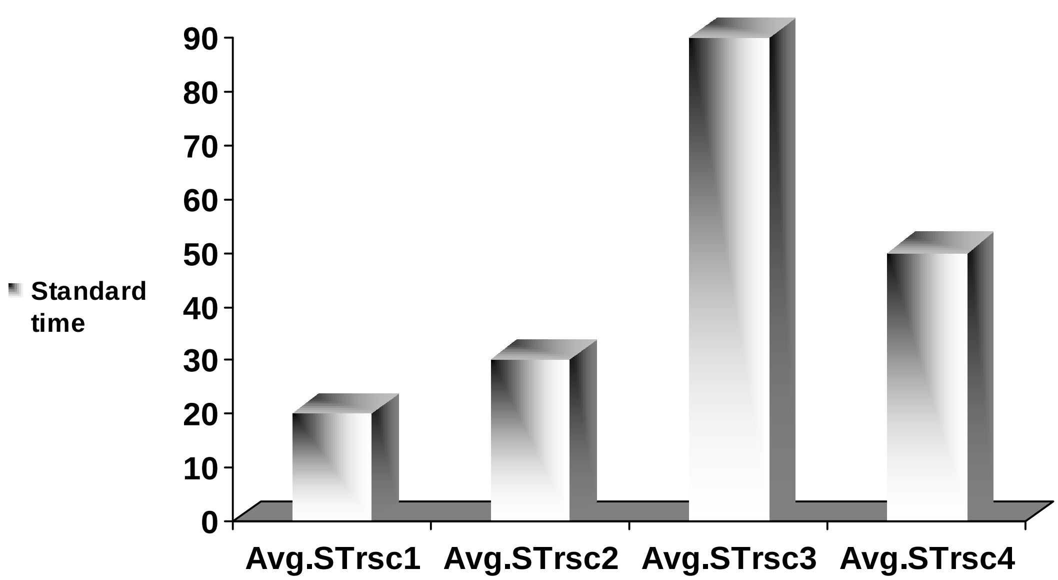

Figure 4.2 Standard times vs. RSC operation

Standard Times of RSC operations vs. RTUs:

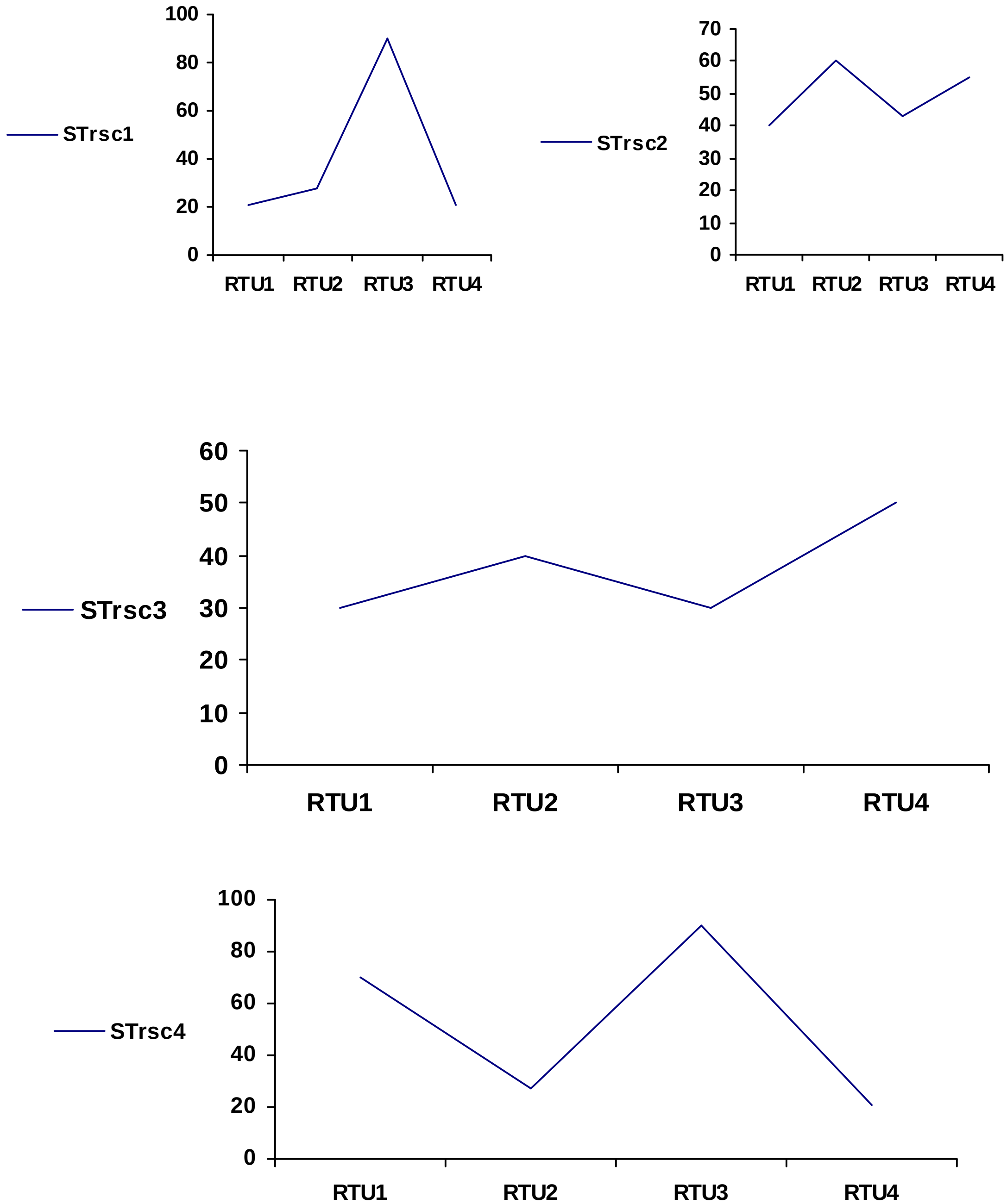

Figure 4.3 Standard Times vs. RTUs

Total time vs. Value Recovery Time for RTUs

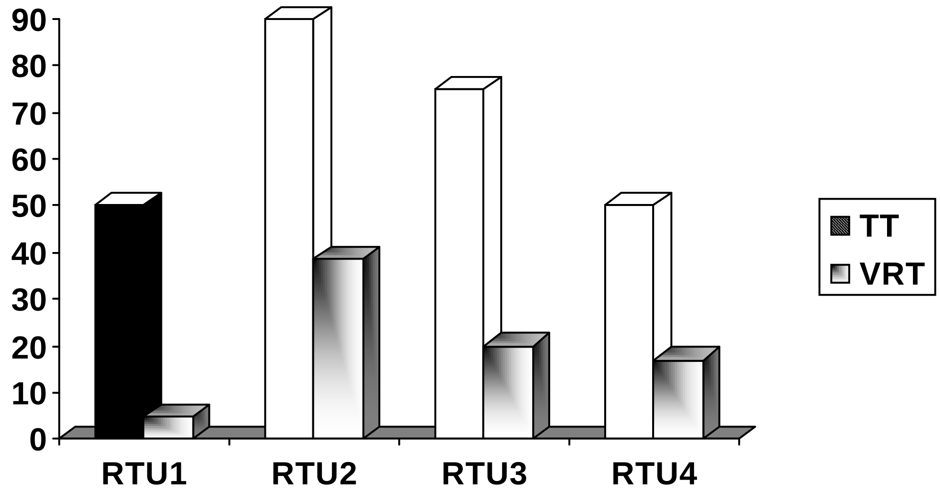

Figure 4.4 Total time and Value Recovery Time for RTUs

Avg. Standard Time vs. Process Categories

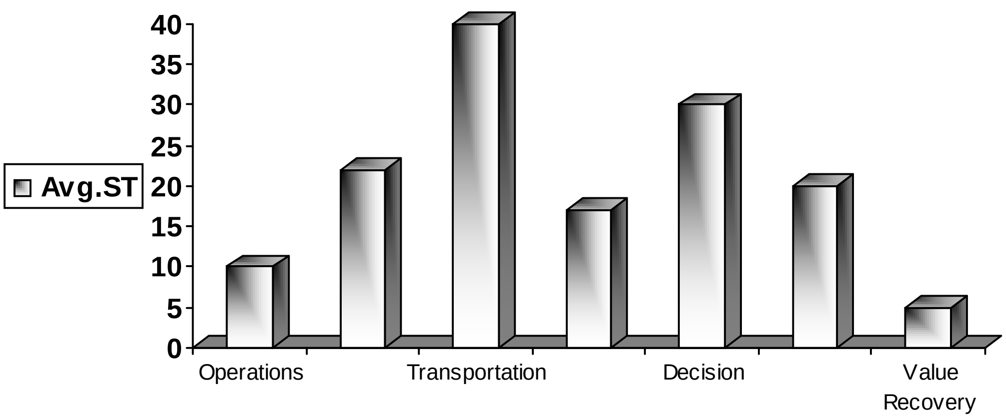

Figure 4.5 Standard times vs. RSC Operations

Time Efficiency of RTUs

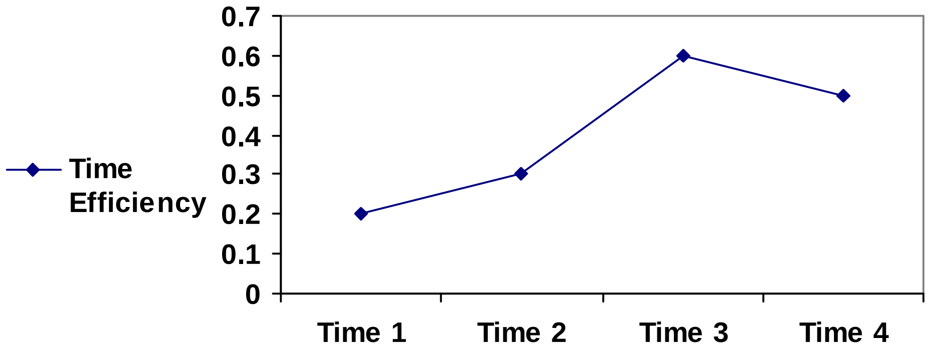

Figure 4.6 Time Efficiency of RTUs

(ii) Other recommendations: In addition to the process parameter analysis, there are some other recommendations that enterprises could think of:

(a) Return reasons at gate keeping site: Some of the companies have implemented this in their gate keeping site. The idea behind this to classify and codify the return reasons so that it takes less time in the AR to pretest them.

(b) Central pool of database that lists all RTUs: Often times, it is always advantageous to have an integrated database that lists all the available RTUs across different units of the same organization. This is one of the most obvious suggestions that have been overlooked by the companies. Successful implementation of this will make sure the asset is fully utilized in the organization.

(c) Standardization of part numbers across different unit of the same organization: Some times, the same part will have different part numbers across different units of the same organization. When this is the case, it takes time to identify the specifications of the product for choosing the best disposition option. Hence we recommend having a standardized part numbering system in place.

(d) Incorporating Design for Disposability (DFX) capabilities: This is a strategic initiative that is driven mainly by the legislation. DFX means that the products should be designed in such a manner that it is ecologically safe and easier to dismantle and dispose. We believe that this will become more of a necessity than an option. The engineering and the design department should take into consideration the disposition issues while designing the product. While DFX is being practiced in some industries, there is still a large scope available for the supply chain engineers. DFX is practiced only in some countries in Europe, U.S and Japan. While in most of the other countries the concept is yet to realize its potential.

(e) Demarcation between FSC and RSC items in warehouses: There should be clear demarcation between the FSC products and the RSC products that are stored in the same warehouse. The picking, kitting, packing and shipping of the wrong components, sub-assemblies will not only add to volume of returns but also to the higher value of the process parameters.

4.2 Goal 2

4.2.1 Methodology

The second goal deals with the “asset recovery (AR)” that forms the crux of the whole reverse logistics operations. It is the process in which typically, the disposition option for a given RTU is chosen and implemented. It acts as the engine of the RL system. The methodology developed here seeks to increase the value that is derived from the asset recovery process per se. The structure of this sub – section is as follows. Firstly, the classification scheme for returns are developed and discussed followed by the classification scheme of the disposition options. Next, the concept of Returns Tracking Unit (RTU) is explained in detail. After this, the "Scoring model" system is introduced that takes into account these two classification schemes. The model, its assumptions and related parameters are explained in detail.

4.2.1.1 Classification scheme for Returns

The basis of classification of returns is an important aspect in RL because a lot of crucial decisions are based on this information. There are quite a few ways of classifying returns that includes:

(i) Based on the value of the total shipment (Products and Packaging)

(ii) Based on the condition of the product (End-of-Life [EOL], End-of-Use [EOU] and Commercial)

(iii) Based on the reason for return (Close outs, Buy-outs, Job outs, Surplus, Defectives, Non-defectives and Salvage)

(iv) Based on the physical characteristics of the product (Metal, non-metal, cardboards, alloys etc)

(v) Based on the place from which the returns are shipped (Manufacturing returns, distribution returns, customer / user returns etc).

(vi) Based on the industry (electronic returns, textile returns, automobile returns etc).

(vii) Based on the type of product (Finished goods, sub assembly, loose components, machines, tools etc).

The next logical step is to select the basis of classification that needs to be adhered to. The answer depends on the nature of problem at hand. For this research, we are focused on evaluating the available disposition options to recover maximum value from the returns. Thus, the "condition of product", "value of the total shipment" and "return reasons" are the three basis that are taken into consideration The reason for this is that the disposition strategy does not vary if the returns are classified on the basis of industry, physical characteristics of the product or the place from which they are shipped. In general, it is good to note that, for the classification schemes that an organizations uses for its RL applications, the basis of classification need not be same for all levels. It should be consistent to reflect the fact that the disposition strategy varies across a given level in the classification scheme. The classification scheme that is utilized for this research is depicted in Figure. 4.7.

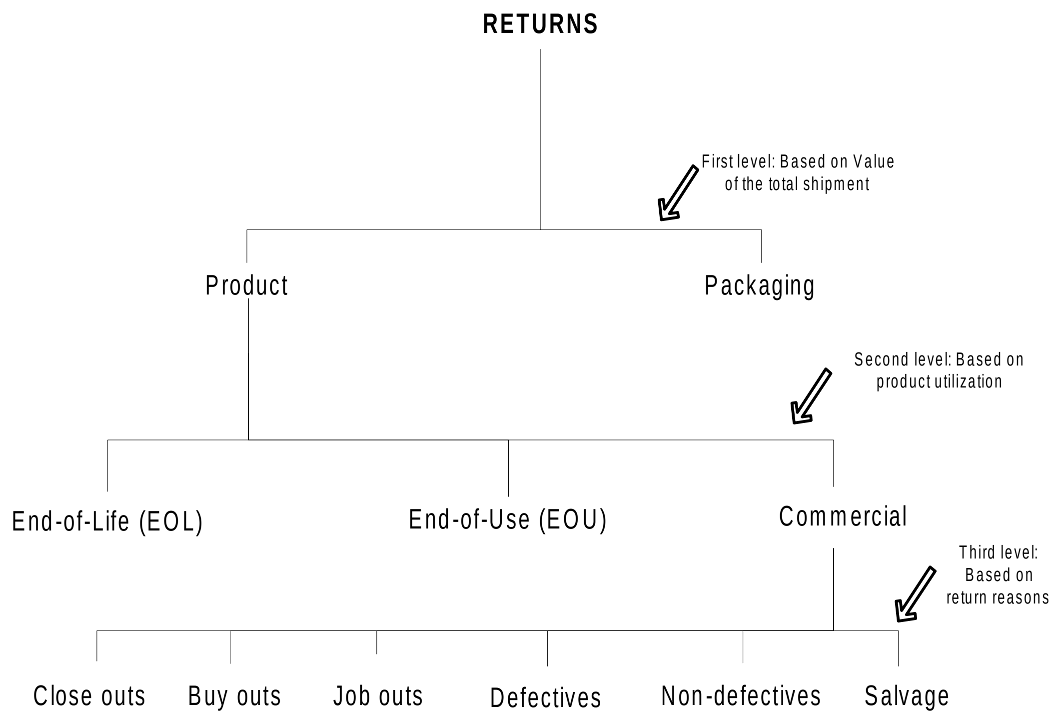

Figure 4.7 Classification Scheme for Returns

For example, EOL and EOU items can be classified further into finished goods, sub-assemblies and loose components. But the available disposition options will not be affected by this classification scheme. Hence we have three levels of classification in the context of this paper.

First – level:

Returns across all industries are classified into two broad types viz., the "product returns" and "packaging returns". While the "product returns" represent the actual physical product that is being returned, the packaging returns include all the packaging materials and other accessories that go with the product. This is the fundamental or the first level of classification. This scope of this research paper lies within the "product" returns category.

Second – level:

The “Product return” category is sub-divided into three major types: End-of-Life (EOL), End-of-Use (EOU) and “Commercial” items. As the name EOL suggests, these are the products that have reached the end of its useful life. Typically, EOL products are taken back from the market to avoid environmental or commercial damages (Krikke et al., 2004). EOU category includes the returns returned after some period of operations due to the end of the lease, trade-in, or product replacement (Krikke et al., 2004). Commercial returns are the returns that are linked to the sales process. Product warranties, product recalls and overstocks are some of the return reasons in this category. Another way to look at this is while EOL products typically are utilized so extensively that very little life is left, commercial returns are relatively not used. EOU products lie some where between these two extremes of spectrum.

Third – level:

“Commercial” returns are typically retail returns that include close-outs, job-outs, buy-outs, surplus, defectives, non-defectives and salvage items. Table 4.2 gives the attributes of each of these types.

Table 4.2 Type of Commercial Returns (Adapted from Rogers and Tibben-Lembke, 1998)

Type	Attributes
Close-outs	First-quality items that the retailer has discontinued from its product mix. In such a case, the retailer may have decided to stop carrying products sold by a certain vendor, in a particular product line
Buy-outs	Occur where one manufacturer buys out a retailer's entire supply of a competitor's product. This purchase frees shelf space so that the manufacturer can put its product where the competitor's product was previously.
Job-outs	Job-outs have come to the end of their normal sales lives. These include seasonal products that are popular only during a certain time of the year.
Surplus	First quality items that the company has in excess but will continue to sell. The firm may have overestimated demand and ordered too many. It could also arise from inaccurate forecasts, minimum production quantity requirements and marketing returns.
Defectives	Truly defective items. The reason for the defective may be any one the supply chain actor. Usually the stakeholder reimburses the buyer with a new product or makes financial adjustments.
Non-defectives	Often, a customer claims that a product is defective in order to return it, when, in fact, it is not defective.
Salvage	Have been used or damaged, and can no longer be sold as new. These items loose value relative to the amount use or damage. The most difficult part of managing salvage is determining its value.

4.2.1.2 Returns Tracking Unit (RTU)

After having classified the returns, it is appropriate to introduce the concept of "Returns Tracking Unit" (RTU). Any product entering the RL pipeline of an organization can be classified according to the seven types mentioned earlier. But we use the first three in the context of this paper. Each item entering the RL pipeline is coded according to the first three basis of classification followed by some additional codes if necessary. The complete code represents a RTU.

This is an important information for the RL pipeline because it tells the organization most of the characteristics of a particular returned product in entering the RL pipeline. This complete coding is illustrated in the example section. A sample coding scheme for all basis of classification is give in Table 4.3. The more the number of basis used in an RTU, more the information it can store. RTU can be thought of similar to an SKU in the forward supply chain (FSC).

Table 4.3 Coding Scheme for all basis of classification

#	Based on	Levels	Codes
1	Proportion of the value of shipment	Product, Packaging	PR, PA
2	Condition of the product	EOL, EOU, Commercial	L, U, C
3	Reason for return	Close-outs, Buy-outs, Job-outs, Surplus, Defectives, Non-defectives, Salvage, Other	C,B,J,SU,D,N,SL,O
4	Physical Characteristics	Metals, Non-metals, Alloys, Other	M,NM,A,O
5	Place from which the returns are shipped	Manufacturing returns, distribution returns, customer / end user returns, Other	M, D, E,O
6	Industry	Electronic, Automobile, Textile, Retail, Other	E,A,T,R,O
7	Type of product	Finished goods, sub-assembly, loose components, machines, tools	FG, SA, LC, M, T

4.2.1.3 Classification Scheme for Disposition Options:

A comprehensive classification scheme for disposition options is developed in this research. Fig. 4.8 illustrates the classification scheme. There are three levels of classifying the options. They are as follows:

First-level:

There are three broad ways of classifying available disposition options including “Direct Recovery”, “Reprocessing” and “Other”. Direct Recovery deals with options that seek to recover value from a returned product without any actual physical processing involved. Reprocessing includes all options that involve treating materials in one form or the other to extract value. Apart from “Direct Recovery” and “Reprocessing”, there is an “Other” category that includes all other means of asset recovery including scraping, donating to charity and land- filling. Usually in this category, there is very minimal value recovered.

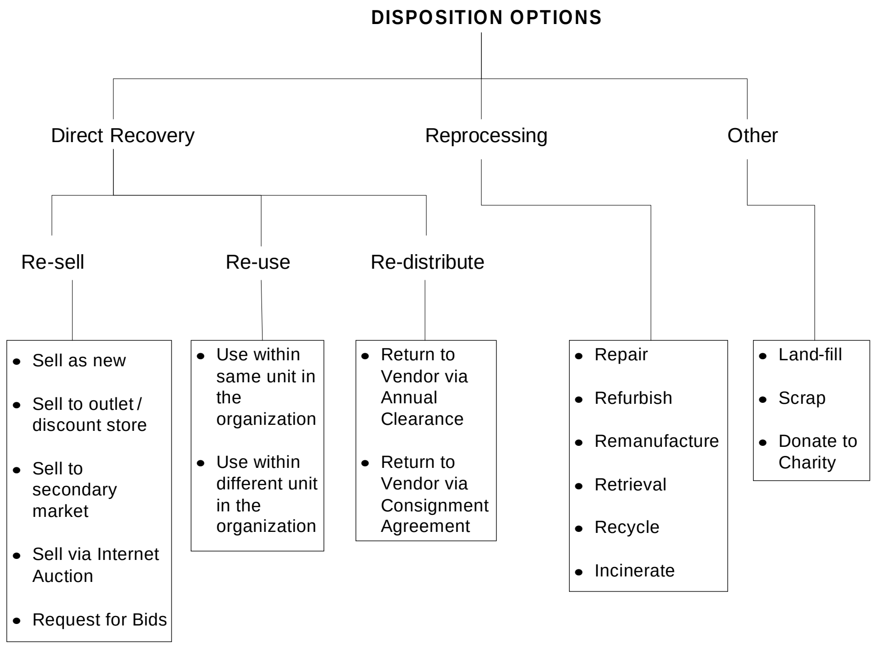

Figure 4.8 Classification Scheme for Disposition Options

<u>Second-level:</u>

Within "Direct Recovery" we classify the options into three types, viz., "Re-sell", "Re-use" and "Re-distribute". While "Re-selling" and "Re-use" are for stakeholders, "Re-distribute" options are for the buyer as it entails him to ship the products upstream to another supply chain actor via arrangements or contracts. However, the supply chain actor who receives the product becomes the stakeholder in this case and can choose any of the third-level disposition options available to him.

<u>Third-level:</u>

The third-level options ranges from "Sell as new" through "Donate to Charity". Since, these options are quite straightforward, further explanation is not undertaken here.

The classification scheme for returns and the disposition options are tied up and are represented in a holistic framework in Table 4.4. The motive behind this framework is to suggest list of possible disposition options for any type of product return.

Table. 4.4 Framework for Disposition Options

RETURN TYPE → STRATEGY ↓	EOL	EOU	COMMERCIAL						
			Close-outs	Buy-outs	Job-outs	Surplus	Defectives	Non-defectives	Salvage
Sell as new	×	×	✓	×	✓	✓	×	✓	×
Sell to outlet or discount store	×	×	✓	×	✓	✓	--	✓	×
Sell to secondary market	×	×	✓	×	✓	✓	--	✓	×
Sell via Internet Auction	×	✓	✓	×	✓	✓	×	✓	×
Request for Bids	×	✓	✓	×	✓	✓	×	✓	×
Use within same unit, same organization	✓	✓	×	×	×	×	×	×	×
Use within different unit, same organization	✓	✓	×	×	×	×	×	×	×
Return to Vendor – Annual Clearance agreement	×	×	✓	✓	✓	✓	✓	✓	✓
Return to Vendor – Consignment Agreement	×	×	✓	✓	✓	✓	✓	✓	✓
Repair	×	✓	×	×	×	×	✓	×	×
Refurbish	×	✓	×	×	×	×	✓	×	×
Remanufacture	×	✓	×	×	×	×	✓	×	×
Retrieval	✓	✓	✓	×	✓	✓	✓	✓	✓
Recycle	✓	✓	✓	✓	✓	✓	✓	✓	✓
Incinerate	✓	✓	✓	✓	✓	✓	✓	✓	✓
Land-fill	✓	✓	✓	✓	✓	✓	✓	✓	✓
Scrap	✓	✓	✓	✓	✓	✓	✓	✓	✓
Donate to Charity	✓	✓	✓	✓	✓	✓	×	✓	✓

-- Dependent upon the type of product/industry under consideration

4.2.2 Scoring System

The scoring model takes into consideration the two most important aspects of a RL system: cost and environment. The magnitude of the score for a given disposition option i (DO_i) is given in Equation 1. The score reflects the expected net loss of implementing a strategy for a given return.

Score for Disposition $Option_i$ (DO_i) = S_i =

(Value of RTU under consideration) +

(Total expected cost of implementing DOi) –

(Expected Recovery Value of DO_i) …………………………………...… Eq.4.6

Value of RTU:

The motivation behind this parameter is to find the value / worth of the RTU. There may be a number of returned products entering the RL system of an organization. The organization needs to consider a single RTU each time it evaluates the options. Typically, if the manufacturer is the stakeholder, he can use the manufacturing cost of the product to reflect this parameter. If the RTU is a capital equipment, he can estimate its present worth using depreciation methods. If it is a purchased part like a tool or any other accessories, he can use the purchase price. If the stakeholder is a retailer or a wholesaler, he can use the purchase price of the products.

Total expected cost of implementing DOi:

As mentioned earlier, there are two aspects of a "closed-loop" supply chain that includes the dimensions of reverse logistics and green logistics. While the former, typically deals with the cost dimensionalities of the RSC system, the latter has to do with environmental issues. These two dimensions are very crucial in designing any closed-loop supply chain system. It does not do any good to have cost-efficient RL practices at the expense of environmental damage. Alternatively, it is also not justifiable on the part of an organization to have eco-friendly practices when the company's bottom line is being ravaged. Enterprises should strike a balance between these two dimensions. Thus, we classify the "total expected cost" into two, viz., "Total expected environmental" costs and "Total expected product recovery" costs.

"Total expected environmental costs" is the summation of all the costs that is expected by the organization to incur for environmental conformance with respect to a given disposition option DO_i. "Total expected product recovery costs" is the summation of all the costs that goes in making the disposition strategy happen that excludes the environmental costs. The summation of both these costs gives the total expected cost of implementing a DO_i. This is given in Equation 4.7 below.

Total expected cost of implementing DO_i =

Total Expected Environmental costs for DO_i +

Total Expected Product Recovery costs for DO_i ……………………… Eq. 4.7

<u>Expected Recovery Value of DO_i:</u>

The expected recovery value of a given disposition is the amount that is expected to be recovered by choosing an option. Estimating this parameter is quite difficult because a lot of factors go into determining the money that can be recovered or realized. Some of the factors include buyer's need, demand in secondary markets etc, highly variable reprocessing costs etc.

Decision: After having evaluated the three components of the score, they are plugged in Eq.1 for all possible disposition options that are mentioned in the framework. The disposition option with the minimal score is selected for disposition for that particular return.

The organization has to perform a detailed activity based costing to have a good estimate of the various costs that will be incurred in a given disposition option. This is illustrated in the next section. It is to be noted here that most of the costs are estimates of the actual costs because until the strategy is implemented, it is difficult for the organization to accurately predict the costs. It is suggested that the organization maintain a database of all these expected cost numbers and use this "historical information" to feed the scoring model in the future. This will ensure more accurate estimation of the model parameters.

4.3 Goal 3

4.3.1 Methodology

The previous two goals dealt with strategies for products that have entered the RSC in one form or the other. An equally important aspect in the design of RSCs is to make sure that the number of returns is minimal in the future. This is a continuous improvement initiative that requires support from all the major players in the supply chain. The idea is that that any one of the supply chain actors will be responsible for initiating the returns in the first place. In other words, that particular supply chain actor is the reason for the product to enter the RSC. Now, based on this, returns are classified according to the supply chain actor who is responsible for the returns. In this research, typical supply chain actors namely the producer / manufacturer, transporter, seller, and consumer are considered. The returns originated by each of them are considered in detail in this sub – section.

4.3.1.1 Producer

The term "producer" and "manufacturer" are used interchangeably to mean the supply chain actor who gets the raw materials from the supplier to transform the product to a usable form. The various reasons that make the producer an initiator of returns are illustrated in the form of a fish – bone chart in Figure 4.9. Each one of them is discussed below:

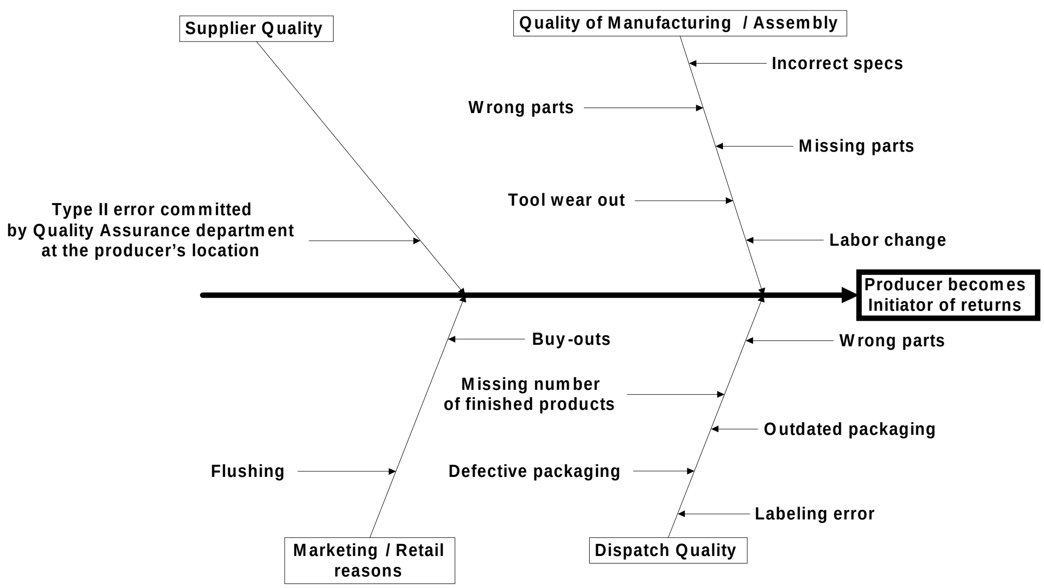

Figure 4.9 Return Reasons with respect to producer / manufacturer

The four possible primary reasons that make producer the "initiator" of returns include supplier quality, quality of manufacturing / assembly, dispatch quality and marketing/retail reasons. The first three reasons occur randomly and are not motivated by the producer at any cost. However, the marketing and retail reasons include all the activities that the producer makes deliberately for a secondary cause.

(i) Supplier Quality

The supplier of raw materials is one of the foremost upstream supply chain actors. Any discrepancy in the quality of incoming product may have a ripple effect across the entire supply chain. Proper care should be undertaken by the supplier to reduce non-conforming products and by the producer in filtering such products to pass through the downstream chain. Thus we are more concerned at the probability of error made by the "Quality Assurance" department at the producer's facility in accepting a faulty product from the supplier. This particular faulty component from the supplier may be transmitted throughout the FSC until the end customer discovers that something is wrong. It is not uncommon to discover this at the downstream of the supply chain because of the inherent complexities involved in the product circuitries. This forces the end customer to return the final product upstream. The type II error committed by the producer may be due to improper sampling procedure or lack of a proper filtering system in place at the producer's facility.

(ii) Quality of Manufacturing / Assembly: The errors involved in the internal production function within the producer's location reflect directly on the quality of the outgoing product. The primary reasons include (1) missing parts (2) incorrect parts (3) incorrect specs (4) tool wear out (5) labor change. All these above mentioned variables act independently or interact with one another to confound the process variability. This can have a significant effect on the quality of the final output of the product coming out of the manufacturing facility.

(iii) Dispatch Quality: It refers to the error committed by the packaging department within the manufacturer's location. This can be attributed to (1) incorrect parts (2) missing number of products (3) outdated packaging (4) defective packaging and (5) labeling error. This also includes transport if transportation is not outsourced to a Third Party Logistics (3PL) provider.

Suggestions: Table 4.5 below gives the primary and the secondary reasons along with the suggestions. The suggestions are mainly given from strategic and tactical perspective. We believe translating these to operational ones need to be done on a case by case basis. The operations department in the organization should tailor these suggestions by setting operational objectives, targets, measures and controls.

Table 4.5 Producer's matrix of suggestions and costs-benefits

REASONS	**SUGGESTIONS**	**COSTS**	**BENEFITS**

1.*Supplier Quality* (Type II error committed by the Quality Assurance department at the producer's location)	• Switching to better sampling plan
	• Increase education and training of the organization personnel
	• Promote industry cooperative efforts
	• Improved technologies
	  • RFID
	  • Bar coding
		• Sampling costs
		• Investment infrastructure in education and technologies
			• Reduction in COGS
			• Reduction in RL cost
			• Reduction in type II error

2. *Quality of Mfg /Assembly*
• Incorrect specs
• Missing parts
• Wrong parts
• Tool wear out
• Labor change
	• Lean, 5S,
	• Poka-yoke
	• Visual representation techniques
	• 6σ training
		• Investment infrastructure costs in
		  • Labor
		  • Technology
		  • Training
		  • Education
			• Reduced process variability
			• Reduced manufacturing returns

Table 4.5 Continued

3. *Dispatch Quality*
• Labeling error
• Defective packaging
• Missing # of products
• Wrong parts
	• Improved packing technology
	• Optimized packing*
	• Final packing list check up against an ERP software output
	• Poka – yoke
	• Visual representation techniques
		• Investment infrastructure costs in
		  • Packing technology software
		  • Machines
			• Reduced labor costs
			• Reduced shipping errors
			• Better customer perception of the organization's product

Optimized Packing*: It is important to figure out the correct carton size for the packing. An under-sized carton will make the packer to squeeze in the final products which may lead to defective packaging. Or the packer might loose time in getting the correct carton size that adds to the productivity loss. An over-sized carton might not be cost-efficient. It can also lead to packing voids that leads to "damaged goods in transit". This can be rectified by figuring out the correct packing size. There are many softwares available in the market to do this. The organization can invest in them or could possibly a packing algorithm to be integrated in its shipping process.

4.3.1.2 Transporter

The term “transporter” is used to refer to the third party organization that is responsible for the physical distribution / transportation of goods. They are more commonly referred to as the Third Party Logistics (3PL) service providers.

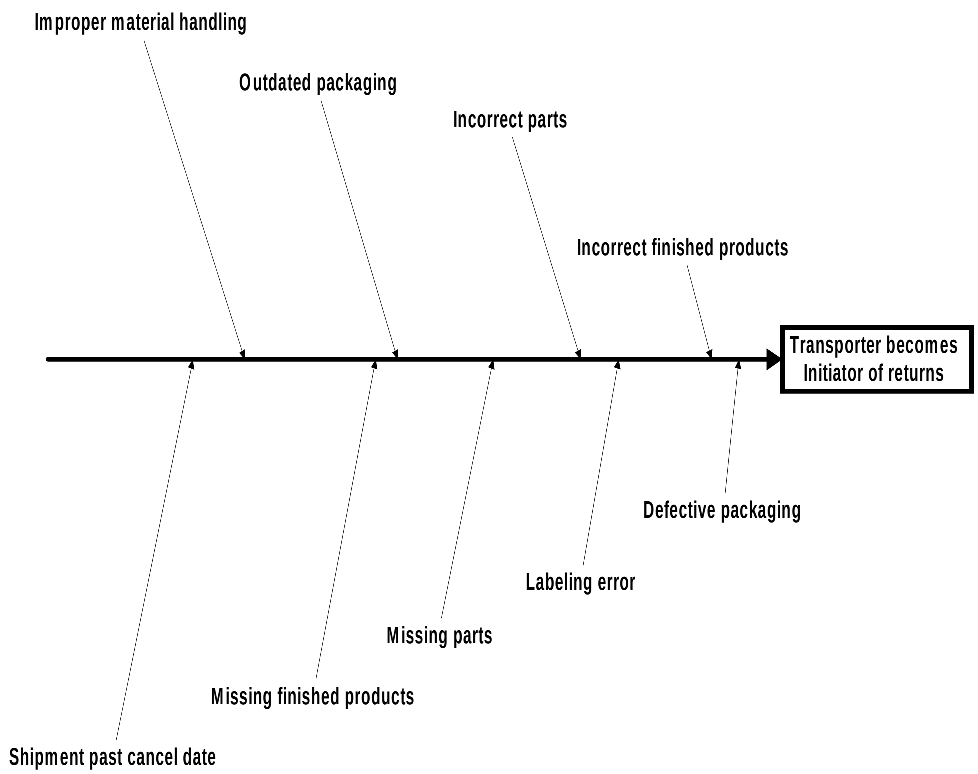

Figure 4.10 Return Reasons with respect to Transporter

Figure 4.10 details out the various primary reasons, from a 3PL perspective, that makes the “transporter” as the initiator of returns. The two main reasons that are important include (i) shipment past cancel date and (ii) improper material handling. These are the two classic cases of a transporter that every transporter seeks to reduce.

(i) Shipments past cancel date: Typically, the contract between a 3PL and an organization makes the transporter financially responsible for the returns. This delay on behalf of the transporter may be classified into two types namely, internal and external. While "internal" reasons include all those activities that are initiated within the transporter organization, "external" factors are governed by forces outside the supply chain. Typical internal factors include: improper planning in Full Track load (FTL) assignments, lack of proper route scheduling / sequencing techniques, labor shortage, resources shortage, system error and communication error. Typical external factors include: legislation acts, fall in economy and other macro economical variables. The focus is on the "internal" reasons in this research. Some of the suggestions include: investment in travel optimization softwares, labor and resources scheduling methods and updating the EDI system within the transporter organization to reflect the latest and dynamic of scenarios.

(ii) Improper material handling: This arises from lack of sophisticated material handling equipments for transporting products. The 3PL service provider will have to perform a capability evaluation checklist to address if he is really capable of handling the client needs. One of the most common quoted reasons for the failure of the 3PL – client relationship is that the 3PL agrees to do whatever the client demands without performing a capability analysis. For example, the 3PL may not be capable enough to handle the holiday season load or may not have the specialized material handling devices needed for high valued products. Hence, as a suggestive measure, the transporter is recommended to perform a capability evaluation to make sure that any slight chance of improper material handling does not happen in the future. Some of the key questions that need to be addressed include:

(i) What is the maximum number of carriers that can be added?

(ii) What is the maximum number of drivers that can be added?

(iii) What additional mode of transportation would be necessary?

(iv) What special storage requirements would be needed in the warehouse?

(v) How often do we need the automatic sorting and collection equipment?

Since the rest of the return reasons have been discussed in the previous section, a checklist that a transporter need to check each time in a chronological order is given so that the transporter does not become the initiator of returns.

(i) Check for the correct parts

(ii) Check for the correct number of parts

(iii) Check for the correct finished goods product

(iv) Check for the correct number of finished goods product

(v) Check for correct packaging

(vi) Check for the labels against the product to eliminate labeling error

(vii) Check packing list before shipping

4.3.1.3 Seller

The term “seller” is used to refer to the wholesaler or the retailer who is typically the last link in the supply chain before the end consumer.

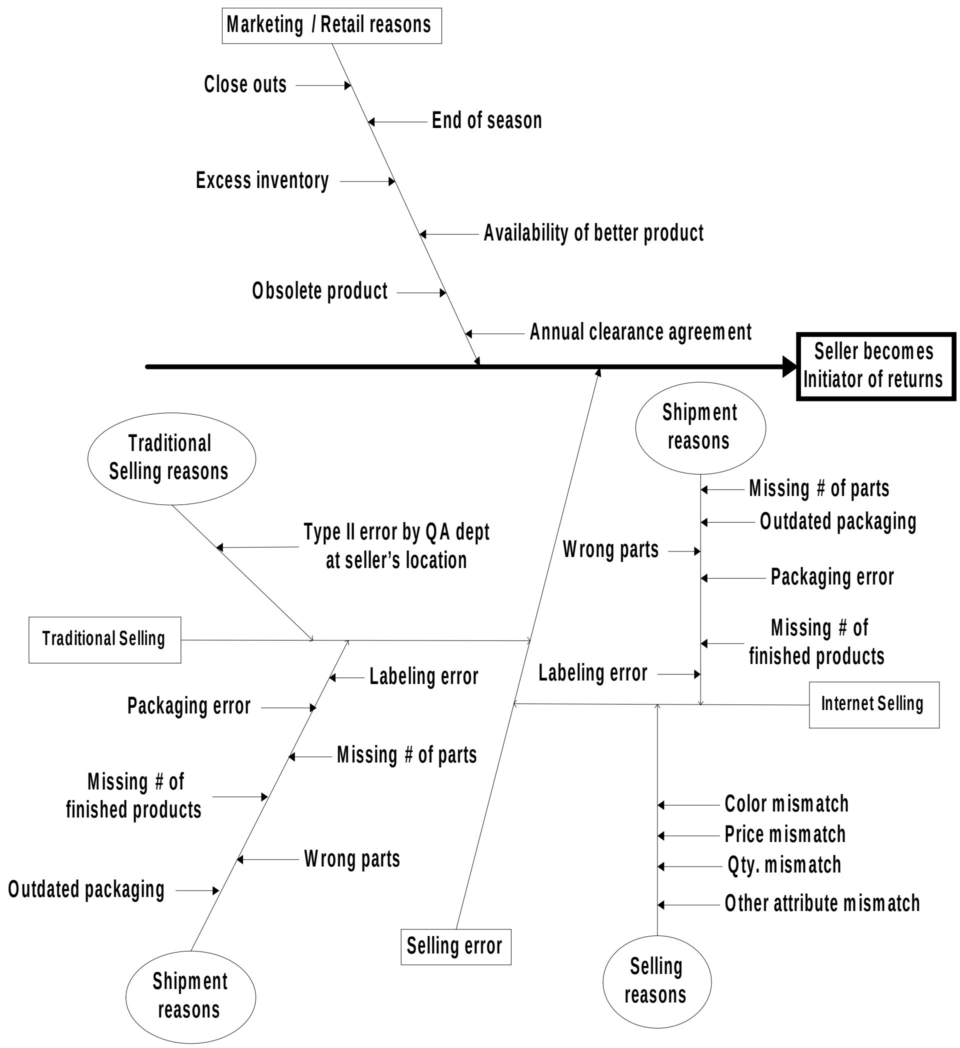

Figure 4.11 Return Reasons with respect to seller

In Figure 4.11, there are two primary reasons that make the "seller" as the initiator of returns. They are "Marketing / Retail" reasons and "Selling error". As discussed earlier, most of the "marketing / retail" secondary reasons are deliberately undertaken by the concerned supply chain actor for a secondary cause. However, there is one secondary reason that is not deliberate, yet not motivated by the seller, namely "availability of better product". They are classified / grouped them in this category because if the organization is not market reactive, its product will soon be outwitted by a better product in terms of price, quality and other popular consumer attributes. Hence, lack of initiative to introduce better products, or slow market launch time for new products is also seen as a reason that makes the seller to take back its old products inventory. The company would plan to do concurrent engineering methods to reduce the market introduction time.

The other primary reason, namely “selling error” can be classified into two secondary reasons: reasons associated with “traditional selling” and “internet selling”. “Traditional selling” is further classified into two tertiary types: “traditional selling error” and “shipment error”. “Traditional selling” reasons are associated with the type II error committed by the quality assurance department at the seller’s location. The common reasons for “shipment error” includes packaging error, missing number of parts, missing number of products, wrong products, labeling error, wrong and defective packaging, shipment past cancel date and material handling error. The suggestions for these kinds of reasons were discussed in the producers section. This section will be focused towards the reasons associated with “Internet selling”.

The reasons associated with internet selling can again be classified into two tertiary reasons like the traditional selling, namely “internet selling reasons” and “shipment reasons”. The internet selling reasons refers to the various mismatches between the attribute of the advertised product and the attribute of the actual product. The most common product attribute mismatches include color mismatch, price mismatch, quantity mismatch, quality mismatch, specifications mismatch.

Distributors indicated a moderate success in recovering assets and reducing inventory investment in their reverse logistics programs (Autry et al., 2001). Hence, any cost-effective method that blocks the product from entering the asset recovery process should be considered carefully. Hence, all the suggestions in this category are related to process improvements in electronic methods of retailing (e – tailing). Before advertisements are made online and public, product attributes of the advertised product and that of the actual product has to be verified by a concerned authority and be shipped to the web-posting department. In effect, there should be a quality check station before the final uploading section. The range of product attributes should be high so that precision is high. For e.g., the sellers system should have codes for different shades of blue to precisely match the actual color of the product. Of late, the number of products returned through online methods of purchasing have drastically went up. So every process improvement methods should be addressed for continuous improvement.

4.3.1.4 Consumer

The term "consumer" is used to refer to both the industrial customer as well as the residential customer. For product returns, a high percentage of returns come from customer returns. Surveys indicate that overall customer returns for general merchandise are estimated to be approximately 6%, although returns vary significantly by industry (Rogers and Tibben – Lembke, 1998. 2001).

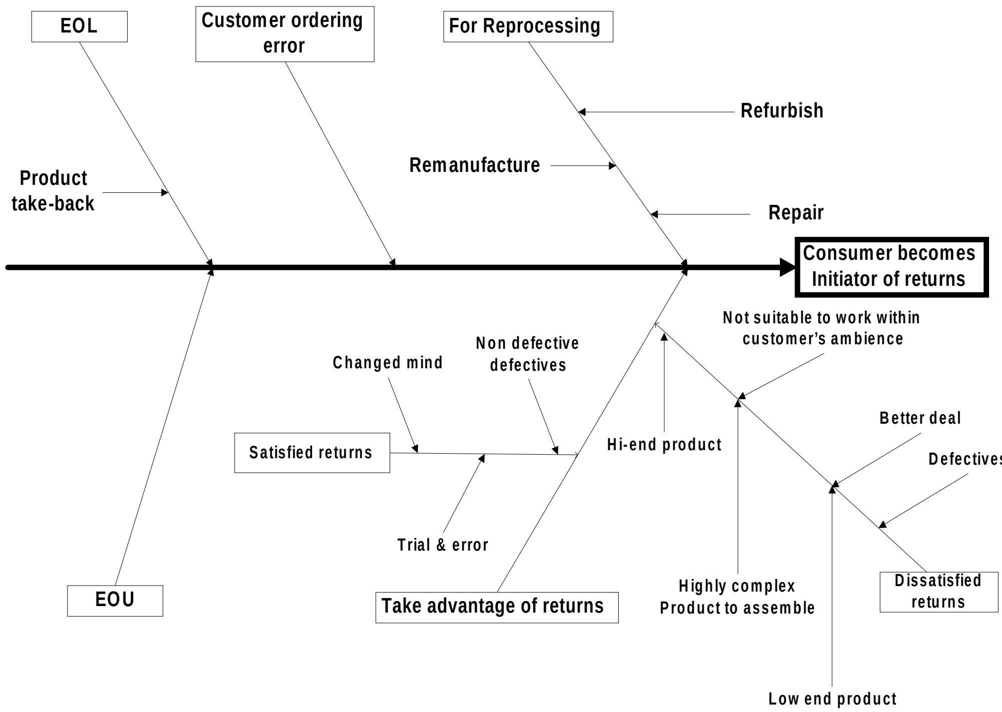

Figure 4.12 Return Reasons with respect to Consumer

Figure 4.12 shows five primary reasons for consumer becoming the initiator of returns. They are EOL, EOU, customer ordering error, "for reprocessing", and "take advantage of returns". The three reasons, "EOL", "EOU" and "For reprocessing" are expected to happen sometime during the product life cycle. EOL stands for End-of-Life that includes all products that have reached the end of their useful lives. EOU stands for End-of-Use that typically includes products that have reached their use period. The use period refers to the rental agreement period or lease period. The organizations can improve the design of the product so that the number of products that come to the RSC can be mitigated. However, these suggestions would be dealt in the engineering design department during the new product development or existing product modification stage.

Customers often end up with having dissatisfied products. The seller might think of (i) allowing free trial for all possible products before purchase (ii) Double checking the product attributes if the sale is through internet and (iii) Publicizing the option of allowing the upgrading feature. This will not only lead reduced future returns but will yield the following secondary benefits namely (i) higher customer retention (ii) higher future sales and (iii) improved customer image. “Dissatisfied returns” provides the company one vantage point to boost the corporate image because it deals directly with the end customer. Also, valuable insights from return reasons can be fed to the FSC to ensure that design problems do not pop up in future. The cost associated with it would be the extra cost of adding upgrading features. However, in the long run, this investment is likely to be overrun by the benefits listed above.

CHAPTER 5

REVISED METHODOLOGY

5.1 Demonstration of Methodology

The initial methodology was discussed in the previous chapter. The next major task in the dissertation work plan was to validate / demonstrate the initial / envisioned methodology using real time companies. This was done by collecting data from a couple of companies in the electronics industrial sector around the Dallas Fort Worth (DFW) metroplex.

5.1.1 Company Description

The two companies were referred to as Company A and Company B.

Company A: Company A was a leading distributor of information technology products with more than 90,000 customers in over 100 countries. Its core business is worldwide logistics management of electronic products with more than 20 fulfillment centers in the U.S., Canada, Latin America, Europe and the Middle East. Ranked in top 200 in the Fortune 500 list, the company's business model enables technology solution providers, manufacturers, and publishers to cost – effectively sell to and support end users ranging from small – to – mid sized businesses (SMB) to large enterprises. The company provides its customers with leading product from over 1,000 manufacturers and publishers in the following product divisions namely components, networking, peripherals, software and systems. Some of the product categories include computer components, digital cameras, networking, peripherals, power devices, software, storage, supplies and accessories, systems and telephony. It sells to qualified computer resellers and retailers.

From ten employees and $2 million in sales in 1983 to 8,400 employees today and sales of over $19.8 billion for the fiscal year ended Jan. 31, 2005, Company A has emerged as the industry's best-performing provider of IT products, logistics management and other value-added services. The company has evolved its business from a "pick, pack and ship" operation into an "integrated supply chain specialist" model where technology makers and sellers rely on Company A as an outsource partner. While continually expanding its offering of vital industry services such as technical support, education and custom configuration, the company has also successfully expanded into international markets throughout the world.

In 1992, the customer base of 25,000 was comprised largely of value-added resellers (VARs), corporate resellers and franchisees. In 2006, it serves more than 100,000 customers including ASPs, ISPs, Web Integrators, VARs, corporate resellers, systems integrators, system builders, government resellers, exporters, retailers, e-tailers, direct marketers, catalogers, and Internet resellers. The Company has developed many specialized programs and business units to help ensure its continued success in both new and traditional business channels.

Company B: Company B has been one of the world's top ten semi conductor suppliers since 1999. It has close to 50, 000 employees, 16 advanced research and development units, 39 design and application centers, 15 main manufacturing sites and 78 sales offices in 36 countries. The Company's sales are well balanced between the industry's five major high – growth sectors: Communications (38 %), Consumer (16%0, Computer (17%), Automotive (15%) and Industrial (14%). It is the one of the top companies in the world in developing and delivering semiconductor solutions across the spectrum of microelectronics applications. Company B produces one of the industry's broadest ranges of semiconductor products, from discrete diodes and transistors through complex System-on-Chip (SoC) devices to complete platform solutions, or Systems-above-Chip (SaC) that bundle chips with reference designs, application software, and manufacturing tools and specifications. Company B is a major supplier to every industry segment, combining its broad range of leading-edge technologies with a rich pool of Intellectual Property (IP) resources and world-class manufacturing machine. Examples of standard products include discrete devices such as transistors, diodes, and thyristors, power transistors such as MOSFETs, bipolars, and IGBTs, analog circuit building blocks such as op amps, comparators, voltage regulators and references, standard logic functions and interfaces, many memory products such as Flash NOR standard or serial, NAND Flash, EPROM/EEPROM, or non-volatile RAM, RF discretes and ICs.

5.1.2 Method of Data collection

The method of data collection was by means of in-depth interviews (IDI) with organization personnel. The interview process consisted of a single session with the Logistics Manager and Production Control Manager of Company A and Company B respectively. Each session lasted for about 3 hrs. The interview was guided by a questionnaire that is attached in appendices A, B and C. The questionnaire was developed in such a way that all the key technical terms are defined clearly before proceeding to another topic. Sometimes, the question was explained in a way that was comprehensible to the interviewee. The same questionnaire was used for both the companies to ensure consistency in the data to be collected.

To be specific, for each of the three goals of the objective, the following information was garnered. The related topics in each of the three goals are given below:

Topic areas in Goal 1:

(i) Identification of the list of relevant supply chain actors in the company.

(ii) Identification of the product flows.

(iii) Determination of the entry and exit points of RSC.

(iv) Determination of the operations between RSC_{entry} and RSC_{exit}.

(v) Determination of standard times for tasks.

(vi) Development and determination of RSC parameters.

(vii) Development of process improvement techniques.

Topic areas in Goal 2:

(i) Identification of the type of returns.

(ii) Identification of the type of disposition options

(iii) Definition of Returns Tracking Unit (RTU)

(iv) Determination of drivers for "Value of RTU (RTU)".

(v) Determination of drivers for "Total Expected Value of Recovery".

(vi) Determination of drivers for "Total expected cost of implementing the disposition option".

Topic areas in Goal 3:

(i) Determination of the possible primary, secondary and the associate tertiary return reasons, if any.

(ii) Development of fool-proof methods to avoid the return

(iii) Determination of costs and benefits of methods.

5.2 Revised Methodology

The interview process exposed some of the issues in the methodology. The suggestions from the industry experts was taken, analyzed for practicality and fitted into the final methodology. In addition, during the course of the interview, there were some discrepancies which needed to be modified and / or fine – tuned. Those were also taken into account in the final revised methodology. This section talks about the final methodology that the organization could use to design their RL processes. There is an implementation guideline that is attached in the "Appendix D" that guides the implementation of each and every step given in the revised methodology.

5.2.1 Goal 1

Step 1: Identify the relevant supply chain actors in "closed – loop" supply chain: The actors in the closed-loop chain are segregated into three based upon their functionalities. As mentioned earlier, a closed – loop supply chain includes both a forward supply chain (FSC) and a reverse supply chain (RSC). The FSC actors are classified into three types. The first type is called the "traditional" that includes but are not limited the following actors: raw material suppliers, wholesaler, retailer and customer. The second category is called the "facilitator" whose function is to facilitate one / more aspect of the supply chain. Typical examples include "third party service providers" that specialize in activities like warehousing, transportation, inventory management, accounting, customs brokerage, freight forwarding, export packaging, export and import management etc. The third category is termed the "reverse supply chain experts" that includes all actors that specialize in RSC activities. Some examples include secondary market players, liquidators, actors who specialize in remanufacturing, repair, refurbishing, recycling, land-filling so on and so forth. The task here is to identify all the possible supply chain actors in each category that an organization has to deal with. Refer Implementation Guideline 1.1 (IG 1.1).

Step 2: Form the "closed-loop" network structure (similar to Figure 5.1) that takes the worst-case scenario of the product and information flow: In the previous step, some of the typical supply chain actors were identified. In this step, it is suggested that the organization map out those actors with the product and information flow between then. A typical figure is illustrated in Figure. 5.1. However, the organizations will have to modify the figure to suit their list of actors and the associated product and information flow among them. The key point to be noted in the step is that the organization has to make sure that the longest possible path a product can take in the closed loop supply chain is included in the network structure. This will be regarded as the worst – case scenario in which the product is handled by the maximum number of supply chain actors. By longest possible path, it is **not** meant to reflect the geographical distances between the various supply chain actors. The notion of the longest path in the supply chain was developed to consider the maximum number of supply chain actors. This multiple handling of product various actors adds a lot of complexity in the chain. Refer IG 1.2.

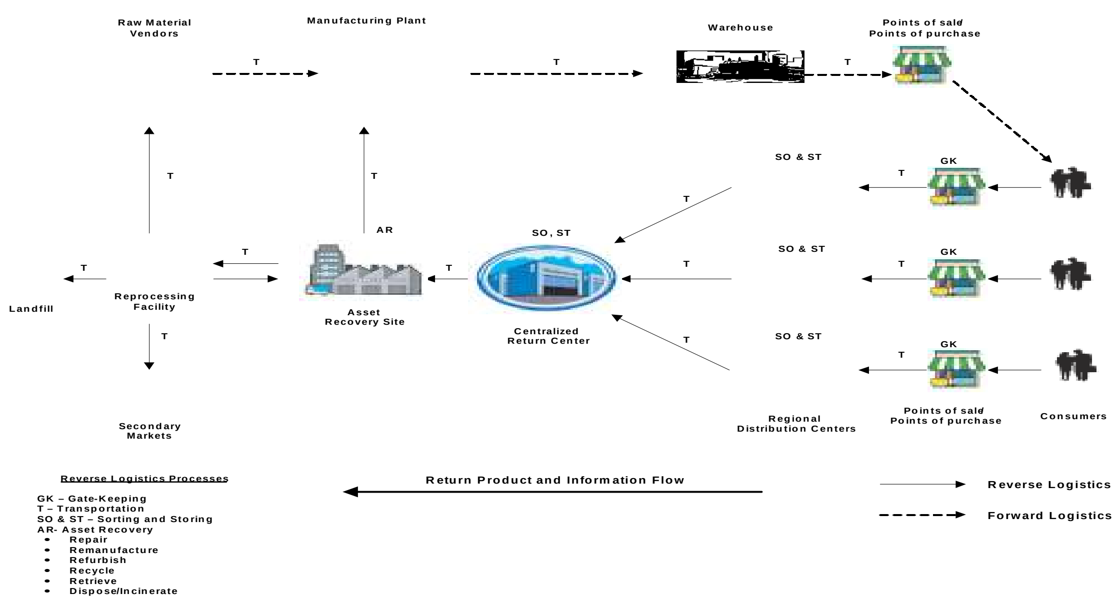

Figure 5.1 Supply Chain Actors

Step 3: Define the RSC_{entry} and RSC_{exit} points: This step is to identify where the RSC operations begin (RSC_{entry}) and end (RSC_{exit}). RSC operations typically begin at gate-keeping and end at different places depending upon the action chosen by the AR stage (refer Figure 5.1). However, it is recommended to identify the earliest RSC entry node and the latest RSC exit points that will be consistent with the longest node assumption. To restate the assumptions, the idea in this network is account for the maximum number of supply chain actors in a given closed loop supply chain. In other words, this "maximum node" structure would take into account the worst case scenario where the product and the information have to flow through the maximum number of points in the closed-loop supply chain. For example, products may actually reach the AR center after GK without even passing through the regional distribution centers (RDC) and the centralized return centers (CRC). But the "maximum node" assumption was developed to account for any product and information flow involving the RDCs and the CRCs that may happen anytime in the future. Refer IG 1.3.

Step 4: Identify the activities involved for each operation between RSC_{entry} and RSC_{exit}: Firstly, the organization should identify the various operations between an RSC_{entry} and RSC_{exit}. After identifying the operations between RSC_{entry} and RSC_{exit}, for each RSC operation, the organization will have to identify the list of activities that typically happen in it. The list of activity might differ depending upon on the RTU. But the purpose of this research, it is suggested to include all possible activities within a given RSC operation. Refer Figure 1.4.

Step 5: For a given RTU and for the first RSC operation, develop a "process flow chart"*:* Develop a "Process Flow Chart" to classify the activities involved in it into "operations", "storage", "inspection", "transportation", "decision", "delay" and "value recovery": The first five categories are typical of a process flow chart. In addition to it, a new category is introduced called the "Value Recovery". The "Value Recovery" category is different from the "operation" category. While the essence of all "value recovery" activities would be to recover as much value as possible for a given RTU, the latter is just any other activity that is needed to complete the RSC operation. The motive behind "Value Recovery" category is to figure out the number of actual "value recovery" activities and the associated time taken. This piece of information will be useful in developing methods to reduce "cycle time of value recovery".

The task now is to document the "Observed time (OT)" for performing a particular activity. After this, the "standard time (ST)" should be figure out based on the OT. Refer to "Process flow chart" in Table 1. While the OT is the actual time taken to perform a task in a given instance it does not take into account the operator allowances etc. Hence, we recommend calculating the ST from the OT. Refer IG 1.5.

Step 6: Identify the list of possible activities that can be classified in the "Value Recovery" category.

For a given RTU and a given RSC operation, typically there might be a number of activities. However, there are only a few among them that can be classified as a "Value Recovery" activity. These "Value Recovery" activities typically include all asset recovery activities. The consideration here is that only the "asset recovery" activity adds value to the process. The rest of the activities could be reduced as a part of the continuous process initiative or in an ideal situation could be eliminated. This is in a way analogous to the differentiation between "Value Added Time (VAT) activity" and

“Non-value added activity in the FSC. Value added activity is one for which the customer pays while for all the other activities (non-value added), the customer is not willing to pay. On a similar note, the reasoning is that only the asset recovery operation is the operation which is instrumental in recovering value from the RTU. Though all the other operations are still needed for the successful asset recovery, they are considered to be supporting operations and consequently non-value added. Hence, there is a great deal of potential in saving time in those operations. Refer IG 1.6. A sample “Process flow chart” is illustrated in Table 5.1.

Table 5.1 Process Flow Chart

RSC OPERATION: Gate keeping
RTU: ABC123

DATE: April 4, 2006
TIME: 11:31:05 PM

Process Categories →	**Operation**		**Storage**		**Decision**		**Inspect**		**Delay**		**Transport**		**Value Recovery**	
Activity ↓	*OT*	*ST*	*OT*	*ST*	*OT*	*ST*	*OT*	*ST*	OT	ST	OT	ST	OT	ST
Inspect documents														
Check for completeness														
Return to customer if not complete														
Check for warranty														
Return to customer if not ok														
Check for product characteristics														
Return to customer if not ok														
Credit customer														
Sort RTU’s														
Pack the products														
Move to store location														
Store														
Issue RMA														

ST_i 5 10 6 7 8 9 2

The calculations are shown in the following page.

Step 7: Calculate the ST of various process categories: In this step, excluding the "value recovery" category, the task here is to sum the STs of all the process categories. This will give the ST of the particular RSC operation. Label them as ST_{RSC1}. Now, sum the STs of "value recovery" activities to get the standard time of value recovery. Label it as $STVR_{RSC1}$. These are given in Eq. 5.1 and 5.2. respectively.

$ST_{RSC1} = \sum ST_i$ (i = "Operation" to "Transport". Value recovery is not to be included) .... *Eq. 5.1.*

$STVR_{RSC1} = \sum$ ST of all activities in "Value Recovery" category............. *Eq. 5.2*

Step 8: Calculate ST for the rest of RSC operations: For the same RTU, repeat step 5 thro 7 for the rest of RSC operations between RSC_{entry} and RSC_{exit}. Doing this will yield ST_{RSC1}, ST_{RSC2} … ST_{RSCn} and $STVR_{RSC1}$, $STVR_{RSC2}$ … $STVR_{RSCn}$.

Step 9: Calculate the "initial" time parameters: There are certain parameters related to time that are introduced in this research. They are used to calculate the final time parameters that are discussed later discussed below.

i) Total time taken by RTU_1 to traverse the RSC: This is labeled as $\mathbf{TT_{RTU1}}$ and is calculated using the following equation (Eq. 5.3.).

$TT_{RTU1} = \sum (ST_{RSC1} + ST_{RSC2} + \ldots ST_{RSCn} + STVR_{RSC1} + STVR_{RSC2} + \ldots STVR_{RSCn})$... *Eq. 5.3.*

ii) Value Recovery Time of RTU_1: This is labeled as $\mathbf{VRT_{RTU1}}$ and is calculated using the following equation (Eq. 5.4.)

$VRT_{RTU1} = \sum (STVR_{RSC1} + STVR_{RSC2} + \ldots STVR_{RSCn})$.............................. *Eq.5.4.*

Similarly calculate VRT_{RTU2} VRT_{RTU3} VRT_{RTU4} ……… VRT_{RTUn}.

Step 10: Perform steps 5 through 9 for all RTUs: It is recommended to perform the steps from 5 though 9 for all RTUs for a significant period of time. The word "significant" is used in a subjective fashion and is dependent upon the return pattern attributes like the average returns per unit time, seasonality etc. The motive behind this step is to get a good profile of the reverse logistics flows in the organization. Typically, it is recommended to use anywhere from month to 3 months to gain a good profile. The idea here is to use a time frame that captures the steady state condition rather than the anomalies. Refer IG 1.10

Step 11: Calculate the following "final" time parameters: Based on the process flow chart calculations, the following parameters are to be calculated.

(i) Average Total Time (Avg. TT): This is the average of TT for all RTUs for the given time period under consideration. Refer Eq. 5.5 and Eq. 5.6.

$TT_{RTU1} = \sum (ST_{RSC1} + ST_{RSC2,} + \ldots + ST_{RSCn} + STVR_{RSC1} + STVR_{RSC2} + STVR_{RSCn})$ .... *Eq.5.5.*

Avg. $TT = \text{Average}(TT_{RTU1}, TT_{RTU2} \ldots TT_{RTUn})$..................................... *Eq. 5.6*

(ii) Average Value Recovery Time (Avg. VRT): This is the average of the VRTs of the various RTUs in the same time period. Refer Eq. 5.7 and Eq. 5.8.

$VRT_{RTU1} = \sum (STVR_{RSC1} + STVR_{RSC2} + STVR_{RSCn})$................................ *Eq.5.7.*

Avg. $VRT = \text{Avg.}(VRT_{RTU1}, VRT_{RTU2} \ldots VRT_{RTUn})$.............................. *Eq.5.8.*

(iii) Time Efficiency (T.E): This parameter is similar to the concept of Lean ratio in the FSC that is given by dividing VAT by the total time taken. This is given by the following formula in Eq. 5.9

T.E = Avg. VRT / Avg. TT.. *Eq.5.9.*

(iv) Non-Value Recovery Time (NVRT): This is the total time that is spent on all activities excluding the VRT. Hence it is given by Eq. 5.10.

NVRT = Avg. TT – Avg. VRT... *Eq.5.10.*

(v)Average Standard Time of process categories (Avg. ST_i): For each of the various process categories listed in the process flow chart, we calculate the average standard time using Eq. 5.11.

Avg. ST of a given process category i =

Total ST of the process category i / # of RTUs under consideration in the given time period.. *Eq.5.11.*

Step 12: Work on continuous process improvements: Steps 1 through 11 described the procedure involved in measuring the cycle time of value recovery. Some key "time" parameters were developed and formulas were given to measure them too. Now, with these parameters, some analyses are suggested that would throw light on the various process parameters. This will be insightful as to where the bottlenecks are in the system. Based on this information, the organization can device further continuous improvement techniques based on the specific cases.

(i) Analyze the process parameters: It is recommended to perform the following analysis of the various parameters. The following figures are examples and do not represent any real time data.

(a) Average Standard Time of RSC operations

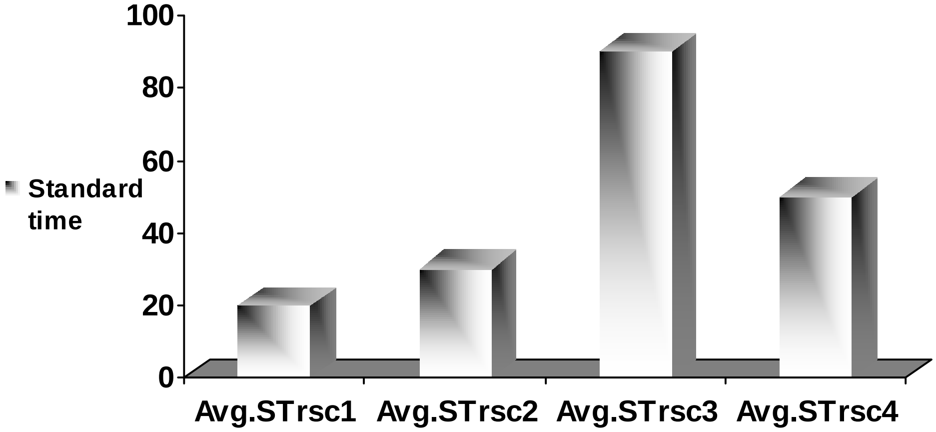

Figure 5.2 Standard times vs. RSC Operations

(b) Standard Times of RSC operations vs. RTUs:

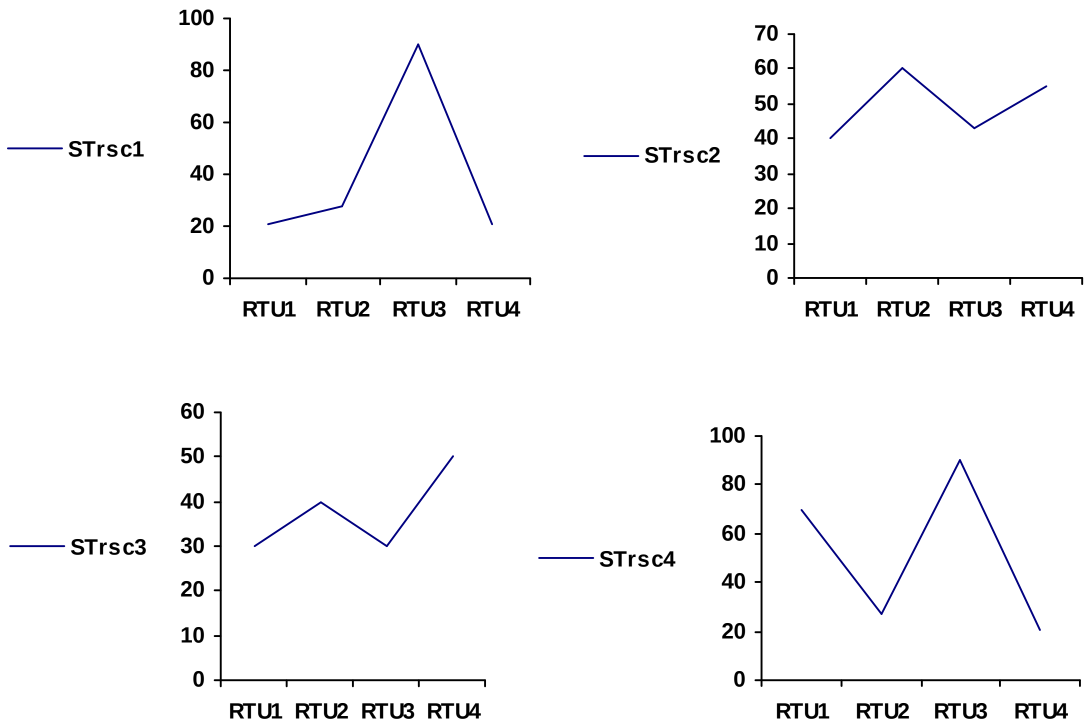

Figure 5.3 Standard Times vs. RTUs

(c) Total time vs. Value Recovery Time for RTUs

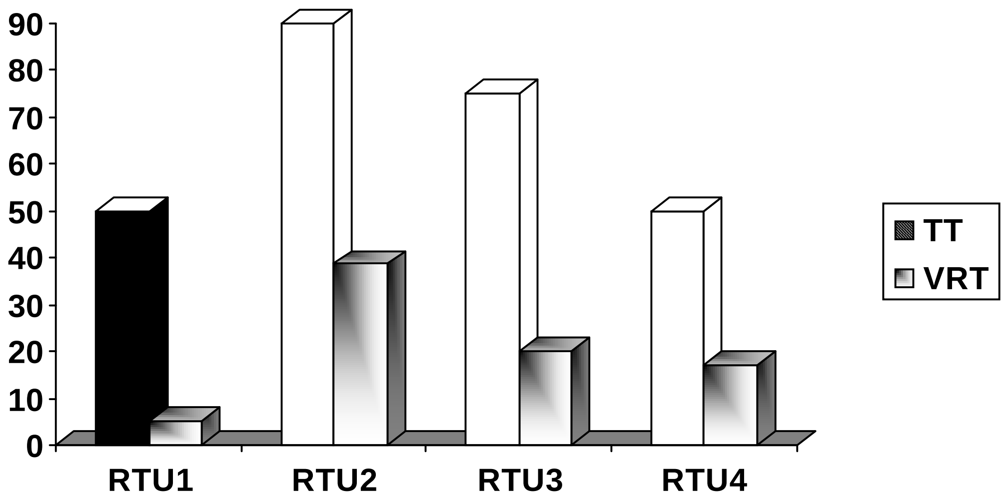

Figure 5.4 Total time and Value Recovery Time for RTUs

(d) Avg. Standard Time vs. Process Categories

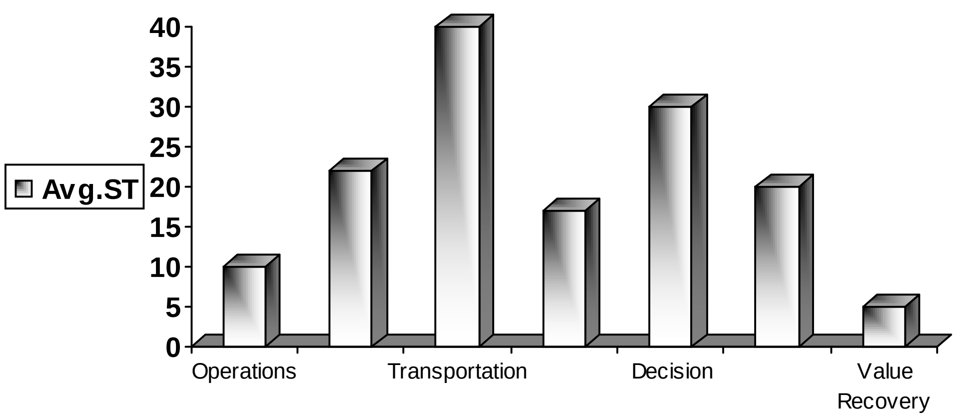

Figure 5.5 Standard times vs. RSC Operations

(e) Time Efficiency of RTUs

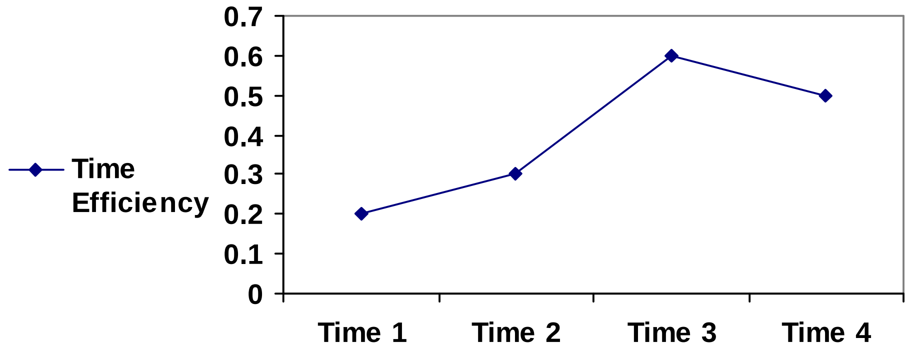

Figure 5.6 Time Efficiency of RTUs

A spider diagram that shows the present state and the target could be developed for each of the time parameters for continuous improvement. The setting of target should be done with consulting other stakeholders of the RSC operation. After the target is established, a Pareto analysis could be undertaken to focus our improvement initiatives. This could be followed by a root cause analysis. All this could possibly done in “quality circles”. The result of the quality circle should be to come up with an implementation plan to reach the target.

(ii**)** Return reasons at gate keeping site: Some of the companies have implemented this in their gate keeping site. The idea behind this to classify and codify the return reasons so that it takes less time in the AR to pretest them.

(iii) Central pool of database that lists all RTUs: Often times, it is always advantageous to have an integrated database that lists all the available RTUs across different units of the same organization. This is one of the most obvious suggestions that have been overlooked by the companies. Successful implementation of this will make sure the asset is fully utilized in the organization.

(iv)Standardization of part numbers across different unit of the same organization: Some times, the same part will have different part numbers across different units of the same organization. When this is the case, it takes time to identify the specifications of the product for choosing the best disposition option. Hence we recommend having a standardized part numbering system in place.

(v) Incorporating Design for Disposability (DFX) capabilities: This is a strategic initiative that is driven mainly by the legislation. DFX means that the products should be designed in such a manner that it is ecologically safe and easier to dismantle and dispose. We believe that this will become more of a necessity than an option. The engineering and the design department should take into consideration the disposition issues while designing the product. While DFX is being practiced in some industries, there is still a large scope available for the supply chain engineers. DFX is practiced only in some countries in Europe, U.S and Japan. While in most of the other countries the concept is yet to realize its potential.

(vi)Demarcation between FSC and RSC items in warehouses: There should be clear demarcation between the FSC products and the RSC products that are stored in the same warehouse. The picking, kitting, packing and shipping of the wrong components, sub-assemblies will not only add to volume of returns but also to the higher value of the process parameters.

5.2.2 Goal 2

The second goal in the methodology deals with the "asset recovery (AR)" that forms the crux of the RL operations. It is the process in which typically, the disposition option for a given RTU is chosen and implemented. It acts as the engine of the RL system. The methodology developed here seeks to increase value that is derived from the asset recovery process per se.

Step 1: Devise the bases of classification scheme for returns: The basis of classification of returns is an important aspect in RL because a lot of crucial decisions are based on this information. There are quite a few ways of classifying returns that includes:

(i) Based on the value of the total shipment (Products and Packaging)

(ii) Based on the condition of the product (End-of-Life [EOL], End-of-Use [EOU] and Commercial)

(iii) Based on the reason for return (Close outs, Buy-outs, Job outs, Surplus, Defectives, Non-defectives and Salvage)

(iv) Based on the physical characteristics of the product (Metal, non-metal, cardboards, alloys etc)

(v) Based on the place from which the returns are shipped (Manufacturing returns, distribution returns, customer / user returns etc).

(vi) Based on the industry (electronic returns, textile returns, automobile returns etc).

(vii) Based on the type of product (Finished goods, sub assembly, loose components, machines, tools etc).

Step 2: Select the appropriate bases of classification: The next logical step is to select the basis of classification that needs to be adhered to. The answer to this depends on the specific returns problem the organization is faced with. Typically, "condition of product", "value of the total shipment" and "return reasons" are the three bases that will be widely used and more appropriate for considerations. The reason for this is that the disposition strategy does not vary if the returns are classified on the basis of industry, physical characteristics of the product or the place from which they are shipped. On the flip side, however, it might be highly relevant to some organizations that deal with a products from different kinds of industries (a distributor) or to an organization that deal with products of similar kind of products but with varying physical and chemical properties. In general, it is to be noted that, for the classification schemes that an organizations uses for its RL applications, the bases of classification need not be same for all levels. It should be consistent to reflect the fact that the disposition strategy varies across a given level in the classification scheme. For example, EOL and EOU items can be classified further into finished goods, sub-assemblies and loose components. But the available disposition options will not be affected by this extra classification scheme. Figure 5.7 depicts a sample classification scheme that has three most important levels that are based on (i) value of total shipment, (ii) product utilization and (iii) return reasons.

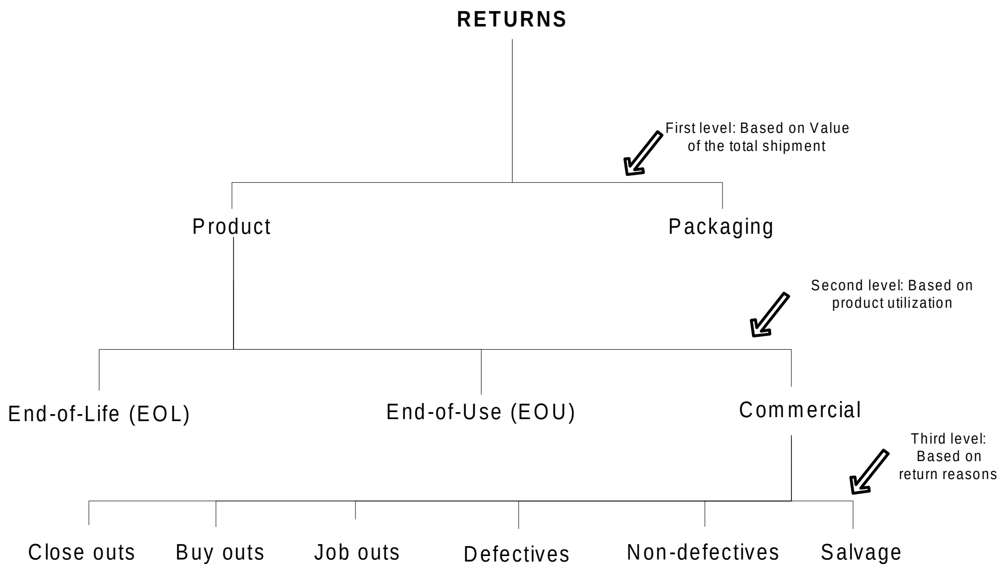

Figure 5.7 Classification Scheme for Returns

First – level: Based on "Value of the total shipment"

Returns across all industries are classified into two broad types viz., the "product returns" and "packaging returns". While the "product returns" represent the actual physical product that is being returned, the packaging returns include all the packaging materials and other accessories that go with the product. This is the fundamental or the first level of classification. This scope of this research paper lies within the "product" returns category.

Second – level: Based on product utilization

The "Product return" category is sub-divided into three major types: End-of-Life (EOL), End-of-Use (EOU) and "Commercial" items. As the name EOL suggests, these are the products that have reached the end of its useful life. Typically, EOL products are taken back from the market to avoid environmental or commercial damages (Krikke et al., 2004). EOU category includes the returns returned after some period of operations due to the end of the lease, trade-in, or product replacement (Krikke et al., 2004). Commercial returns are the returns that are linked to the sales process. Product warranties, product recalls and overstocks are some of the return reasons in this category. Another way to look at this is while EOL products typically are utilized so extensively that very little life is left, commercial returns are relatively not used. EOU products lie somewhere between these two extremes of spectrum.

Third – level: Based on return reason

"Commercial" returns are typically retail returns that include close-outs, job-outs, buy-outs, surplus, defectives, non-defectives and salvage items. Table 5.2 gives the attributes of each of these types.

Table 5.2 Type of Commercial Returns
(Adapted from Rogers and Tibben-Lembke, 1998)

Type	**Attributes**
Close-outs	First-quality items that the retailer has discontinued from its product mix. In such a case, the retailer may have decided to stop carrying products sold by a certain vendor, in a particular product line
Buy-outs	Occur where one manufacturer buys out a retailer's entire supply of a competitor's product. This purchase frees shelf space so that the manufacturer can put its product where the competitor's product was previously.
Job-outs	Job-outs have come to the end of their normal sales lives. These include seasonal products that are popular only during a certain time of the year.
Surplus	First quality items that the company has in excess but will continue to sell. The firm may have overestimated demand and ordered too many. It could also arise from inaccurate forecasts, minimum production quantity requirements and marketing returns.
Defe-ctives	Truly defective items. The reason for the defective may be any one the supply chain actor. Usually the stakeholder reimburses the buyer with a new product or makes financial adjustments.
Non-defectives	Often, a customer claims that a product is defective in order to return it, when, in fact, it is not defective.
Salvage	Have been used or damaged, and can no longer be sold as new. These items loose value relative to the amount use or damage. The most difficult part of managing salvage is determining its value.

Step 3: Figure out the Returns Tracking Unit.

After having classified the returns, the next step is to figure out the Returns Tracking Unit (RTU). The concept of RTU was explained in detail in Chapter 1. Any product entering the RL pipeline of an organization can be classified according to the seven bases of classification mentioned earlier. Each item entering the RL pipeline is coded according to the selected bases of classification. The complete code represents a RTU. A sample coding scheme for all basis of classification is give in Table 5.3.

Table 5.3 Coding Scheme for all basis of classification

#	**Based on**	**Levels**	**Codes**
1	Proportion of the value of shipment	Product, Packaging	PR, PA
2	Condition of the product	EOL, EOU, Commercial	L, U, C
3	Reason for return	Close-outs, Buy-outs, Job-outs, Surplus, Defectives, Non-defectives, Salvage, Other	C,B,J,SU,D,N,SL,O
4	Physical Characteristics	Metals, Non-metals, Alloys, Other	M,NM,A,O
5	Place from which the returns are shipped	Manufacturing returns, distribution returns, customer / end user returns, Other	M, D, E,O
6	Industry	Electronic, Automobile, Textile, Retail, Other	E,A,T,R,O
7	Type of product	Finished goods, sub-assembly, loose components, machines, tools	FG, SA, LC, M, T

This is an important information for the RL pipeline because it tells the organization most of the characteristics of a particular returned product in entering the RL pipeline. The more the number of basis used in an RTU, more the information it can store. An example of RTU could be “PR – U – O – Fabricator 142A”. This implies that this fabricating machine (Fabricator 142A) belongs to the “product” category, “end-of-use” type, falling into the “other” type of the return reason. Thus “PR – U – O – Fabricator 142A” is a RTU. In some cases, after the testing process is done, there might be more child RTUs from the parent RTUs. To give an example of this concept, say for example, an used computer is returned. At this point, it is an RTU which might be “PR-U-D-4100”. Now during the actual inspection during “asset recovery” stage later in the RL pipeline, it might be known that the CPU is a separate RTU by itself and the metal components are a separate RTU by itself. The disposition option varies for each of the two different child RTUs. In such cases, the details of the parent RTU should be attributed to the child RTU.

Step 4: Classify the disposition options

A comprehensive classification scheme for disposition options was developed. Figure 5.8 illustrates the classification scheme. There are three levels of classifying the options. They are as follows:

<u>First-level:</u>

There are three broad ways of classifying available disposition options including “Direct Recovery”, “Reprocessing” and “Other”. Direct Recovery deals with options that seek to recover value from a returned product without any actual physical processing involved. Reprocessing includes all options that involve treating materials in one form or the other to extract value. Apart from "Direct Recovery" and "Reprocessing", there is an "Other" category that includes all other means of asset recovery including scraping, donating to charity and land- filling. Usually in this category, there is very minimal value recovered.

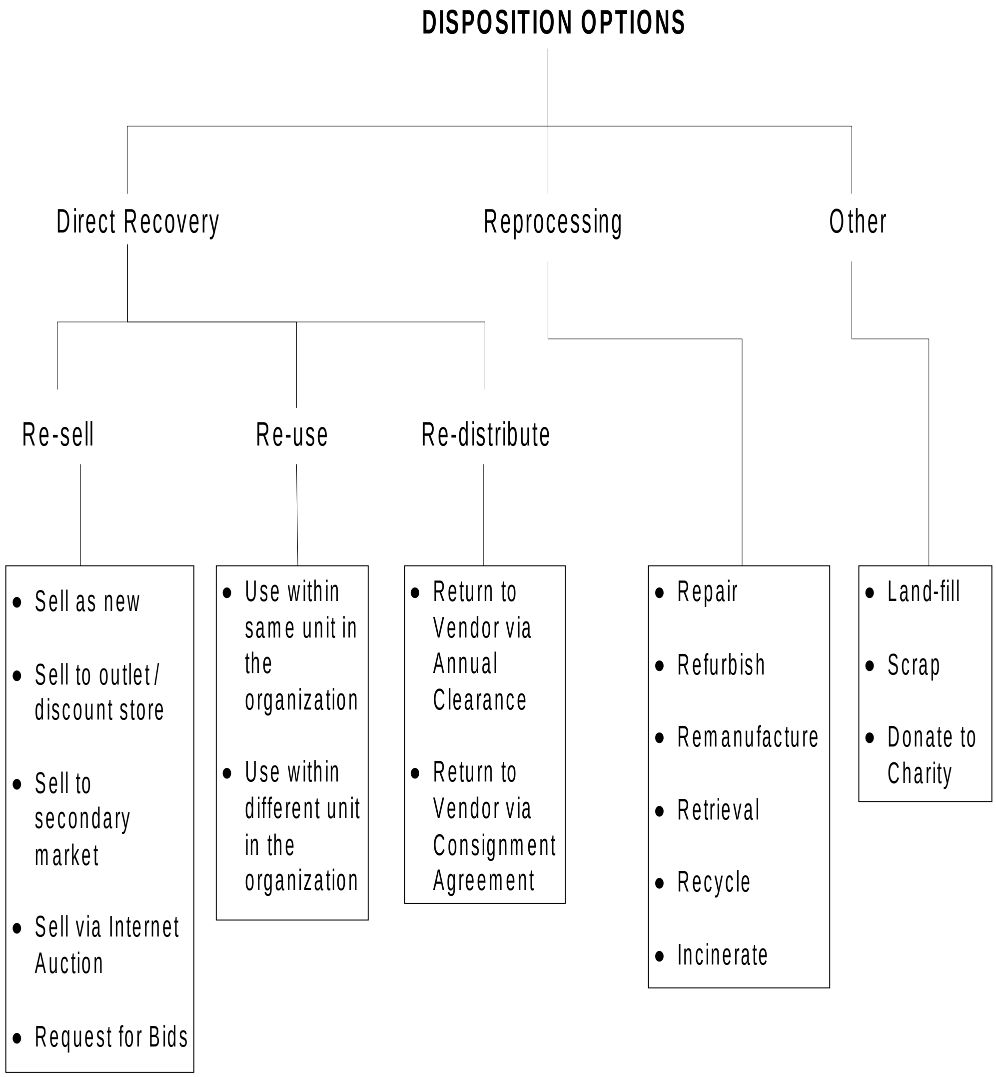

Figure 5.8 Classification scheme for disposition Options

Second-level:

Within “Direct Recovery” we classify the options into three types, viz., “Re-sell”, “Re-use” and “Re-distribute”. While “Re-selling” and “Re-use” are for stakeholders, “Re-distribute” options are for the buyer as it entails him to ship the products upstream to another supply chain actor via arrangements or contracts. However, the supply chain actor who receives the product becomes the stakeholder in this case and can choose any of the third-level disposition options available to him.

Third-level:

The third-level options ranges from “Sell as new” through “Donate to Charity”. Since, these options are quite straightforward, further explanation is not undertaken here.

Step 5: Map the disposition options and the return type: The developed classification scheme for returns and the disposition options should be tied up and represented. Refer the holistic framework in Table 5.4. The motive behind this framework is to suggest list of possible disposition options for any type of product return. Refer IG 2.5.

Table 5.4 Framework for Disposition Options

RETURN TYPE →			**COMMERCIAL**						
STRATEGY ↓	**EOL**	**EOU**	**Close-outs**	**Buy-outs**	**Job-outs**	**Surplus**	**Defectives**	**Non-defectives**	**Salvage**
Sell as new	×	×	✓	×	✓	✓	×	✓	×
Sell to outlet or discount store	×	×	✓	×	✓	✓	--	✓	×
Sell to secondary market	×	×	✓	×	✓	✓	--	✓	×
Sell via Internet Auction	×	✓	✓	×	✓	✓	×	✓	×
Request for Bids	×	✓	✓	×	✓	✓	×	✓	×
Use within same unit, same organization	✓	✓	×	×	×	×	×	×	×
Use within different unit, same organization	✓	✓	×	×	×	×	×	×	×
Return to Vendor – Annual Clearance agreement	×	×	✓	✓	✓	✓	✓	✓	✓
Return to Vendor – Consignment Agreement	×	×	✓	✓	✓	✓	✓	✓	✓
Repair	×	✓	×	×	×	×	✓	×	×
Refurbish	×	✓	×	×	×	×	✓	×	×
Remanufacture	×	✓	×	×	×	×	✓	×	×
Retrieval	✓	✓	✓	×	✓	✓	✓	✓	✓
Recycle	✓	✓	✓	✓	✓	✓	✓	✓	✓
Incinerate	✓	✓	✓	✓	✓	✓	✓	✓	✓
Land-fill	✓	✓	✓	✓	✓	✓	✓	✓	✓
Scrap	✓	✓	✓	✓	✓	✓	✓	✓	✓
Donate to Charity	✓	✓	✓	✓	✓	✓	×	✓	✓

-- Dependent upon the type of product/industry under consideration

Step 6: Evaluate the "Value of RTU under consideration: The methodology includes a "scoring model" that evaluates the various disposition option for a particular RTU and selects the best possible plausible option in terms of value recovered. The scoring model takes into consideration the two most important aspects of a RL system: cost and environment. The magnitude of the score for a given disposition option i (DO_i) is given in Equation 5.12. The score reflects the expected net loss of implementing a disposition option for a given RTU.

Score for Disposition $Option_i$ (DO_i) = S_i =

(Value of RTU under consideration) +

(Total expected cost of implementing DOi) **–**

(Expected Recovery Value of DO_i) …………………………………….. Eq.5.12

<u>Value of RTU:</u>

There are three parameters that need to be figured out in the calculation of a score for a disposition option and a given RTU. Firstly, the "Value of RTU under consideration" needs to be found out.

The motivation behind this parameter is to find the actual value / worth of the RTU. There may be a number of returned products entering the RL system of an organization. The organization needs to consider a single RTU each time it evaluates the options. Typically, if the manufacturer is the stakeholder, he can use the manufacturing cost of the product to reflect this parameter. If the RTU is capital equipment, he can estimate its present worth using depreciation methods. If it is a purchased part like a tool or any other accessories, he can use the purchase price. If the stakeholder is a retailer or a wholesaler, he can use the purchase price of the products. Hence this parameter varies based on the supply chain actor. It gives an approximation of the amount of money locked in this return. More details about how exactly to go about finding out this parameter are given in IG 2.6.

Step 7: Evaluate the "Total expected cost of implementing Disposition Option": As mentioned earlier, there are two aspects of a "closed-loop" supply chain that includes the dimensions of reverse logistics and green logistics. While the former, typically deals with the cost dimensionalities of the RSC system, the latter has to do with environmental issues. These two dimensions are very crucial in designing any closed-loop supply chain system. It does not do any good to have cost-efficient RL practices at the expense of environmental damage. Alternatively, it is also not justifiable on the part of an organization to have eco-friendly practices when the company's bottom line is being ravaged. Enterprises should strike a balance between these two dimensions. Thus, the "total expected cost" is classified into two parts namely, "Total expected environmental" costs and "Total expected product recovery" costs.

"Total expected environmental costs" is the summation of all the costs that is expected by the organization to incur for environmental conformance with respect to a given disposition option DO_i. "Total expected product recovery costs" is the summation of all the costs that goes in making the disposition strategy happen that excludes the environmental costs. The summation of both these costs gives the total expected cost of implementing a $DO_{i.}$ This is given in Equation 5.13 below. Refer IG 2.7 to get a clear picture of the various costs involved in these two types of costs.

Total expected cost of implementing DO_i = Total Expected Environmental costs for DO_i + Total Expected Product Recovery costs for DO_i …………………… Eq. 5.13.

Step 8: Evaluate the "Expected Recovery Value of Disposition Option: The expected recovery value of a given disposition is the amount that is expected to be recovered by choosing an option. Estimating this parameter is quite difficult because a lot of factors go into determining the money that can be recovered or realized. Some of the factors include buyer's need, demand in secondary markets etc, highly variable reprocessing costs etc. Refer IG 2.8 to figure out the various cost categories of this parameter.

Step 9: Repeat steps 6 though 8 for all possible disposition options: The process of estimating the parameters of the model will have to be repeated for various parameters.

Step 10: Decide on the option based on the score Decision: After having evaluated the three components of the score, they are plugged in Eq.5.12 for all possible disposition options that are mentioned in the framework. The disposition option with the minimal score is selected for disposition for that particular return.

The organization has to perform a detailed activity based costing to have a good estimate of the various costs that will be incurred in a given disposition option. It is to be noted here that most of the costs are estimates of the actual costs because until the strategy is implemented, it is difficult for the organization to accurately predict the costs. It is suggested that the organization maintain a database of all these expected cost numbers and use this "historical information" to feed the scoring model in the future. This will ensure more accurate estimation of the model parameters.

5.2.3 Goal 3

The previous two goals dealt with strategies for products that have entered the RSC in one form or the other. An equally important aspect in the design of RSCs is to make sure that the number of returns is minimal in the future. This is a continuous improvement initiative that requires support from all the major players in the supply chain.

The idea is that that any one of the supply chain actors will be responsible for initiating the returns in the first place. In other words, that particular supply chain actor is the reason for the product to enter the RSC. For this research considers a typical OEM at the center of the closed loop supply chain model (Refer Figure 5.1). The flow of product is from the manufacturer, seller and then the consumer. Now, after the sale is made, the consumer can return it to any of these three supply chain actor depending upon the specific case. In other words, any of these actors could become the stakeholder of returns. Now, the issue is to figure out the "initiator" of returns which becomes tricky and cumbersome at times. The research assumes that since it is a product manufactured by the central firm, it has its part of share throughout the chain because of its brand image. Hence, it behooves this firm to collaborate with other major supply chain actors in its model to make sure that there is minimal number of their product returns. This firm will work with other players to make sure that the product returns in the future are minimal. Now, based on this, returns are classified according to the supply chain actor who is responsible for the returns. In this research, typical supply chain actors namely the producer / manufacturer, transporter, seller, and consumer are considered. The returns originated by each of them are considered in detail in the following sections. Each step in the methodology is applicable to any of the supply chain actors namely the producer, wholesaler, distributor, transporter etc. Each player can perform some or all of the following steps depending upon its applicability and relevance to the situation.

Step 1: Outline the various return reasons initiated by "Producer"

This research considers a manufacturing organization to be at the centre of the supply chain. This firm in the closed loop supply chain is connected both upstream and downstream to a multitude of other supply chain actors. This firm is actually responsible for performing the function of production / manufacturing / assembly. Refer Figure 5.9. This firm at the central point in the chain is juxtaposed by tier 1 suppliers and customers on either side. In addition to it, there are the transporters, retailers and distributors who service them. The various reasons that make the producer an initiator of returns are illustrated in the form of a fish – bone chart in Figure 5.9. Each one of them is discussed below:

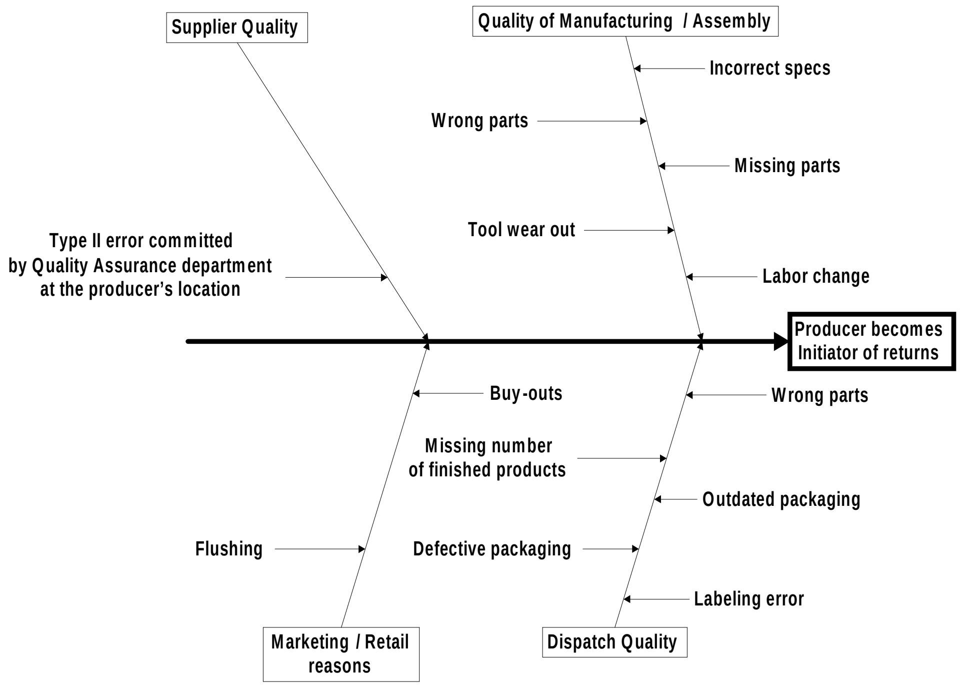

Figure 5.9 Return Reasons with respect to Producer / Manufacturer

The four possible primary reasons that make producer the "initiator" of returns include supplier quality, quality of manufacturing / assembly, dispatch quality and marketing/retail reasons. The first three reasons occur randomly and are not motivated by the producer at any cost. However, the marketing and retail reasons include all the activities that the producer makes deliberately for a secondary cause.

(i) Supplier Quality: The supplier of raw materials is one of the foremost upstream supply chain actors. Any discrepancy in the quality of incoming product will have a ripple effect across the entire supply chain. Proper care should be undertaken by the supplier to reduce non-conforming products and by the producer in filtering such products to pass through the downstream chain. Thus, more focus is on the probability of error made by the "Quality Assurance" department at the producer's facility in accepting a faulty product from the supplier. This particular faulty component from the supplier may be transmitted throughout the FSC until the end customer discovers that something is wrong. It is not uncommon to discover this at the downstream of the supply chain because of the inherent complexities involved in the product circuitries. This forces the end customer to return the final product upstream. The type II error committed by the producer may be due to improper sampling procedure or lack of a proper filtering system in place at the producer's facility.

(ii) Quality of Manufacturing / Assembly: The errors involved in the internal production function within the producer's location reflect directly on the quality of the outgoing product. The primary reasons include (1) missing parts (2) incorrect parts (3) incorrect specs (4) tool wear out (5) labor change. All these above mentioned variables act independently or interact with one another to confound the process variability. This has a significant effect on the quality of the final output of the product coming out of the manufacturing facility.

(iii) Dispatch Quality: It refers to the error committed by the packaging department within the manufacturer's location. This can be attributed to (1) incorrect parts (2) missing number of products (3) outdated packaging (4) defective packaging and (5) labeling error. This also includes transport if transportation is not outsourced to a Third Party Logistics (3PL) provider. Refer IG 3.1 to explore on the implementation details of this step.

Step 2: Develop methods to eliminate / reduce it: Table 5.5 below gives the primary and the secondary reasons along with the suggestions. Typically, they are from a strategic and tactical perspective. Translating these to operational ones need to be done on a case by case basis. The operations department in the organization should tailor these suggestions by setting operational objectives, targets, measures and controls.

Table 5.5 Producer’s matrix of suggestions and costs-benefits

REASONS	SUGGESTIONS	COSTS	BENEFITS

1.*Supplier Quality* (Type II error committed by the Quality Assurance department at the producer’s location)	• Switching to better sampling plan
	• Increase education and training of the organization personnel
	• Promote industry cooperative efforts
	• Improved technologies
	    • RFID
	    • Bar coding
		• Sampling costs
		• Investment infrastructure in education and technologies
			• Reduction in COGS
			• Reduction in RL cost
			• Reduction in type II error

2. *Quality of Mfg /Assembly*
• Incorrect specs
• Missing parts
• Wrong parts
• Tool wear out
• Labor change
	• Lean, 5S,
	• Poka-yoke
	• Visual representation techniques
	• 6σ training
		• Investment infrastructure costs in
		    • Labor
		    • Technology
		    • Training
		    • Education
			• Reduced process variability
			• Reduced manufacturing returns

Table 5.5 Continued

3. *Dispatch Quality*
• Labeling error
• Defective packaging
• Missing # of products
• Wrong parts
	• Improved packing technology
	• Optimized packing*
	• Final packing list check up against an ERP software output
	• Poka – yoke
	• Visual representation techniques
		• Investment infrastructure costs in
		  • Packing technology software
		  • Machines
			• Reduced labor costs
			• Reduced shipping errors
			• Better customer perception of the organization's product

Optimized Packing*: It is important to figure out the correct carton size for the packing. An under-sized carton will make the packer to squeeze in the final products which may lead to defective packaging. Or the packer might loose time in getting the correct carton size that adds to the productivity loss. An over-sized carton might not be cost-efficient. It can also lead to packing voids that leads to "damaged goods in transit". This can be rectified by figuring out the correct packing size. There are many types of software available in the market to do this. The organization can invest in them or could possibly a packing algorithm to be integrated in its shipping process.			

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Step 3: Outline the various return reasons initiated by Transporter”

In the context of this research, the term “transporter” is used to refer to the third party organization that is responsible for the physical distribution / transportation of goods. They are more commonly referred to as the Third Party Logistics (3PL) service providers.

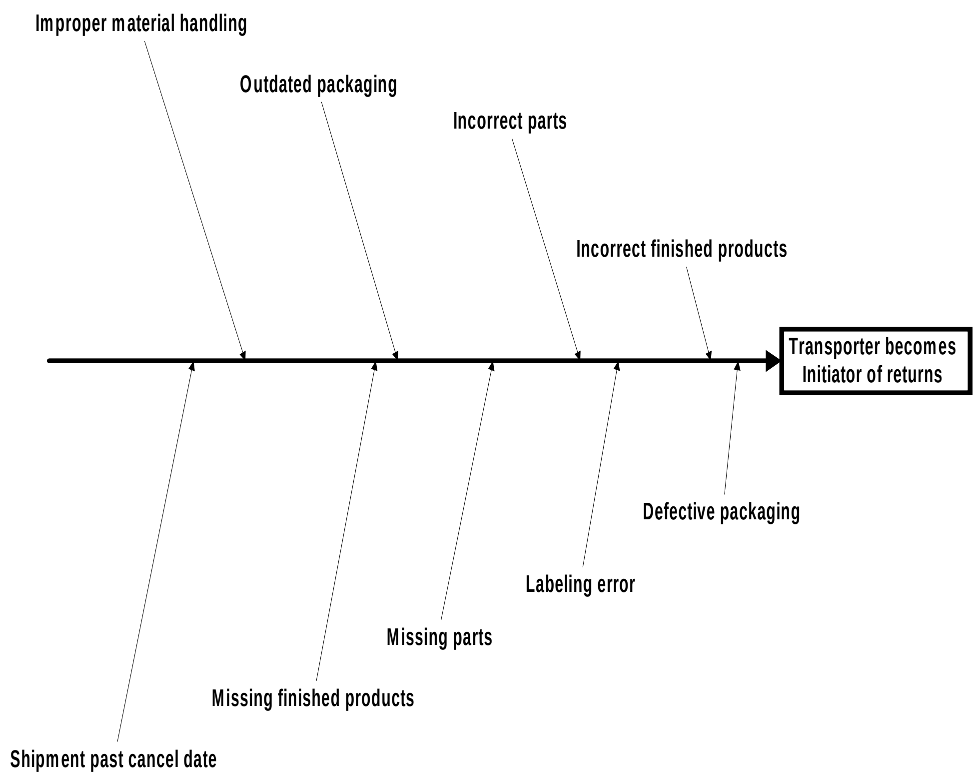


Figure 5.10 Return Reasons with respect to Transporter

Figure 5.10 details out the various primary reasons, from a 3PL perspective, that makes the “transporter” as the initiator of returns. The two main reasons that are important include (i) shipment past cancel date and (ii) improper material handling. These are the two classic cases of a transporter that every transporter seeks to reduce.

Step 4: Develop methods to eliminate / reduce it: The task in the step is to develop improvement initiatives for the return reasons originated by the transporter. The following paragraphs talks about the classical return reasons with respect to the transporter:

(i) Shipments past cancel date: Typically, the contract between a 3PL and an organization makes the transporter financially responsible for the returns. This delay on behalf of the transporter may be classified into two types namely, internal and external. While "internal" reasons include all those activities that are initiated within the transporter organization, "external" factors are governed by forces outside the supply chain. Typical internal factors include: improper planning in Full Track load (FTL) assignments, lack of proper route scheduling / sequencing techniques, labor shortage, resources shortage, system error and communication error. Typical external factors include: legislation acts, fall in economy and other macro economical variables. The focus is on the "internal" reasons in this research. Some of the suggestions include: investment in travel optimization softwares, labor and resources scheduling methods and updating the EDI system within the transporter organization to reflect the latest and dynamic of scenarios.

(ii) Improper material handling: This arises from lack of sophisticated material handling equipments for transporting products. The 3PL service provider will have to perform a capability evaluation checklist to address if he is really capable of handling the client needs. One of the most common quoted reasons for the failure of the 3PL – client relationship is that the 3PL agrees to do whatever the client demands without performing a capability analysis. For example, the 3PL may not be capable enough to handle the holiday season load or may not have the specialized material handling devices needed for high valued products. Hence, as a suggestive measure, the transporter is recommended to perform a capability evaluation to make sure that any slight chance of improper material handling does not happen in the future. Some of the key questions that need to be addressed include:

(i) What is the maximum number of carriers that can be added?

(ii) What is the maximum number of drivers that can be added?

(iii) What additional mode of transportation would be necessary?

(iv) What special storage requirements would be needed in the warehouse?

(v) How often do we need the automatic sorting and collection equipment?

Since the rest of the return reasons have been discussed in the previous section, a checklist that a transporter need to check each time in a chronological order is given so that the transporter does not become the initiator of returns.

(i) Check for the correct parts

(ii) Check for the correct number of parts

(iii) Check for the correct finished goods product

(iv) Check for the correct number of finished goods product

(v) Check for correct packaging

(vi) Check for the labels against the product to eliminate labeling error

(vii) Check packing list before shipping

Step 5: Outline the various return reasons initiated by the Seller: The term "seller" is used to refer to the wholesaler or the retailer who is typically the last link in the supply chain before the end consumer.

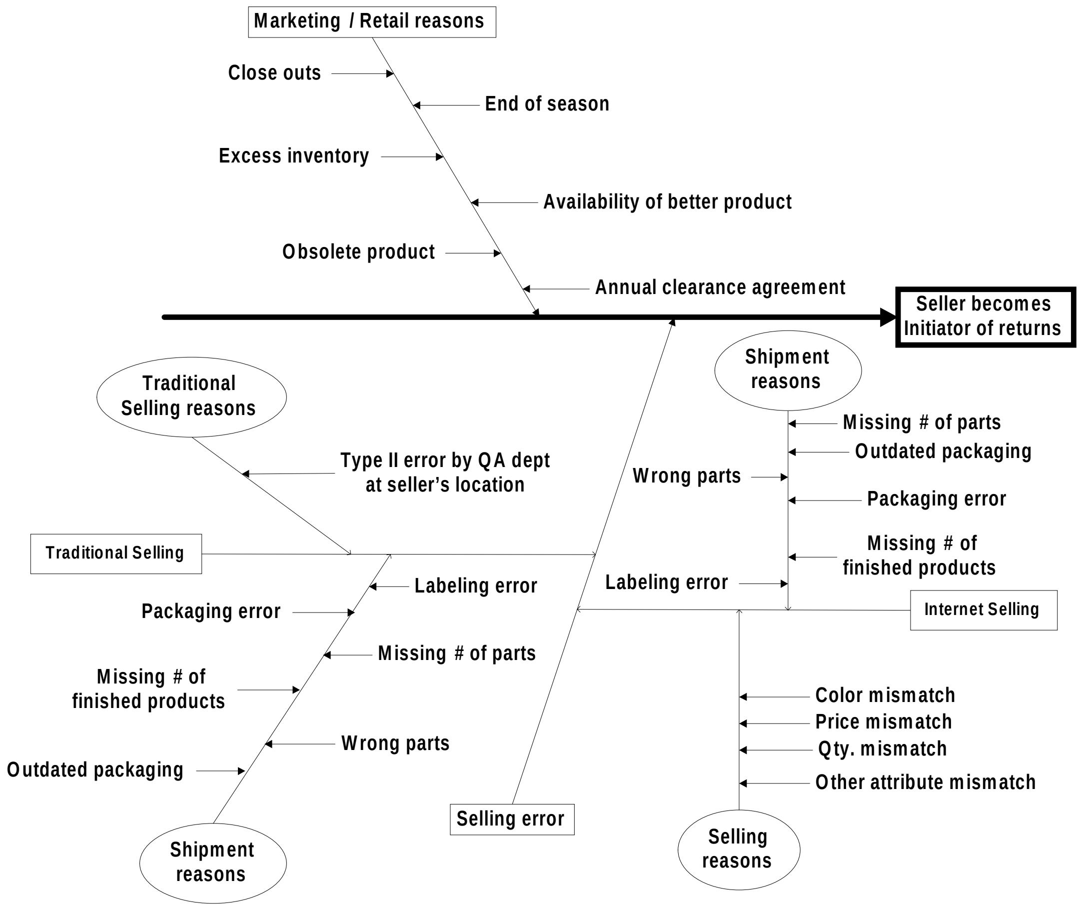


Figure 5.11 Return Reasons with respect to Seller

In Figure 5.11, there are two primary reasons that make the "seller" as the initiator of returns. They are "Marketing / Retail" reasons and "Selling error". As discussed earlier, most of the "marketing / retail" secondary reasons are deliberately undertaken by the concerned supply chain actor for a secondary cause. However, there is one secondary reason that is not deliberate, yet not motivated by the seller, namely “availability of better product”. They are classified / grouped them in this category because if the organization is not market reactive, its product will soon be outwitted by a better product in terms of price, quality and other popular consumer attributes. Hence, lack of initiative to introduce better products, or slow market launch time for new products is also seen as a reason that makes the seller to take back its old products inventory. The company would plan to do concurrent engineering methods to reduce the market introduction time.

The other primary reason, namely “selling error” can be classified into two secondary reasons: reasons associated with “traditional selling” and “internet selling”. “Traditional selling” is further classified into two tertiary types: “traditional selling error” and “shipment error”. “Traditional selling” reasons are associated with the type II error committed by the quality assurance department at the seller’s location. The common reasons for “shipment error” includes packaging error, missing number of parts, missing number of products, wrong products, labeling error, wrong and defective packaging, shipment past cancel date and material handling error. The suggestions for these kinds of reasons were discussed in the producers section. This section will be focused towards the reasons associated with “Internet selling”.

The reasons associated with internet selling can again be classified into two tertiary reasons like the traditional selling, namely “internet selling reasons” and “shipment reasons”. The internet selling reasons refers to the various mismatches between the attribute of the advertised product and the attribute of the actual product.

The most common product attribute mismatches include color mismatch, price mismatch, quantity mismatch, quality mismatch, specifications mismatch. Refer IG 3.5.

Step 6: Develop methods to eliminate / reduce it: Distributors indicated a moderate success in recovering assets and reducing inventory investment in their reverse logistics programs (Autry et al., 2001). Hence, any cost-effective method that blocks the product from entering the asset recovery process should be considered carefully. The suggestions related to traditional selling reasons and shipment reasons were covered in the previous sections. Hence, this section will focus on process improvements in electronic methods of retailing (e – tailing).

Before advertisements are made online and public, product attributes of the advertised product and that of the actual product has to be verified by a concerned authority and be shipped to the web-posting department. In effect, there should be a quality check station before the final uploading section. The checking station should verify the price, quality, and other product attributes.

If the range of product attributes is high, then it should be pretty evident in the electronic methods of selling as well. For e.g., the sellers system should have codes for different shades of blue to precisely match the actual color of the product. Since the electronic methods of selling are "feel, touch and try" type of selling, it is the responsibility of the seller to accurately represent the product attributes. Retailers, nowadays, present a pictorial representation of their products in multiple views. Of late, the number of products returned through online methods of purchasing have drastically went up. So every process improvement methods should be addressed for continuous improvement. Refer IG 3.6.

Step 7: Outline the various return reasons initiated by the consumer: The term "consumer" is used to refer to both the industrial customer as well as the residential customer. For product returns, a high percentage of returns come from customer returns. Surveys indicate that overall customer returns for general merchandise are estimated to be approximately 6%, although returns vary significantly by industry (Rogers and Tibben – Lembke, 1998. 2001).

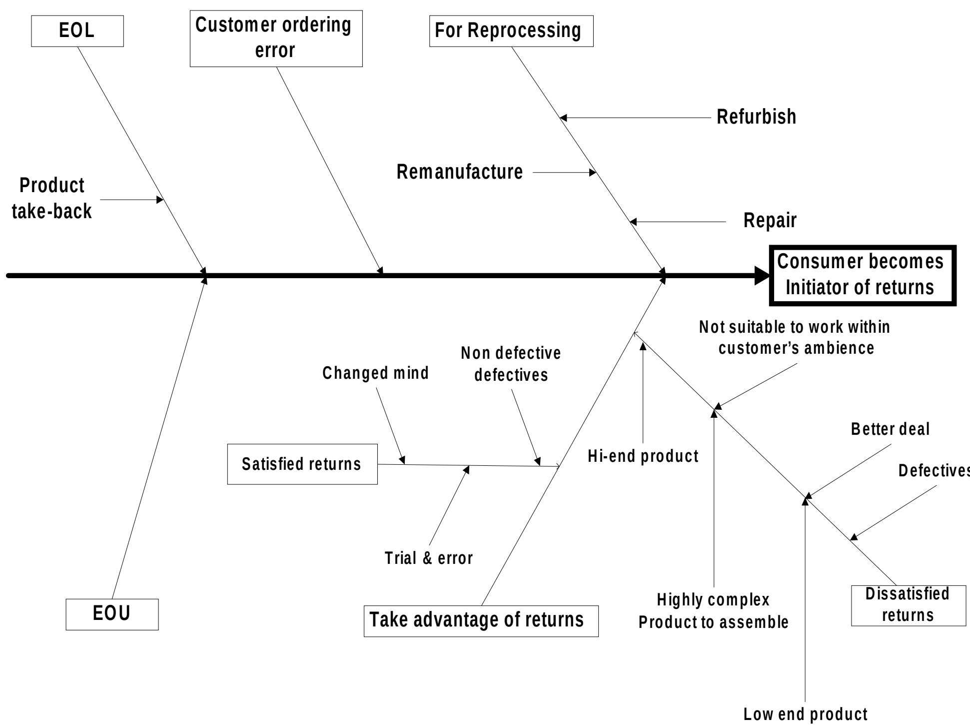


Figure 5.12 Return Reasons with respect to Consumer

Figure 5.12 shows five primary reasons for consumer becoming the initiator of returns. They are EOL, EOU, customer ordering error, "for reprocessing", and "take advantage of returns". The three reasons, "EOL", "For reprocessing" and "EOU" are expected to happen sometime during the product life cycle. EOL stands for End-of-Life that includes all products that have reached the end of their useful lives. Customers do return the products for reprocessing that includes options like remanufacturing, refurbishing and repair. These three differ in the degree / extent to which the rework operation is being done on the product. The key concern for the stakeholder here though is if the product is within its warranty period. If it is still in the warranty period, the stakeholder will have to incur the cost of doing the operations. If not, then the customer ends up paying the costs of reprocessing. The payments are made upfront to cover for the additional costs of procurements of parts, labor and transportation back to the customer.

EOU stands for "End-of-Use" to refer to all the products that have reached their use period. The use period refers to the rental agreement period or lease period. The quality of the products coming back is an area of concern of the stakeholder. Usually, there is a thorough quality check before this EOU enters the RSC. The issue here is how best to utilize this product.

After these, there is the ordering error on the part of the customer that can happen anytime. The typical errors include wrong product, wrong number of products, wrong combination of products (in case of electronic assemblies), wrong method of payment, wrong method of shipments and so on.

Finally, customers do take advantage of the liberal return policies on the part of sellers and manufacturers to gain competitive edge. Return reasons in this category are classified into two main types (i) satisfied returns and (ii) dissatisfied returns.

Organizations have very little leeway in curbing the number of returns associated with to "satisfied returns". The various reasons for dissatisfaction are given in Figure 5.8 that includes "highly complex product to assemble", "high end product", "low end product", "not suitable to work in customer's ambience", "availability of better deals", and finally "defective products".

Step 8: Develop methods to eliminate / reduce it: One of the obvious things to do for the organizations is to improve the product design so that the number of products that coming to the RSC can be mitigated. However, these suggestions would be dealt in the engineering design department during the new product development or existing product modification stage. Customers often end up having dissatisfied products. The seller and the manufacturer should think of (i) allowing free trial for all possible products before purchase (ii) Double checking the product attributes if the sale is through internet and (iii) Publicizing the option of allowing the upgrading feature. This will not only lead reduced future returns but will yield the following secondary benefits namely (i) higher customer retention (ii) higher future sales and (iii) improved customer image. "Dissatisfied returns" provides the company one vantage point to boost the corporate image because it deals directly with the end customer. Also, valuable insights from return reasons can be fed to the FSC to ensure that design problems do not pop up in future. The cost associated with it would be the extra cost of adding upgrading features. However, in the long run, this investment is likely to be overrun by the benefits listed above.

CHAPTER 6

CONCLUSIONS

6.1 Results

In this research, a new methodology for designing a reverse supply chain was developed. One of the main justifications to develop this methodology was the rapid technological obsolescence and the consequent piling up of inventory in the consumer electronics industry. Efficiency of a reverse supply chain was defined across three attributes of time taken to recover value from returns, the actual value recovered from them and the number of returns that enter the reverse stream in the future. These three attributes were analyzed in detail and a step by step approach was developed to improve each one of them. The developed methodology was demonstrated in two organizations in the Dallas Fort Worth metroplex. Demonstration was achieved through interview sessions that covered a wide range of topics. The interview questions are included in Appendices A, B and C respectively for each of the three goals. After the interview sessions, several inputs and insights were garnered. The methodology was fine tuned to incorporate any necessary changes.

An "Implementation Guideline" was developed with the objective of aiding any individual or team in an organization to go about implement the design methodology via the individual steps given. Thus, a one – to – one correspondence between the step in the methodology and its corresponding guideline was achieved. The implementation guideline acts as an instruction manual that will guide the implementers even without the presence of the actual steps in the methodology.

As mentioned earlier, the essence of the methodology was conceived and developed through observations, research studies and case analysis from the electronics industry in general and consumer electronics in particular. It is in this segment of the industry in which the importance of time is highly realized. This is due to the rapid development of technology. As a result, the influx of products into the returns pool increases dramatically. Thus, it was this particular industry that needs a structured methodology to design its reverse supply chain more than any other. However, the methodology can be applied to all industries that manufacture products.

6.2 Contributions

This study provides several contributions to the body of knowledge in revere supply chain.

Firstly, it develops a methodology that is comprehensive about the salient aspects of reverse supply chain in the consumer electronics industry. The methodology requires an organization to move from functional focus within an organization to a collaborative relationship among supply chain participants. Thus, it enables organization that implements the methodology to move up the supply chain evolution ladder.

Secondly, the methodology is equally applicable to both types of organizations: (i) the one in which there are no structured approach to solve returns problems and (2) the other type in which some degree of procedures and methods are in place which needs further tuning to become comprehensive. This methodology provides a structured approach in the form of quick fixes as well as long term solutions to solve problems related to reverse supply chain in enterprises. Any of the three goals can be implemented in isolation depending upon the specific circumstance an organization is confronted with. Also, some of the essential steps can be extracted from the methodology and can be used as short term fixes. On the flip side, an organization that plans to start a disciplined approach to returns problems can use the entire methodology to design their reverse supply chain efficiently.

Thirdly, the methodology introduces certain key terms and parameters that academicians, industrial experts and researchers can use. There were some new parameters that were developed as a part of reducing the cycle time of value recovery for returns. These time parameters provide useful insights and can be used as performance measures in industry. These parameters can be measured based on some predetermined time periods to assess an attribute related to cycle time of value recovery. Academicians can use these parameters to develop linear programming problems, further explore the cause and effect analysis, and sensitivity analysis of them to yield insightful information about how to cut down cycle time of value recovery.

6.3 Future Research

There are many areas in which constructive work can be done extrapolating some of the salient features of this research. To begin with, in the case of goal 1, the "time" parameters that are developed can be used to figure out any possible relationship between a variable on the particular time parameter. Also, useful statistics like correlation coefficient can be figured out to decipher clues for lean process improvement. In addition to the already developed time parameters, other parameters that are specific to a particular industry should be developed.

The classification scheme for returns as well as disposition options should include more choices and types such as when new methods of disposition become available. All the updates should be reflected in the scoring model. There are some areas in which more accurate cost estimation needs to be done. Hence, procedures should be developed specific to reverse supply chains that help in analyzing the cost centers. However, only after a detailed analysis of the various returns operations and the procedures, can there be a well documented procedure to accurately estimate costs involved in the scoring model. This was mentioned in the implementation guideline section as a precautionary step.

Finally, the cause and effect method should be developed for various possible supply chain stakeholders. This methodology focused on four major actors namely, the producer, the transporter, the seller and the consumer. A similar analysis can be undertaken for other players who effect the returns management process.

APPENDIX A

QUESTIONNAIRE FOR GOAL 1

Overview: The purpose of this interview session is to garner information that will help validate my methodology. This section is related to the first goal of the methodology that seeks to reduce the time taken to recover value from the returns. The interview questions will be focused towards the following areas:

1. Reverse Logistics (RL) network structure.
2. Identification of various operations within the RL boundaries of an organization
3. RL process time parameters
4. Techniques to reduce the time taken for value recovery.

The interview will be expected to last between 45 minutes to 1 hr.

Questions 1 through 8

Motive: The purpose of this set of questions is to test the validity of the RL network structure that serves as the basic framework of this research. Refer Figure A.1. It depicts the various actors and the associated operations in the forward supply chain (FSC) as well as the reverse supply chain (RSC). The network was developed to include the longest possible path a returned product **can possibly** travel in a supply chain.

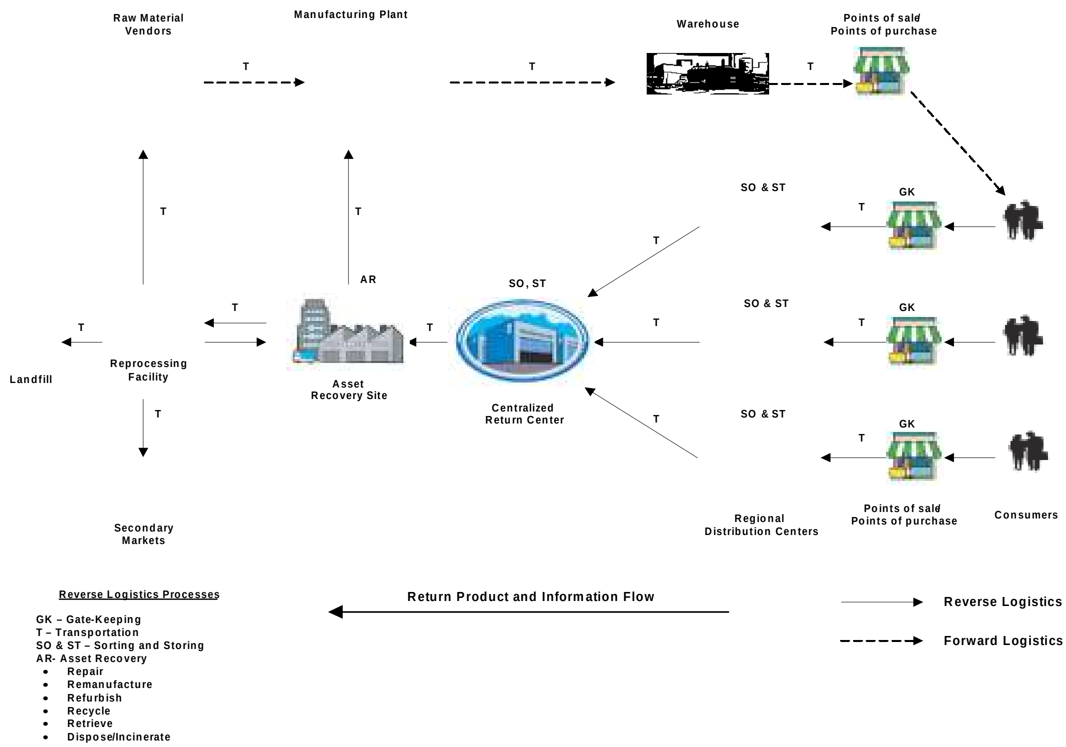


Figure A.1 A typical reverse supply chain network structure

1. Do you think this network structure captures the longest possible path?

   ☐ Yes ☐ No ☐ Partly captures

2. If the answer to question #1 was "No", or "partly captures", please enlist some of the additional nodes that should have been included in the network above.

3. What are some of the nodes that you think is redundant?

4. How far does this figure represent the flow of materials in real time? Use a scale of 1 through 7 with 1 being **“not at all representative”** and 7 being **“highly representative”**. Please use the space below to explain any reasoning, if necessary.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

5. Comment of the following statement: “Any RL / RSC improvement initiative should begin with the mapping of the major actors and the associated operations (similar to Fig. A1). This will be mandatory for success in returns management”.

☐ Fully agree ☐ Somewhat agree ☐ Can’t say

☐ Somewhat disagree ☐ Fully Disagree

6. If your answer to question #5 is “can’t say”, “somewhat disagree” or “fully disagree”, please indicate the reason below.

Questions 7 – 9:

Motive: The purpose of this set of questions is to explore the concept of RTU and test its validity and applicability in the context of RL / RSC design. Please refer to the following definition:

“A Returns Tracking Unit (RTU) is defined as any item under consideration for which value recovery is to be performed. An RTU may be a finished product, sub-assembly or a loose component. It can be thought of as an RL equivalent of Stock Keeping Unit (SKU)”.

7. What is the equivalent term used in your organization to capture the concept of RTU mentioned above?

8. Typically, in which stage of RSC operation is the actual RTU is identified? (check all that apply).

☐ Gate keeping ☐ Sorting and Storing

☐ Transportation ☐ Asset Recovery

☐ Other ____

9. How beneficial would the concept of RTU be in the design of RL / RSC? Use a scale of 1 through 7 with 1 being **"highly beneficial"** and 7 being **"Not at all beneficial**". Please use the space below to explain any reasoning, if necessary.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

Questions 10 – 12:

Motive: The purpose of this set of questions is to explore the parameter "cycle time of value recovery (CTVR)". It is defined as the average time taken by a returned product to traverse from the first operation in the RSC to the last one.

10. How do you measure CTVR in your organization?

11. Comment on the following statement. CTVR makes most sense when it is measured for a given individual RTU.

    ☐ Yes ☐ No ☐ Can't say because (use the space below)

12. “The most important thing to do in reducing the magnitude of CTVR is having a structured methodology for measuring it”. Comment on the validity of this statement. Use a scale of 1 through 7 with 1 representing **“not at all valid”** and 7 representing **“highly valid”**. Please use the space below to explain any reasoning, if necessary.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

Questions 13 – 27:

Motive: The purpose of this set of questions is to test the validity, applicability / practicality of the methodology developed to measure the CTVR.

13. <u>**The first step**</u> in measuring the CTVR is to identify the relevant supply chain actors in the closed loop supply chain (that includes both FSC and RSC). Since it would be highly difficult to identify all the possible actors, it is recommended to identify

the major actors that are highly influential in the RSC operations. What is the expected difficulty level of identifying the actors? Use a scale of 1 through 7 with 1 representing **“highly easy”** and 7 representing **“highly difficult”**. Please use the space below to explain any reasoning, if necessary.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

14. **The second step** is to map the product and information flow along the identified supply chain actors (similar to Figure A1). In your opinion, what are the possible barriers to performing this step?

15. In your opinion, what are the possible advantages of identifying and mapping the supply chain actors in a network structure?

16. What are some of the "to – do's" that you suggest with respect to identifying and mapping the supply chain actors and the relevant product and information flows?

17. **<u>The third step</u>** is to define the entry and exit points of returns management process. RSC_{entry} is defined as the earliest point / position in the RSC where returns enter and RSC_{exit} is defined as the latest point / position in the RSC where the last RSC operation is performed. What are the typical RSC_{entry} and RSC_{exit} points in your organization?

18. **The fourth step** is to identify the activities involved for each operation between $RSC_{entry\ and}$ $RSC_{exit.}$ What are the potential impediments in identifying the different operations between $RSC_{entry\ and}$ RSC_{exit} ?

19. What are some of the RSC operations in your organization between $RSC_{entry\ and}$ $RSC_{exit?}$

20. What are some of the potential impediments in identifying the activities for a given RSC operation between $RSC_{entry\ and}$ RSC_{exit} ?

21. **<u>The fifth and the sixth steps are</u>** to develop a process flow chart for a given RTU and a given RSC operation. In addition to the traditional five categories of process flow chart, namely, “operation”, “inspection”, “storage”, “decision” and “delay”, the methodology suggests to include a new category namely “Value Recovery” that is relevant to RSC. In your opinion, rate the inclusion of this new category along these attributes. Use a scale of 1 through 7 with 1 representing **“lower level of attribute”** and 7 representing **“higher level of attribute”**. Use Table A.1 Please use the space below to explain any reasoning, if necessary.

Table A.1 Testing the efficacy of “Value Recovery” concept

Attribute	1	2	3	4	5	6	7
Validity							
Applicability							
Practicality							
Ease of impelmentability							

Questions 22 – 23:

Motive: The purpose of this set of questions is to test whether the process of classifying an "asset recovery" "activity as "value recovery" activity is valid and truly representative and useful for further analysis. The methodology seeks to identify the activities that can be categorized in the "Value recovery" category. The "Value recovery" activities typically include all "asset recovery" activities because only "asset recovery" activities add value to the process. This, in a way, is similar to the "Value Added Time" principle in lean manufacturing. While the rest of categories namely "operations", "storage", "decision", "transport" and "delay" could ideally be eliminated, only "value recovery activities" add real value to the process, for which the customer is ready to pay and through which the organization is able to reap maximum benefits.

22. In your opinion, how useful is the process of classifying the "asset recovery" activity as "value recovery" activity? (Use a scale of 1 through 7 with 1 representing **"least useful"** and 7 representing **"highly useful"**). Please use the space below to explain any reasoning, if necessary.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

23. In your opinion, how valid is the process of classifying the "asset recovery" activity as "value recovery" activity. (Use a scale of 1 through 7 with 1 representing **"least valid"** and 7 representing **"highly valid"**). Please use the space below to explain any reasoning, if necessary.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

<u>Questions 24 – 28:</u>

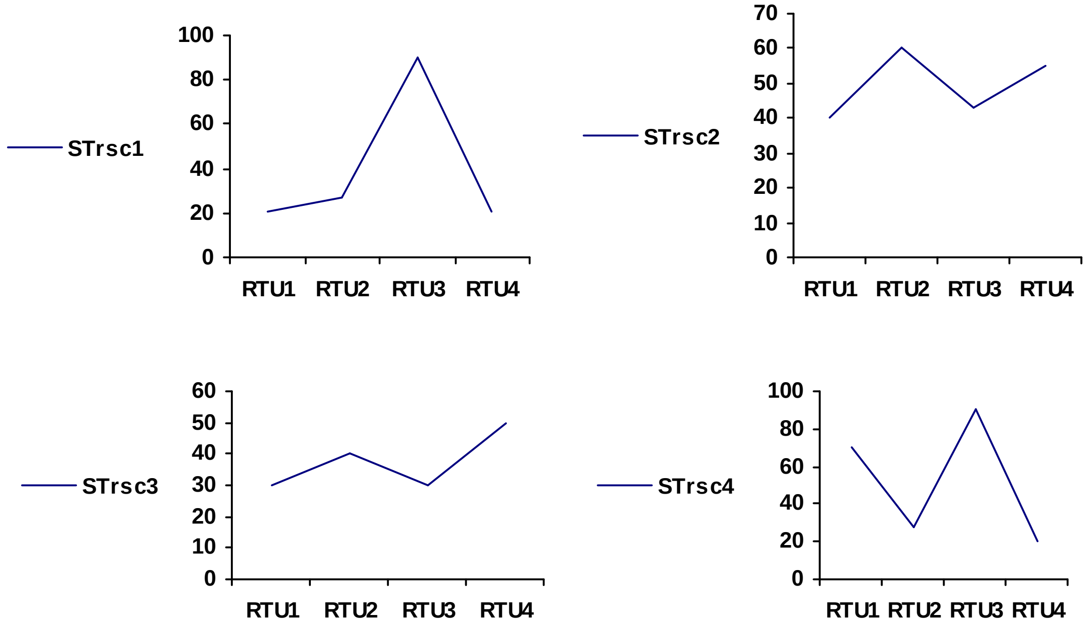
<u>Motive:</u> The purpose of this set of questions is to test the validity of the time parameters that are developed in the methodology.

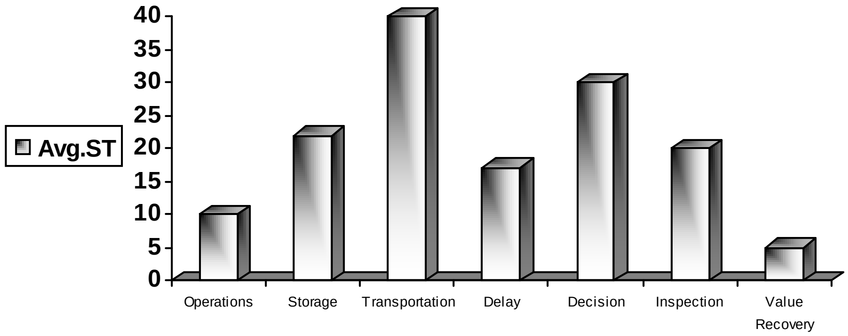
The last five steps of the methodology are to calculate some time parameters based on the observed time and standard time. After calculating the "total standard time" of each RSC operation for a given RTU, the methodology recommends to iterate this process for different RTUS for a considerable period of time (e.g., a month). This will yield "standard time of all RSC operations" and "standard time of value recovery for all RSC operations" in the same period. Avg. Total Time (Avg. TT): It is defined as the average total time of all RTUs for the given time period under consideration. The following parameters are developed based on the above calculations.

a. Avg. VRT: This is defined as the average VRTs of the various RTUs in the same period.
b. Time Efficiency: Avg. VRT / Avg. TT.
c. Non – value recovery time (NVRT): This is defined as the total time that is spent on all activities excluding VRT.

   NVRT = Avg. TT – Avg. VRT

The purpose of calculating these time parameters is to identify where an improvement initiative can be justified. Refer Figure A2.





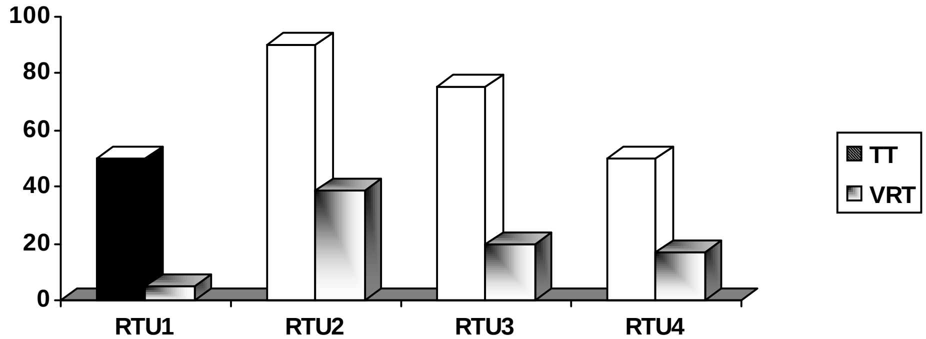


Figure. A.2 Analysis of various time parameters

24. Comment of the following attributes on this kind of analyses.

Use a scale of 1 through 7 (with 1 representing **“lower level of attribute”** and 7 representing **“higher level of attribute”**. Please use the space below to explain any reasoning, if necessary.

Table A.2 Testing the efficacy of “time parameter” analyses

Attribute	1	2	3	4	5	6	7
Validity							
Applicability							
Practicality							

25. Do you think this will directly impact the reduction of CTVR in future?

☐ Yes ☐ No

☐ With some changes ____

26. In your opinion, what are some of the impediments in coming up with this kind of analyses?

Questions 27 – 34:

Motive: The purpose of this set of questions is to explore the advantages and disadvantages of some of the possible suggestions for reducing CTVR.

27. Classifying and coding the return reasons can greatly increase the velocity of returns flow in the RSC loop. It requires the organization to adopt a structured approach for classifying the RTU based on the reason and coding them so that less time is spent in the "Asset Recovery" stage in inspecting it. What are some of the shortcomings of this suggestion?

28. In your opinion, what are some of the practical impediments in implementing it?

29. It is recommended to have a centralized database of all RTUs accessible to everyone involved in it. In other words, this seeks to incorporate a new slab in the legacy / ERP or any other business process automation systems. What are some of the disadvantages of this suggestion?

30. In your opinion, what are some of the practical impediments in implementing it?

31. One of the suggestions is to standardize the part numbers across different unit of the same organization. An organization that has multiple divisions spread all over the country and / or globe might be duplicating the time and effort involved in identifying the same product with different part numbers. In such cases, it is advisable to have one standardized system across different divisions of the same organization. Sometimes, it might be handy to go by the common industry standard part numbers. This is one way to reduce the CTVR. What are the merits and demerits of this system?

32. What are some of the real time difficulties that you expect to pop up in the implementation of the system?

33. One of the suggestions is to clearly distinguish and demarcate between FSC and RSC items. The picking, kitting, packing and shipping of the wrong components, sub-assemblies will not only add to volume of returns but also to the higher value of the process parameters. What are the potential disadvantages of this system?

34. What are some of the potential practical impediments to this system?

APPENDIX B

QUESTIONNAIRE FOR GOAL 2

Overview: The purpose of this interview session is to garner information that will help validate my methodology. This section is related to the second goal of the methodology that seeks to increase the value recovered from returned products. The interview questions will be focused towards following areas:

1. Classification scheme for returns.
2. Classification scheme for disposition options.
3. Feasibility / practicality of disposition options for a given returned product.
4. Evaluation / scoring of the disposition options

The interview will be expected to last between 45 minutes to 1 hr.

Questions 1 thro 8

Motive: The purpose of this set of questions is to explore the classification scheme for incoming returns. Refer Figure B.1.

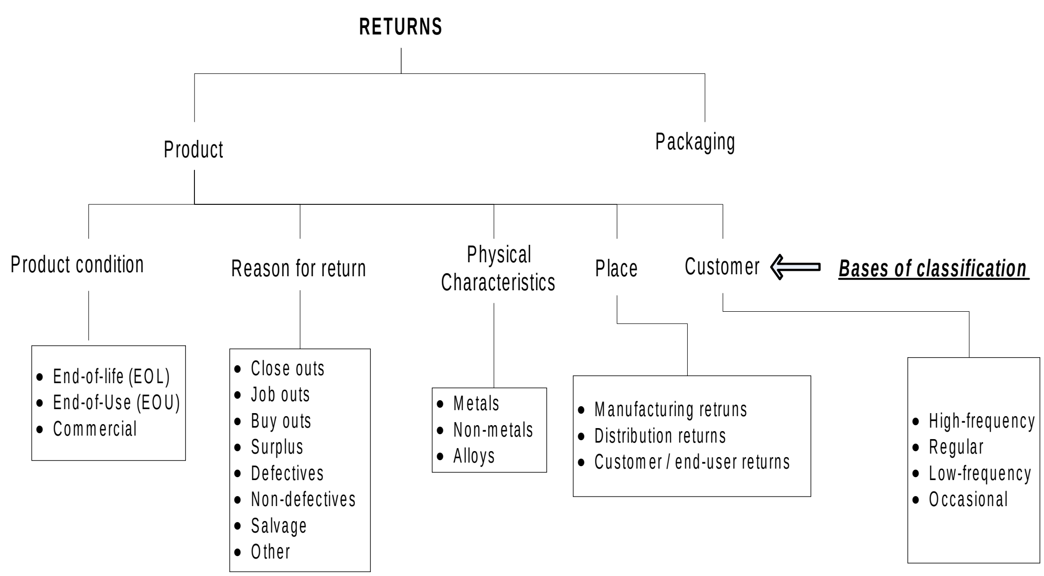


Figure B.1 Classification scheme for Returns

1. Do you classify returns into “**products**” and “**packaging**” returns?

☐ Yes ☐ No

☐ With some changes ____

2. Do you classify product returns based on the “**product condition”**? (e.g. *EOL, EOU, and Commercial*)

☐ Yes ☐ No

☐ With some changes ____

3. Refer to Table B.1. Do you classify product returns based on the “**reason for return**”? (e.g., *close-outs, job-outs, buy-outs, surplus, defectives, non-defectives, salvage , other*)

☐ Yes ☐ No

☐ With some changes ____

Table B.1 Definition of “Commercial” categories (Rogers and Tibben- Lembke, 1998)

Type	**Attributes**
Close-outs	First-quality items that the retailer has discontinued from its product mix. In such a case, the retailer may have decided to stop carrying products sold by a certain vendor, in a particular product line.
Buy-outs	Occur where one manufacturer buys out a retailer’s entire supply of a competitor’s product. This purchase frees shelf space so that the manufacturer can put its product where the competitor’s product was previously.
Job-outs	Job-outs have come to the end of their normal sales lives. These include seasonal products that are popular only during a certain time of the year.

Table B.1 Continued

Surplus	First quality items that the company has in excess but will continue to sell. The firm may have overestimated demand and ordered too many. It could also arise from inaccurate forecasts, minimum production quantity requirements and marketing returns.
Defectives	Truly defective items. The reason for the defective may be any one the supply chain actor. Usually the stakeholder reimburses the buyer with a new product or makes financial adjustments.
Non-defectives	Often, a customer claims that a product is defective in order to return it, when, in fact, it is not defective.
Salvage	Have been used or damaged, and can no longer be sold as new. These items loose value relative to the amount use or damage. The most difficult part of managing salvage is determining its value.

4. Do you classify product returns based on the “**physical characteristics**”? *(Metals, non-metals, alloys*)

☐ Yes ☐ No

☐ With some changes ____

5. Do you classify product returns based on the “**place”** from which the returns are shipped? (*manufacturing returns, distribution returns, customer / end user returns, other*)

☐ Yes ☐ No

☐ With some changes ____

6. Do you classify product returns based on “**customers”** from where returns are shipped? (*high frequency customer, regular, low frequency, occasional*)

☐ Yes ☐ No

☐ With some changes ____

7. Please list the changes that you would like to make for the above mentioned bases of classification for questions #1 thro 6. In addition to it, please list any other bases of classification that is currently employed in your organization.

8. On a scale of 1 through 7, how far do the bases of classification for returns capture the real world situations? Use a scale of 1 through 7 with 1 being **“not at all representative”** and 7 being **“highly representative”**. Please use the space below to explain any reasoning, if necessary.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

Questions 9 – 18

Motive: The purpose of this set of questions is to explore the classification scheme for the disposition options. Refer Figure B.2.

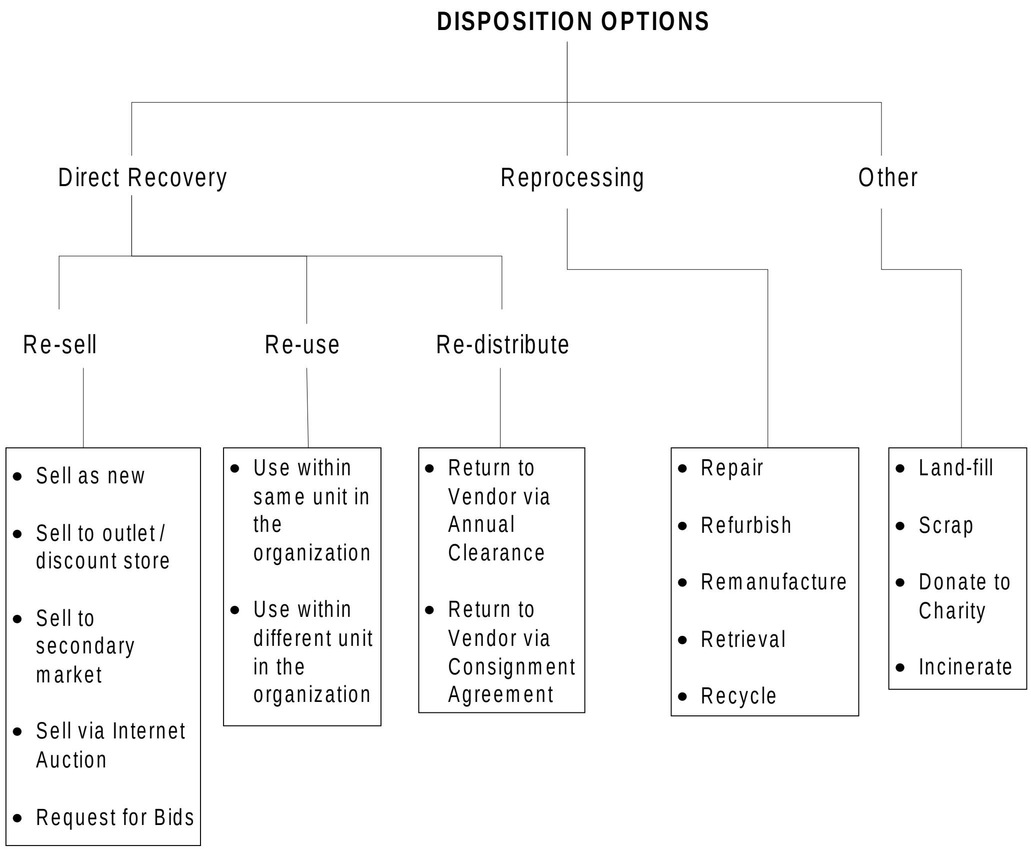


Figure B.2 Classification scheme for disposition options

9. What are the various "Direct Recovery" options that you follow in your organization? (Direct Recovery: This means that the returned item is not treated further and that the item is put into use in the same condition in which it was returned).

10. Direct Recovery" is classified into three sub-types, namely, "Re-sell", "Re-use", and "Re-distribute" (See Figure B2). In addition to these, what are the other types of "direct recovery" options you consider in your organization?

11. From the list of "Re-selling" options, please check the options that you practice / exercise in your organization.

a. Sell as new

☐ Yes ☐ No

☐ With some changes ____

b. Sell to outlet / discount store

☐ Yes ☐ No

☐ With some changes ____

c. Sell to secondary market

☐ Yes ☐ No

☐ With some changes ____

d. Sell via internet auction

☐ Yes ☐ No

☐ With some changes ____

e. Request for bids

☐ Yes ☐ No

☐ With some changes ____

12. From the list of "Re-use" options, please check the options that you practice / exercise in your organization.

a. Use within the same geographic unit in the organization

☐ Yes ☐ No

☐ With some changes ____

b. Use within different geographic unit in the organization

☐ Yes ☐ No

☐ With some changes ____

13. From the list of "Re-distribute" options, please check the options that you practice / exercise in your organization.

a. Return to vendor via annual clearance

☐ Yes ☐ No

☐ With some changes ____

b. Return to vendor via consignment agreement

☐ Yes ☐ No

☐ With some changes ____

14. From the list of "Re-processing" options, please check the options that you practice / exercise in your organization.

a. Repair (A "Repair" operation is defined as restoring the product to working order. In the process if repair, some component may be repaired or replaced).

☐ Yes ☐ No

☐ With some changes ____

b. Refurbish (A "Refurbish" operation is defined as inspecting and upgrading critical modules. In the process, some modules may be repaired or replaced by upgrades).

☐ Yes ☐ No

☐ With some changes ____

c. Remanufacture (A "Remanufacture" operation is defined as manufacturing new products partly from old components).

☐ Yes ☐ No

☐ With some changes ____

d. Retrieval (A "Retrieval" operations is defined as removing selected components from the products. The selected components typically include working components, costly components etc).

☐ Yes ☐ No

☐ With some changes ____

e. Recycle

☐ Yes ☐ No

☐ With some changes ____

15. From the list of "Other" options, please check the options that you practice / exercise in your organization.

a. Incinerate

☐ Yes ☐ No

☐ With some changes ____

b. Landfill

☐ Yes ☐ No

☐ With some changes ____

c. Scrap

☐ Yes ☐ No

☐ With some changes ____

d. Donate to charity

☐ Yes ☐ No

☐ With some changes ____

16. Please list any other disposition options that are followed in your organization.

17. On a scale of 1-7, how do you rate the classification scheme of disposition options? Use a scale of 1 through 7 with 1 being **“not at all representative”** and 7 being **“highly representative”**. Please use the space below to explain any reasoning, if necessary.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

18. What type of testing is done to analyze the condition of a product?

Questions 19 – 37

<u>*Motive:*</u> We try to evaluate / score the various disposition options for a given RTU. After evaluation, we select the best strategy based on the scores. The purpose of this set of questions is to validate the parameters of the evaluation / scoring scheme. There are three parameters that go into the model. They are given in Equation 1.

Score for Disposition Option$_i$ (*DO_i*) = S_i =   *(Value of RTU under consideration) + (Total expected cost of implementing DOi) –*   *(Expected Recovery Value of DO_i)* --- *Eq.1*

Questions 19 – 24:

These set of questions focus specifically on "**Value of RTU under consideration**".

19. Comment of the following statement. "If the stakeholder of RTU is a manufacturer, this parameter can be found out by calculating the cost of production".

☐ Fully agree ☐ Somewhat agree ☐ Can't say

☐ Somewhat disagree ☐ Fully Disagree

20. If the answer to question #22 is “somewhat disagree” or “fully disagree”, please explain why using the space below

21. What other factors, according to you, determines the actual worth / “Value of RTU” for a manufacturer?

22. Comment on the following statement. “If the stakeholder is a wholesaler / retailer, this parameter is found out by calculating the cost of purchase”.

☐ Fully agree ☐ Somewhat agree ☐ Can’t say

☐ Somewhat disagree ☐ Fully Disagree

23. If the answer to question #22 is “somewhat disagree” or “fully disagree”, explain why.

24. What other factors, according to you, determines the actual worth / "Value of RTU" for a wholesaler / retailer?

Questions 25 – 30:

<u>*Motive:*</u> These set of questions focus specifically on **"Total expected cost of implementing the Disposition Option (DO_i)** that is defined as the summation of the total expected environmental and the total expected product recovery costs for a given disposition option.

Total expected cost of implementing DO_i = *Total Expected Environmental costs for DO_i + Total Expected Product Recovery costs for DO_i* --- *Eq.2*

"Total expected environmental costs for disposition option" is defined as the summation of all costs that is expected by the organization to incur for environmental conformance with respect to a given disposition option".

"Total expected product recovery costs" is the summation of all the costs that goes in making the disposition option happen that excludes the environmental costs.

25. The following represent some of the factors that determine the "total expected environmental costs". For each of them, indicate their degree of influence on the "total expected environmental costs". Use a scale of 1 through 7 with 1 representing **"not at all valid"** and 7 representing **"highly valid"**. Please use the space below to explain any reasoning, if necessary.

a. Cost of conformance to EPA standards.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

b. Cost of conformance to OSHA standards.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

c. Cost of conformance to ISP 14000 requirements standards.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

d. Cost paid to the federal government

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

e. Additional transportation and distribution cost for handling the returns in a environmental friendly fashion.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

f. Marketing / publicizing costs to promote eco-friendly products

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

g. Cost paid to third party specializing in environmental issues related to a specific disposition option.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

26. According to you, what are some of the other costs that might affect the "total expected environmental costs?

27. The following represent some of the factors that determine "total expected product recovery" for direct recovery options. For each of them, indicate their degree of influence on the "total expected product recovery". Use a scale of 1 through 7 with 1 representing "**not at all valid**" and 7 representing **"highly valid"**. Please use the space below to explain any reasoning, if necessary.

a. Cost paid to the external agencies

   i. Registration cost for the services (e.g., websites / auctions / trade exchanges / marketplaces).

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

   ii. Transportation cost of the physical goods from the seller to the buyer's place).

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

iii. Transportation cost of the possible buyer to the stakeholder site for physical inspection

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

iv. Commission paid to the external agencies for effecting the value recovery

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

v. Commission paid to the external agencies for customs clearance etc.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

b. Costs incurred by the organization for its own operations

i. Transportation cost

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

ii. Marketing and advertising costs (request for bids, tenders, secondary markets etc)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

iii. Material handling costs (costs to repackage, relabel etc).

c. Miscellaneous and overhead costs

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

28. The following represent some of the factors that determine "total expected product recovery" for **"reprocessing"** options. For each of them, indicate their degree of influence on the "total expected product recovery". Use a scale of 1 through 7 with 1 representing "**not at all valid**" and 7 representing **"highly valid"**. Please use the space below to explain any reasoning, if necessary.

a. Cost of inspection to identify the nature of defect

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

b. Energy cost involved in "reprocessing"

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

c. Labor cost of "reprocessing" operations

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

d. Cost of additional material required for "reprocessing" operations

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

e. Other overhead / miscellaneous costs for "reprocessing" operations

29. According to you, on what are some of the major costs that you expect to be included in this term?

30. The following represent some of the factors that determine "total expected product recovery" for **"Other"** options. For each of them, indicate their degree of influence on the "total expected product recovery". Use a scale of 1 through 7 with 1 representing "**not at all valid**" and 7 representing **"highly valid"**. Please use the space below to explain any reasoning, if necessary.

a. Land-filling costs

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

b. Transportation costs to the concerned destination

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

Questions 31 – 35:

31. These set of questions focus specifically on **"Expected Value of Recovery of DO_i"**. It is defined as the amount that is expected to be recovered by choosing a disposition option.

Score for Disposition Option$_i$ (*DO_i*) = S_i = *(Value of RTU under consideration) + (Total expected cost of implementing DOi) – (Expected Recovery Value of DO_i)* --- *Eq.1*

32. The following represent some of the factors that determine the "expected value recovery" for direct recovery options. For each of them, indicate their degree of influence on the "expected recovery value" of direct recovery. Use a scale of 1 through 7 with 1 representing **"not at all valid"** and 7 representing **"highly valid"**). Please use the space below to explain any reasoning, if necessary.

(viii) Demand in the secondary market

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

(ix) Capability of third party

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

(x) Buyer's need

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

(xi) Transportation cost to the destination

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

(xii) Demand in other units of the organization

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

(xiii) Vendor’s Annual Clearance agreement terms

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

(xiv) Vendor’s consignment agreement quantity

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

33. The following represent some of the factors that determine the “expected value recovery” for **“reprocessing”** options. For each of them, indicate their degree of influence on the “expected recovery value” of direct recovery. Use a scale of 1 through 7 with 1 representing **“not at all valid”** and 7 representing **“highly valid”**). Please use the space below to explain any reasoning, if necessary.

    a. Quality of RTU

    ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

    b. Infrastructure at the reprocessing facility

    ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

    c. Contracts available for stakeholders

    ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

34. What are the other parameters that you think should be included in Eq.1 shown below?

Score for Disposition Option$_i$ (DO_i) = S_i = *(Value of RTU under consideration) + (Total expected cost of implementing DOi) –* *(Expected Recovery Value of DO_i)* --- *Eq.1*

35. In your opinion, how far do this evaluation / scoring equation capture the real time variables? Use a scale of 1 through 7 with 1 being **“not at all representative”** and 7 being **“highly representative”**. Please use the space below to explain any reasoning, if necessary.

    ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

APPENDIX C

QUESTIONNAIRE FOR GOAL 3

Overview: The purpose of this interview session is to garner information that will help validate my methodology. This section is related to the third goal of the methodology that seeks to reduce the number of future returns. The interview questions will be focused towards following areas:

1. Return reasons and recommendations to reduce the returns initiated by the producer / manufacturer.
2. Return reasons and recommendations to reduce the returns initiated by the end consumer.
3. Return reasons and recommendations to reduce the returns initiated by the seller / vendor.
4. Return reasons and recommendations to reduce the returns initiated by the transporter.

The interview will be expected to last between 45 minutes to 1 hr.

Questions 1 – 20:

Motive: The purpose of this set of questions is to explore the return reasons initiated by the manufacturer. The various ways by which a producer / manufacturer can be an "initiator" is illustrated in the form of a fish-bone chart in Figure C.1. These set of questions are designed to test the validity of the developed reasons.

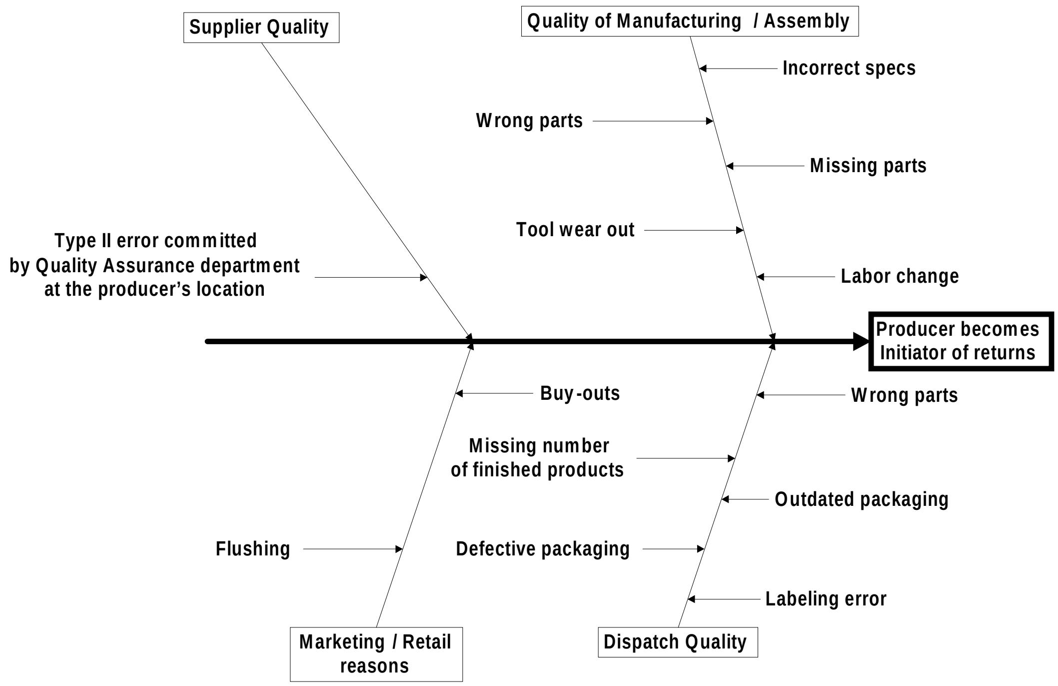


Figure C.1 Reasons for returns initiated by Producer / Manufacturer

1. Comment of the following statement. "Quality of manufacturing / assembly" is a crucial factor that makes the producer / manufacturer to be the initiator of returns.

☐ Fully agree ☐ Somewhat agree ☐ Can't say

☐ Somewhat disagree ☐ Fully Disagree

2. If you answer to question #1 is "fully agree" or somewhat agree" please go to question #3. If your answer is "fully disagree" or "somewhat disagree" or "can't say" please describe why.

3. Refer to Table C.1. It lists the various secondary reasons which makes "quality of manufacturing / assembly" to be one of the primary reasons for producer / manufacturer taking up the role of initiator of returns. Indicate the validity level of these secondary reasons. Use a scale of 1 through 7 with 1 representing **"not at all valid"** and 7 representing **"highly valid".** Please use the space below to explain any reasoning, if necessary.

Table C.1 Validity level of various secondary reasons of the primary reason - "Quality of Manufacturing / Assembly"

Secondary Reasons	**Validity Level**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Incorrect specifications							
Missing Parts							
Tool Wear out							
Labor Change							

4. Please list other secondary reasons that makes “Quality of manufacturing / assembly” to be one of the primary reasons for producer / manufacturer taking up the role of initiator of returns.

5. Comment of the following statement. “Dispatch Quality” is a crucial factor that makes the producer / manufacturer to be the initiator of returns.

☐ Fully agree ☐ Somewhat agree ☐ Can’t say

☐ Somewhat disagree ☐ Fully Disagree

6. If you answer to question #5 is “fully agree” or somewhat agree” please go to question #7. If your answer is “fully disagree” or “somewhat disagree” or “can’t say” please describe why.

7. Refer to Table C.2. It lists the various secondary reasons that make "Dispatch Quality" to be one of the primary reasons for producer / manufacturer taking up the role of initiator of returns. Indicate the validity level of these secondary return reasons. Use a scale of 1 through 7 with 1 representing **"not at all valid"** and 7 representing **"highly valid".** Please use the space below to explain any reasoning, if necessary.

Table C.2 Validity level of various secondary reasons for the primary reason - "Dispatch Quality"

Secondary Reasons	**Validity Level**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Wrong parts							
Missing number of finished products							
Defective Packaging							
Outdating Packaging							
Labeling error							

8. Please list other secondary reasons that make “Dispatch Quality” to be one of the primary reasons that makes producer / manufacturer the initiator of returns.

9. Comment of the following statement. “Marketing / Retail reasons” is a crucial factor that makes the producer / manufacturer to be the initiator of returns.

☐ Fully agree ☐ Somewhat agree ☐ Can’t say

☐ Somewhat disagree ☐ Fully Disagree

10. If you answer to question #9 is “fully agree” or somewhat agree” please go to question #11. If your answer is “fully disagree” or “somewhat disagree” or “can’t say” please describe why.

11. Refer to Table C.3. It lists the various secondary reasons which makes "Marketing / Retail reasons" to be one of the primary reasons for producer / manufacturer taking up the role of initiator of returns. Indicate the validity level of these secondary reasons. Use a scale of 1 through 7 with 1 representing **"not at all valid"** and 7 representing **"highly valid".** Please use the space below to explain any reasoning, if necessary.

Table C.3 Validity level of the various secondary reasons for the primary reason - "Marketing / Retail reasons"

Secondary Reasons	**Validity Level**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Flushing							
Buy – outs							

12. Please list other secondary reasons that makes “Marketing / retail reasons” to be one of the primary reasons that makes producer / manufacturer the initiator of returns.

13. “Supplier Quality” is a crucial factor that makes the producer / manufacturer to be the initiator of returns.

☐ Fully agree ☐ Somewhat agree ☐ Can’t say

☐ Somewhat disagree ☐ Fully Disagree

14. If you answer to question #13 is “fully agree” or somewhat agree” please go to question #15. If your answer is “fully disagree” or “somewhat disagree” or “can’t say” please describe why.

15. Type II error committed by quality department at the producer's location affects the supplier quality. Indicate the validity level of this secondary reason on the primary reason – Supplier Quality. Use a scale of 1 through 7 with 1 representing **"not at all valid"** and 7 representing **"highly valid"**. Please use the space below to explain any reasoning, if necessary.

16. Please rate the suggestions along the following attributes in Table C.4.

a. Capability of suggestions: On a scale of 1 through 7 with 1 representing "will not all be a solution to this problem" and 7 representing "best solution to the problem at hand"

b. Practicality of suggestions: On a scale of 1 through 7 with 1 representing "highly impractical solution to implement and 7 representing "can be implemented with considerable ease".

Table C.4 Validity of Suggestions

Reasons	**Suggestions**	**Capability of suggestions (A score of 1 thro 7)**	**Practicality of suggestions (A score of 1 thro 7)**
Quality of Mfg. / Assembly	Lean techniques (5S, Visual representation and 6σ).		
Dispatch Quality	Final packing list check up against ERP s/w output.		
	Lean techniques (Poka-yoke, Visual representation).		
	Optimized Packaging technology		
Supplier Quality	Switching to a better sampling plan		
	Increase education and training of the organization personnel.		
	Promote industry wide co-operative efforts.		
	Improved technologies like RFID and bar-coding in inspection.		

17. Some of the costs associated with these suggestions are given below. Please indicate if the costs mentioned below represent the costs expected by the organization for the suggestions given above. Use a scale of 1 through 7 where 1 represents **"not at all representative"** and 7 represents **"Highly representative"**). Please use the space below to explain any reasoning, if necessary.

a. Sampling costs ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐6 ☐ 7

b. Investment infrastructure in

i. Education ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐6 ☐ 7

ii. Technologies ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐6 ☐ 7

iii. Labor ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐6 ☐ 7

iv. Training ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐6 ☐ 7

v. Packing tech s/w ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐6 ☐ 7

vi. Machines ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐6 ☐ 7

18. In addition to this list, please enlist some of the other expected costs.

19. Some of the benefits associated with these suggestions are given below. Please indicate if the benefits mentioned below represent that expected by the organization for the suggestions given above. Use a scale of 1 through 7 where 1 represents **“not at all representative”** and 7 represents **“Highly representative**”. Please use the space below to explain any reasoning, if necessary.

    a. Improved customer perception ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐6 ☐ 7

    b. Reduction in

        i. Cost of Goods Sold (COGS) ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐6 ☐ 7

        ii. Reverse Logistics (RL) costs ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐6 ☐ 7

iii.	Type II error	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐6 ☐ 7
iv.	Process variability	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐6 ☐ 7
v.	Manufacturing returns	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐6 ☐ 7
vi.	Labor costs	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐6 ☐ 7
vii.	Shipping errors	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐6 ☐ 7

20. In addition to this list, please enlist some of the other expected costs.

Questions 21 – 23:

Motive: The purpose of this set of questions is to explore the return reasons initiated by the transporter. These set of questions are designed to test the validity of the developed reasons.

21. Refer Figure C.2. The various ways by which a transporter can be an "initiator" is illustrated in the form of a fish-bone chart in Figure C.2. Comment on the validity level of these primary reasons. Use a scale of 1 through 7 where 1 represents **"not at all valid"** and 7 represent **"highly valid"**. Use Table C5. Please use the space below to explain any reasoning, if necessary.

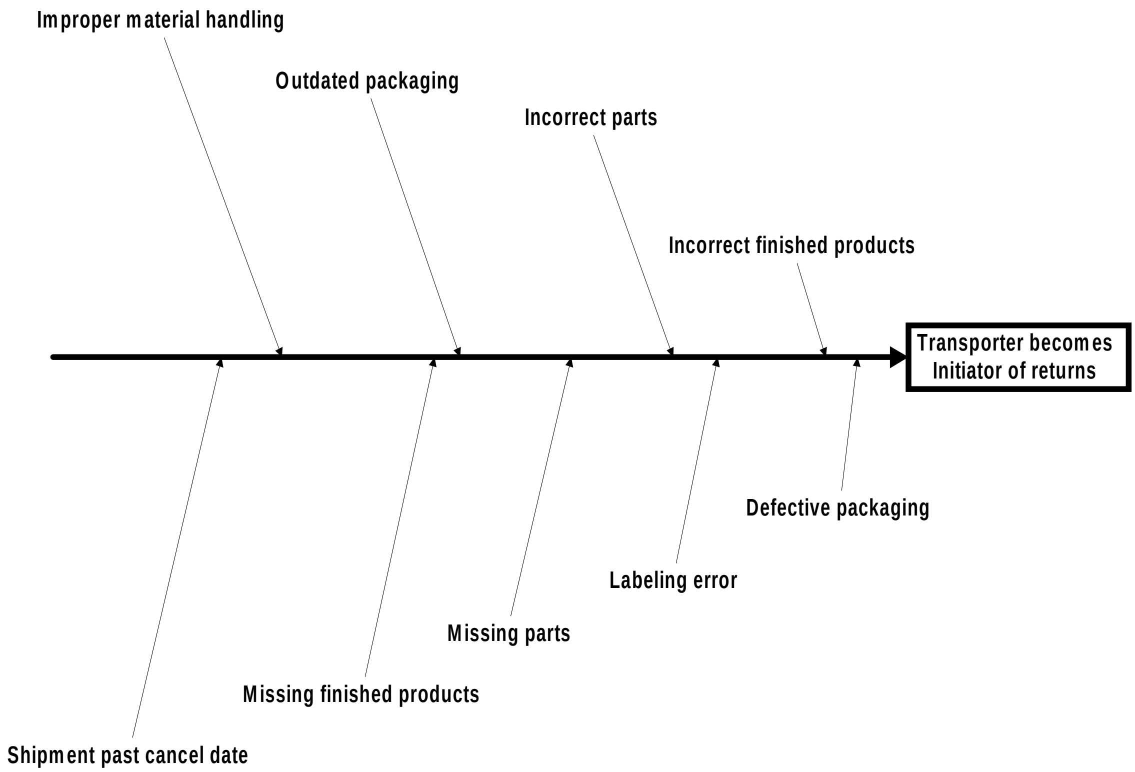


Fig. C.2 Primary reasons for returns initiated by Transporter

Table C.5 Return reasons initiated by transporter

Primary reasons	**Validity Level**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Improper material handling							
Shipments past cancel date							
Missing finished products							
Missing parts							
Labeling error							
Defective packaging							
Incorrect finished products							
Incorrect parts							
Outdated packaging							

22. What are some of the other reasons that make transporter the initiator of returns?

23. The probability of transporter taking up the role of an initiator is directly related to how well the client understands the transporter's capabilities. The following represent some of the critical checklist points that a transporter and its client should mutually consider for a minimal return rate due to the transporter (due to improper material handling and shipment past cancel date). Please comment on the level of importance of these points. Use a scale of 1 through 7 where 1

representing **"least influential"** and 7 representing **"most influential"**. Please use the space below to explain any reasoning, if necessary.

Table C.6 Checklists table for a transporter and its client

Checklist points	**Level of importance**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Maximum number of carriers that can be added							
Maximum number of operators							
Capability of additional mode of transportation service, if needed							
Specialized transport / storage requirements							
Upgrading infrastructure investment capability							

Questions 24 – 30:

Motive: The purpose of this set of questions is to explore the return reasons initiated by the seller. These set of questions are designed to test the validity of the developed reasons.

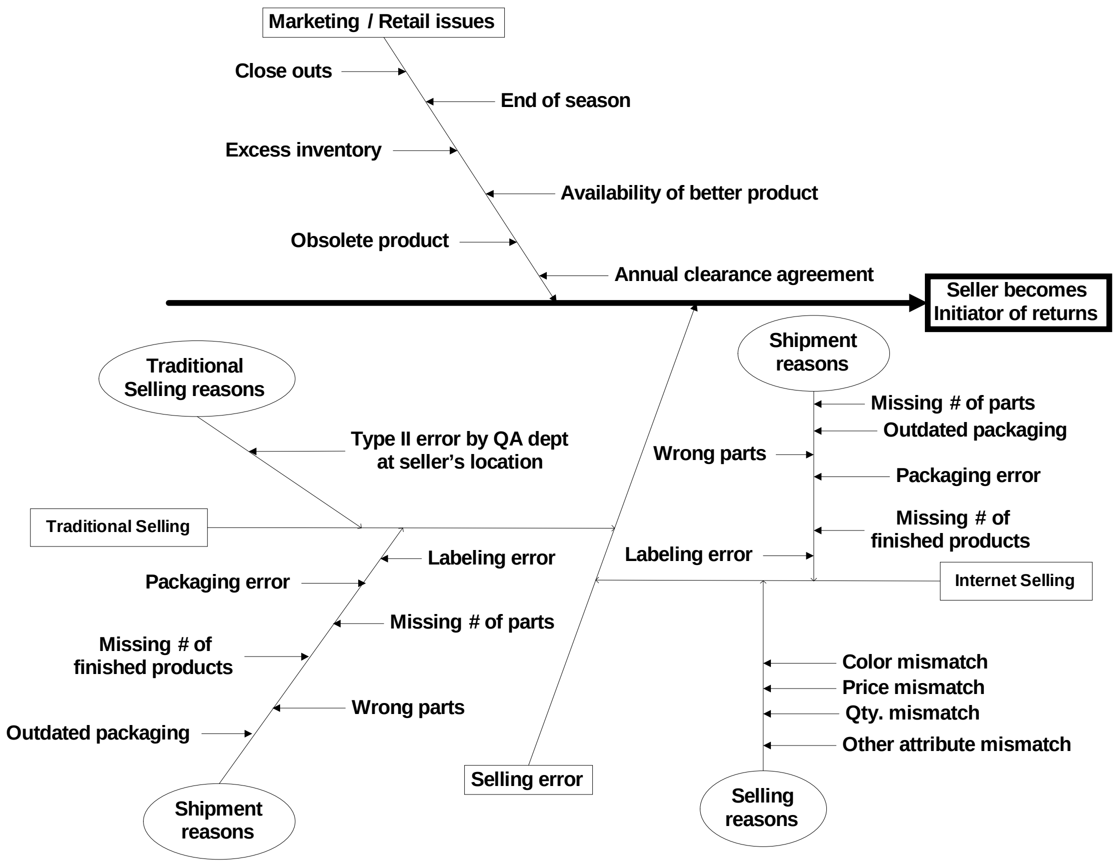


Figure C.3 Return reasons initiated by Seller

24. Refer Figure C.3. Comment of the following statement. "Marketing / Retail reasons" is a crucial factor that makes the seller to be the initiator of returns.

☐ Fully agree ☐ Somewhat agree ☐ Can't say

☐ Somewhat disagree ☐ Fully Disagree

25. If you answer to question # 24 is “fully agree” or somewhat agree” please go to question # 26. If your answer is “fully disagree” or “somewhat disagree” or “can’t say” please describe why.

26. Refer to Table C.7. It lists the various secondary reasons that makes “Marketing / retail issues” to be one of the primary reasons for seller taking up the role of initiator of returns. Indicate the validity level of the return reasons. Use a scale of 1 through 7 with 1 representing **“not at all valid”** and 7 representing **“highly valid”**. Please use the space below to explain any reasoning, if necessary.

Table C.7 Validity level of the various secondary reasons for the primary reason - “Marketing / Retail issues”

Causes	**Validity Level**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Close outs							
End of season							
Excess inventory							
Availability of better products							
Obsolete product							
Annual clearance agreement							

27. Please list other causes that makes “Marketing / retail issues” to be one of the reasons that makes seller the initiator of returns.

28. Comment of the following statement. “Selling error” is a crucial factor that makes the seller to be the initiator of returns.

☐ Fully agree ☐ Somewhat agree ☐ Can’t say

☐ Somewhat disagree ☐ Fully Disagree

29. If you answer to question #28 is “fully agree” or somewhat agree” please go to question #30. If your answer is “fully disagree” or “somewhat disagree” or “can’t say” please describe why.

30. Refer to Table C.8. It lists the various secondary, tertiary, quaternary reasons that make "Selling error" to be one of the reasons for seller taking up the role of initiator of returns. Indicate the validity level of the return reasons. Use a scale of 1 through 7 with 1 representing **"not at all valid"** and 7 representing **"highly valid"**. Please use the space below to explain any reasoning, if necessary.

Table C.8 Validity level of the various causes of the reason - "Selling error"

Reasons	**Validity Level**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Traditional Selling							
Traditional Selling Reasons							
Type II error committed by QA dept. at seller's location							
Shipment Reasons							
Labeling error							
Packaging error							
Missing # of parts							
Missing # of finished products							
Wrong parts							
Outdated packaging							
Internet Selling							
Shipment Reasons							
Missing # of parts							
Outdated packaging							
Wrong parts							
Packaging error							
Missing # of finished products							
Labeling error							
Selling reasons							
Color mismatch							
Quantity mismatch							
Price mismatch							
Other product attribute mismatch							

31. Refer Table C.9 The following points represent some of the process improvement techniques that mitigate the number of errors due to selling (both traditional as well as online). Comment on the practicality and usefulness of them. Use a scale of 1 through 7 with 1 representing **“not at all valid”** and 7 representing **“highly valid”.** Please use the space below to explain any reasoning, if necessary.

Table C.9 Practicality of suggestions to improve on the errors due to “selling”

Suggestions	**Capability of suggestion to solve the problem**							**Ease of implementation**						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Presence of a “Quality check” station before web-posting to ensure correct matches.														
Presenting the user with pictures, free demos, manuals, trial versions, etc in the website for all possible products and services.														
Better sampling plan for quality check of products from upstream supply chain members.														
Lean techniques (poka-yoke and visual representation techniques) at seller’s place.														

APPENDIX D

IMPLEMENTATION GUIDELINES

The revised methodology was discussed in Chapter 5. The previous section talked about the revised methodology. For each of the goals in the methodology there were a series of steps that needs to be adhered. For implementing each of those steps, an organization should have a work plan of how to go about each one of them. Consequently, this calls for an "Implementation guideline" that will guide the organization in the successful implementation of each of the steps given in the methodology.

Before going in to the nuances of each of the steps in the three goals separately, the organization has to adopt a structured approach. The approach calls in for a few dedicated personnel for this purpose. Some of the key tasks include:

(i) A "Project Champion" should be responsible for the implementation. This is a mandatory step because reverse logistics is usually given a least priority. Hence for the successful implementation, a "Project Champion" should be appointed by the top management. Ideally, he / she will be from the Logistics Department. Alternatively, the departmental head from "Procurement / Purchase" or "Marketing / Sales" could serve to be the champion because of their close interaction with the returns management function of the organization.

(ii) The Project Champion should have a couple of sub-ordinates conversant with the returns management process of the organization. Ideally, the sub-ordinates are expected to be carrying out the project implementation as a full-time responsibility. Some of the techniques that they need to be familiar with are the time study measurements, process flow diagrams, lean manufacturing basics, supply chain material and information flows, network optimization, cost accounting etc.

(iii) Since it calls for an inter-disciplinary approach from an organization, all the departmental heads should be cognizant of the salient features of the methodology. In addition to it, there should be an unhampered information flow across departments to the Project Champion and the sub-ordinates.

(iv) The essential feature of this methodology can be divided into two distinct areas: (a) Issue dealing with the existing / current returns (b) Issues dealing with possible future returns. While goal 1 and 2 deal with the former, goal 3 deals with the latter. It is recommended to handover the tasks in goal 1 and goal 2 to one sub-ordinate and goal 3 to another.

(v) To begin with, the sub-ordinates will start performing the steps listed in the “implementation guideline” section for each of the three goals. The steps are quite straight forward.

(vi) A lot of times, they will have to visit outside the organization to various channel members to collect, corroborate and consolidate data.

(vii) In some situations, certain assumptions are to be made. For instance, in coming up with the parameters of the scoring model, some “expected value measures are to be taken care of”. In these situations, before making key assumptions, necessary evidences should be collected. Historical data could also be used.

(viii) The anticipated completion of the project would be from 6 months to 1 year window.

(ix) The first level denotes the goal number that ranges from 1 through 3. The second number refers to the step number. Hence "IG 2.3" would refer to the third step in the second goal.

Steps in Implementation Guidelines

IG 1.1: The task here is to identify the major players in each category and **not** the names of the individual organizations. Hence, a top level diagram that includes the major influential players should be mapped. The sub – ordinates should consider the following:

(i) For each of the major products that the organization deals with, trace the flow of products all the way from tier 1 supplier to tier 1 customer in the FSC. This will give a picture of the product and information flow between the various actors.

(ii) Trace back the flow of products to identify the major players in the RL cycle. Depending upon the contract and agreements, returns could originate anywhere in the supply chain. All points after tier 1 customers are still to be considered the "end customer" for this research.

(iii) For doing the above two steps, the sub – ordinates should co-ordinate with various departments of the company including sales and marketing, finance, procurement, maintenance, logistics, manufacturing / operations. The sub – ordinates will be discussing the flow of products into and out of their domain. This will enable them not only in identification of FSC and RSC actors but will also help them in the sub – sequent steps of mapping the product flow.

IG 1.2: After identification of the actors are done, it suggested to map them for flow of products and information. The task here will be to map the product and information flow in such a way that the network structure includes the longest possible path a product can follow. This is done to take the worst – case scenario into consideration. As mentioned in the methodology section, the focus is not on the geographical distance but on the number of actors in the supply chain.

IG 1.3: The sub – ordinates should analyze the network structure developed and identifying the RSC_{entry} and RSC_{exit} points. They will just pick two nodes in the structure, one for each. This will roughly fix the demarcation limits between the FSC and RSC frontier.

IG 1.4: The following are the tasks that need to be performed in step 4.

(i) Enlist the various operations between RSC_{entry} and $RSC_{exit.}$ The typical operations include gate-keeping, sorting, storing, transportation, asset recovery. These might be a top level description for some organizations. If needed, each of them could possibly be analyzed to see if more than one operation is confounded in them. For example, an operation called “cross – docking” may be included as one of the RSC operation. If it is trivial (in terms of frequency of occurrence), it would be wise to included it as an activity under the operation “Storage” or “Transportation” depending upon the individual situation. The objective is to list all the major operations in the RSC.

(ii) For each identified operation, enlist the various activities. As mentioned in the methodology, the list of activities will not be standard for different operations. It differs based on the activity, based on the SKU etc. However, it is recommended to include all possible activities. The sub – ordinates will start performing an activity flow diagram for each operation to get a comprehensive list of activities. The process of doing the activity flow diagram can be done as long as the list of activities becomes comprehensive.

IG 1.5: Step 5 recommends doing a "Process Flow" Chart. Hence, the sub – ordinates should be pretty aware of the labor allowances, fatigue and all other time calculations like normal time, standard time etc. Classify each activity into the classical process categories of "operation", "storage", "decision", "inspection" and "delay". Refer to the Process Flow Chart in the following page.

Table D.1 Process Flow Chart

RSC OPERATION: Gate keeping
RTU: ABC123

DATE: April 4, 2006
TIME: 11:31:05 PM

Process Categories →	**Operation**		**Storage**		**Decision**		**Inspect**		**Delay**		**Transport**		**Value Recovery**	
Activity ↓	*OT*	*ST*	*OT*	*ST*	*OT*	*ST*	*OT*	*ST*	OT	ST	OT	ST	OT	ST
Inspect documents														
Check for completeness														
Return to customer if not complete														
Check for warranty														
Return to customer if not ok														
Check for product characteristics														
Return to customer if not ok														
Credit customer														
Sort RTU's														
Pack the products														
Move to store location														
Store														
Issue RMA														
ST_i	5			10		6		7		8		9		2

IG 1.6: After classifying the activities into the process categories, the classification is checked again if any of them can be included in the "Value recovery" category. The "value recovery" activity is that category that includes all the asset recovery operations. Some of the typical asset recovery operations include remanufacturing, refurbishing, repair, recycle etc. The process of classifying an activity into the "Value recovery" category is sometimes subjective that is based on the decision of the person doing the process flow chart. Hence there should be consensus arrived between the sub – ordinates, project champion and other relevant members. This is important because it will give a picture of how much time is spent effectively in the "value recovery" in the reverse stream. The sub – ordinates are expected to be conversant of the reverse logistics operations to judiciously classify the activities into various process categories.

IG 1.7: Excluding the "value recovery" category, the task here is to sum the STs of all the process categories. This will give the ST of the particular RSC operation. Label them as ST_{RSC1}. It is given by:

$ST_{RSC1} = \sum ST_i$ (i = "Operation" to "Transport". Value recovery is not to be included).

Now, sum the STs of "value recovery" activities to get the standard time of value recovery. Label it as $STVR_{RSC1}$. It is given by:

$STVR_{RSC1} = \sum$ ST of all activities in "Value Recovery" category

IG 1.8: For the same RTU, follow IG 1.5 thro IG 1.7 for the rest of RSC operations between RSC_{entry} and RSC_{exit}. Doing this will yield ST_{RSC1}, ST_{RSC2} … ST_{RSCn} and $STVR_{RSC1}$, $STVR_{RSC2}$ … $STVR_{RSCn}$.

IG 1.9: Calculate the following time parameters:

i) Total time taken by RTU_1 to traverse the RSC: This is labeled as $\mathbf{TT_{RTU1}}$ and is calculated using the following equation:

$TT_{RTU1} = \sum (ST_{RSC1} + ST_{RSC2} + \ldots ST_{RSCn} + STVR_{RSC1} + STVR_{RSC2} + \ldots STVR_{RSCn})$

ii) Value Recovery Time of RTU_1: This is labeled as $\mathbf{VRT_{RTU1}}$ and is calculated using the following equation:

$VRT_{RTU1} = \sum (STVR_{RSC1} + STVR_{RSC2} + \ldots STVR_{RSCn})$

Similarly calculate VRT_{RTU2} VRT_{RTU3} VRT_{RTU4} ……… $VRT_{RTUn.}$

IG 1.10: It is recommended to run through IG 1.5 through IG 1.9 for all RTUs for a significant period of time. The word "significant" is used in a subjective fashion and is dependent upon the return pattern attributes like the average returns per unit time, seasonality etc. The motive behind this step is to get a good profile of the reverse logistics flows in the organization. Typically, it is recommended to use anywhere from month to 3 months to gain a good profile. The idea here is to use a time frame that captures the steady state condition rather than the anomalies.

IG 1.11: Based on the process flow chart calculations, the following parameters are to be calculated.

(i) Average Total Time (Avg. TT): This is the average of TT for all RTUs for the given time period under consideration.

$TT_{RTU1} = \sum (ST_{RSC1} + ST_{RSC2,} + \ldots + ST_{RSCn} + STVR_{RSC1} + STVR_{RSC2} + STVR_{RSCn})$.

Avg. TT = Average (TT_{RTU1}, TT_{RTU2} …TT_{RTUn}).

(ii) Average Value Recovery Time (Avg. VRT): This is the average of the VRTs of the various RTUs in the same time period.

$VRT_{RTU1} = \sum (STVR_{RSC1} + STVR_{RSC2} + STVR_{RSCn})$

Avg. VRT = Avg. (VRT_{RTU1}, VRT_{RTU2} …VRT_{RTUn}).

(iii) Time Efficiency (T.E): This parameter is similar to the concept of Lean ratio in the FSC that is given by dividing VAT by the total time taken. This is given by the following formula:

T.E = Avg. VRT / Avg. TT.

(iv) Non-Value Recovery Time (NVRT): This is the total time that is spent on all activities excluding the VRT. Hence it is given by:

NVRT = Avg. TT – Avg. VRT.

(v)Average Standard Time of process categories (Avg. ST_i): For each of the various process categories listed in the process flow chart, we calculate the average standard time using:

Avg. ST of a given process category i =

Total ST of the process category i / # of RTUs under consideration in the given time period.

IG 1.12: Step 12 in the methodology corresponds to process improvement techniques based on the time parameters collected from the process flow chart analysis. Some of the key issues to be noted in this regards are as follows:

(i) The process of data analysis should be standardized.

(ii) Data analysis should include “scenario analysis”, and “sensitivity analysis”.

(iii) For constructing the spider chart, a target that is reasonable should be developed. This has to get the consensus of all the concerned personnel in the process.

(iv) Refer to the following set of figures to get a picture of the possible kind of analyses that could be used.

(a) Average Standard Time of RSC operations

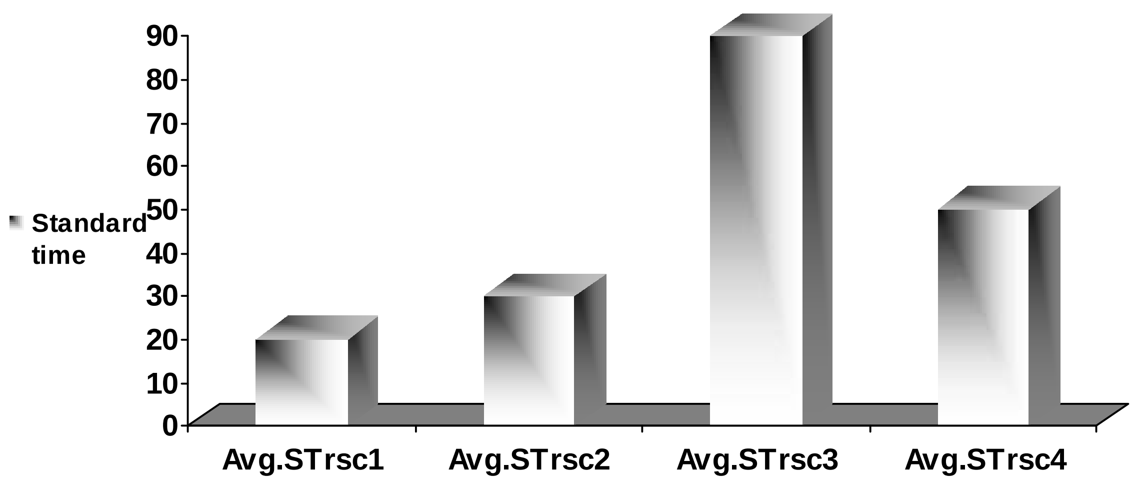


Figure D.1 Standard Times vs. RSC Operations

(b) Standard Times of RSC operations vs. RTUs:

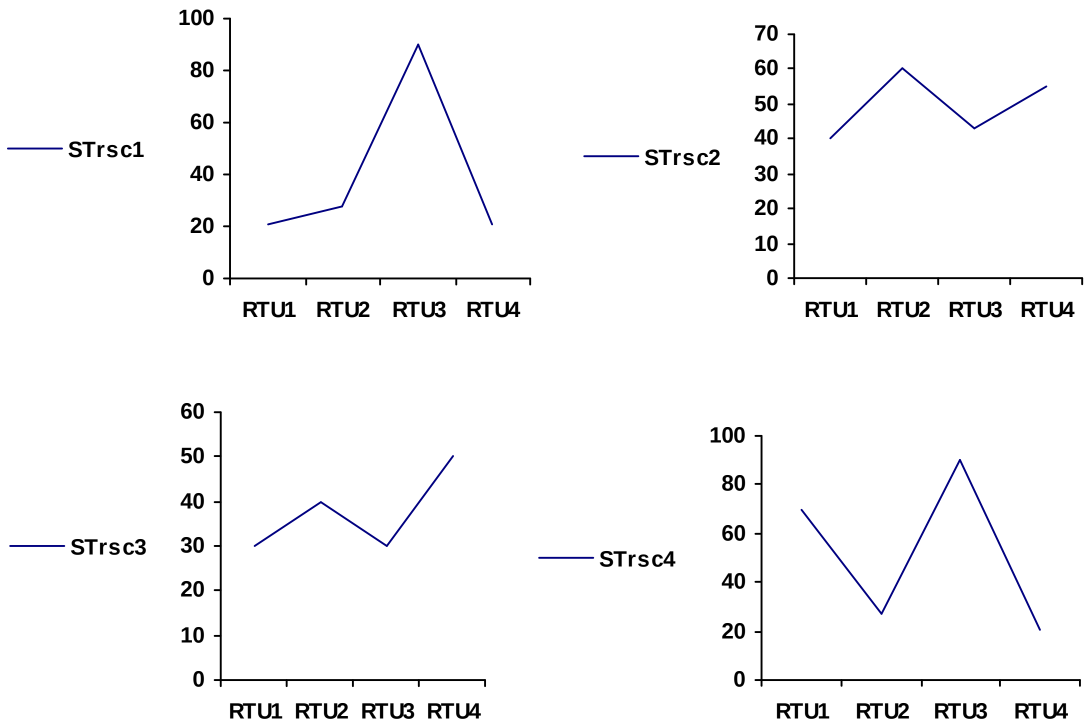


Figure D.2 Standard Times vs. RTUs

(c) Total time vs. Value Recovery Time for RTUs

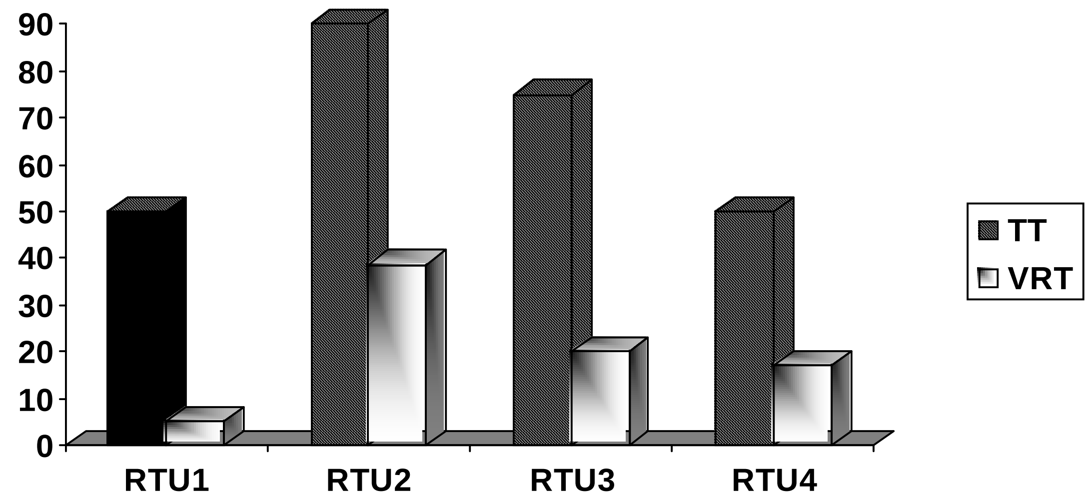


Figure D.3 Total time and Value Recovery Time for RTUs

(d) Avg. Standard Time vs. Process Categories

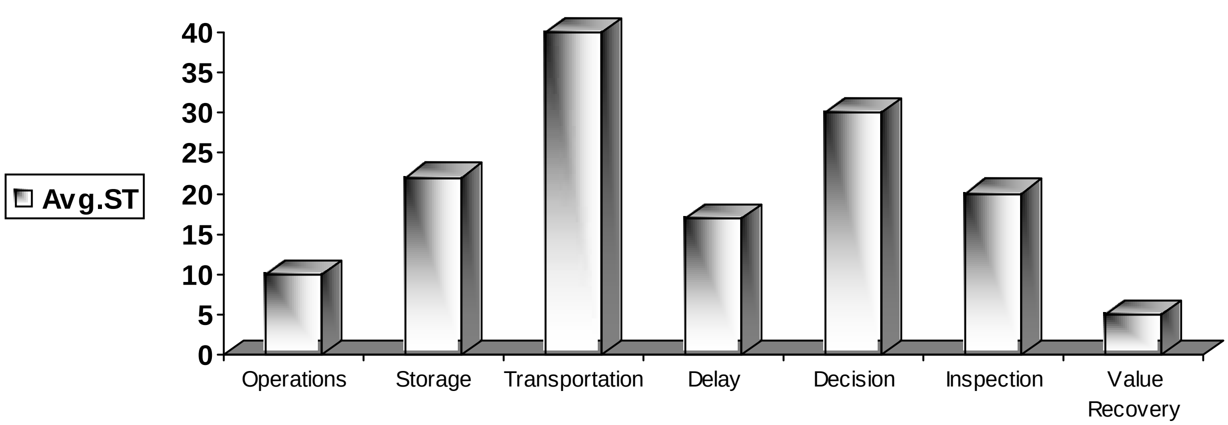


Figure D.4 Standard Times vs. RSC Operations

(e) Time Efficiency of RTUs

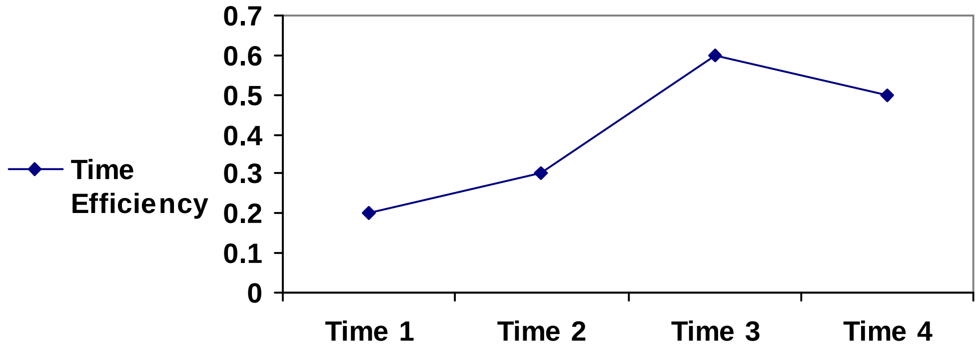


Figure D.5 Time Efficiency of RTUs

Goal 2

IG 2.1: The first step in the second goal of the methodology seeks to identify bases of classification. The sub-ordinates need to analyze the returns stream so that bases of classification can be developed. Some of the bases of classification that can be used by the sub-ordinates include:

(i) Based on the value of the total shipment (Products and Packaging)

(ii) Based on the condition of the product (End-of-Life [EOL], End-of-Use [EOU] and Commercial)

(iii) Based on the reason for return (Close outs, Buy-outs, Job outs, Surplus, Defectives, Non-defectives and Salvage)

(iv) Based on the physical characteristics of the product (Metal, non-metal, cardboards, alloys etc)

(v) Based on the place from which the returns are shipped (Manufacturing returns, distribution returns, customer / user returns etc).

Table B.1 Continued

(vi) Based on the industry (electronic returns, textile returns, automobile returns etc).

(vii) Based on the type of product (Finished goods, sub assembly, loose components, machines, tools etc).

If these above bases are not enough to capture the returns profile in the organization, then the sub-ordinate should seek to decipher additional bases of classifying depending upon the specific situation.

IG 2.2: The second step in the methodology is to choose the bases to be used for the problem respectively Given that the bases of classification have been developed , the sub-ordinates will now have to choose the selected bases of classification that will be adhered to. They will be examining each bases of classification for relevance to the returns problem in the organization.

IG 2. 3: From the following table, codify the returns into identifiable RTUs.

Table D.2 Type of Commercial Returns

#	**Based on**	**Levels**	**Codes**
1	Proportion of the value of shipment	Product, Packaging	PR, PA
2	Condition of the product	EOL, EOU, Commercial	L, U, C
3	Reason for return	Close-outs, Buy-outs, Job-outs, Surplus, Defectives, Non-defectives, Salvage, Other	C,B,J,SU,D,N,SL,O
4	Physical Characteristics	Metals, Non-metals, Alloys, Other	M,NM,A,O
5	Place from which the returns are shipped	Manufacturing returns, distribution returns, customer / end user returns, Other	M, D, E,O

Table D.2 Continued

6	Industry	Electronic, Automobile, Textile, Retail, Other	E,A,T,R,O
7	Type of product	Finished goods, sub-assembly, loose components, machines, tools	FG, SA, LC, M, T

If there are any additional bases of classification identified by the sub – ordinates, they should ensure that it gets documented.

IG 2.4: The next step in the methodology is to classify the disposition options. The sub-ordinates will have to perform the activity similar to classifying the returns. They will identify the various plausible disposition options available in the organization. They will constantly explore new disposition alternatives and update them in the classification scheme that they had developed for the disposition options. They could probably use the following classification scheme. They could add / delete disposition options based on their unique needs.

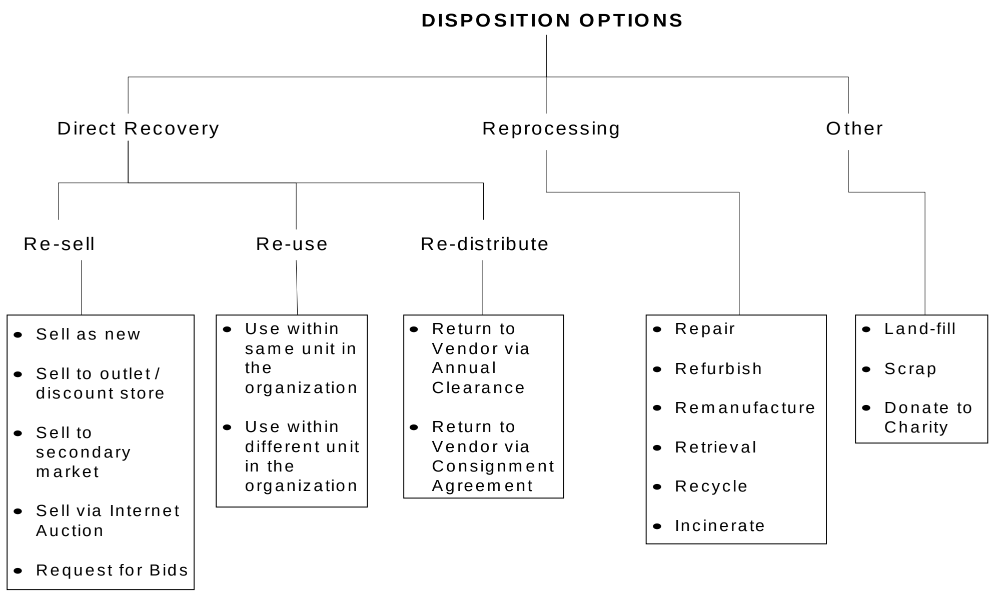


Figure D.6 Classification of Disposition Options

IG 2.5: After having identified and classified the return type and the disposition options available in the organization, the sub – ordinates will tie them in a holistic framework. For each return type, they will check across the options that are feasible and plausible in the first place. Refer the table in the following page.

Table D.3 Framework for Disposition Options

RETURN TYPE → STRATEGY ↓	EOL	EOU	COMMERCIAL						
			Close-outs	**Buy-outs**	**Job-outs**	**Surplus**	**Defectives**	**Non-defectives**	**Salvage**
Sell as new	×	×	✓	×	✓	✓	×	✓	×
Sell to outlet or discount store	×	×	✓	×	✓	✓	--	✓	×
Sell to secondary market	×	×	✓	×	✓	✓	--	✓	×
Sell via Internet Auction	×	✓	✓	×	✓	✓	×	✓	×
Request for Bids	×	✓	✓	×	✓	✓	×	✓	×
Use within same unit, same organization	✓	✓	×	×	×	×	×	×	×
Use within different unit, same organization	✓	✓	×	×	×	×	×	×	×
Return to Vendor – Annual Clearance agreement	×	×	✓	✓	✓	✓	✓	✓	✓
Return to Vendor – Consignment Agreement	×	×	✓	✓	✓	✓	✓	✓	✓
Repair	×	✓	×	×	×	×	✓	×	×
Refurbish	×	✓	×	×	×	×	✓	×	×
Remanufacture	×	✓	×	×	×	×	✓	×	×
Retrieval	✓	✓	✓	×	✓	✓	✓	✓	✓
Recycle	✓	✓	✓	✓	✓	✓	✓	✓	✓
Incinerate	✓	✓	✓	✓	✓	✓	✓	✓	✓
Land-fill	✓	✓	✓	✓	✓	✓	✓	✓	✓
Scrap	✓	✓	✓	✓	✓	✓	✓	✓	✓
Donate to Charity	✓	✓	✓	✓	✓	✓	×	✓	✓

IG 2.6: For a given RTU, the various possible disposition options are to be evaluated. In order to do this, the three parameters of the scoring model need to be figured out. The three parameters are given in the following equation.

Score for Disposition Option$_i$ (DO$_i$) = S$_i$ = (Value of RTU under consideration) + (Total expected cost of implementing DOi) – (Expected Recovery Value of DO$_i$).

In this step, the value of RTU is to be found out. The sub – ordinates need to work with the cost – accounting, finance and other relevant department to figure out the actual worth of the RTU under consideration. The actual worth / value of the RTU under may be found out by different methods. For example, in case if the organization that is faced with the responsibility of recovering value from returns (stakeholder of returns) is a manufacturer, then the cost of production might be a good approximation to be used because the amount gives you the money invested from the part of the manufacturing concern. If the stakeholder of the return is a distributor of returns, then the purchase price of the product might well approximate this parameter. Again, this rule will not be applicable to all RTUs. Hence, a cross- functional team should be formed from selected functional units of the organization. Typically, cost – accounting, purchase, finance, sales and manufacturing are expected to be represented in this team along with the Project Champion and the sub – ordinates. The algorithm for finding out the value for various kinds of RTU should be approved by all the members of the cross – functional team before standardizing and documenting.

IG 2.7: The task here is to calculate the total expected value of implementing a disposition option for the given RTU. This has two components namely, the total expected product recovery cost and the total expected environmental costs. The total expected product recovery costs typically include all the costs that will be incurred by the organization in making the disposition option happen. Some examples of some of the type of costs to consider include:

i. Cost paid to external agencies:
    a. Registration cost for the services (e.g., websites / auctions / trade exchanges / marketplaces).
    b. Transportation cost of the physical goods from the seller to the buyer's place).
    c. Transportation cost of possible buyer to the stakeholder site for physical inspection
    d. Commission paid to external agencies for effecting the value recovery
    e. Commission paid to external agencies for customs clearance etc.

ii. Registration costs for the asset recovery services: This includes the cost of registration in a website / auction site / e- portal etc.

iii. Transportation cost: The cost of transportation of the possible buyers to the site for physical inspection of the materials. This holds good in the case of bulk unopened packages of goods returned for a reason, heavy machineries that are difficult to transport etc.

iv. Costs incurred by the organization for its own operations
    a. Transportation cost

b. Marketing and advertising costs (request for bids, tenders, secondary markets etc)

c. Material handling costs (costs to repackage, re-label etc).

v. Miscellaneous and overhead costs

a. Cost of inspection to identify the nature of defect

b. Energy costs

c. Labor cost

d. Cost of additional material required for asset recovery.

e. Other overhead / miscellaneous costs, if any, for asset recovery.

The same cross – functional team will be responsible for identifying the categories of cost and the various costs in each category. Again any new addition of a cost category or a particular cost in a category should be updated in a proper documented fashion so that the process is streamlined.

Next, the teams will also have to consider the environmental costs associated with the various disposition options. The following represent some of the key environmental costs:

(i) Cost of conformance to EPA standards.

(ii) Cost of conformance to OSHA standards.

(iii) Cost of conformance to ISP 14000 requirements standards.

(iv) Cost paid to the federal government

(v) Additional transportation and distribution cost for handling the returns in a environmental friendly fashion.

(vi) Marketing / publicizing costs to promote eco-friendly products

(vii) Cost paid to third party specializing in environmental issues related to a specific disposition option.

The cross – function team will have to find out additional costs, if any, that are related to the environmental issues.

Both the "total expected costs of product recovery" and the "total expected environmental costs" for various disposition options should be reviewed by the team with the Project Champion. It should then by documented so that for a given RTU and a given disposition option, the various categories of costs are known and that all that needs to be done is crunching numbers.

IG 2.8 The task is to figure out the "Total expected recovery value" of a disposition option. This parameter is pretty difficult to estimate because of the presence of lot of uncertain factors. The following represent some of the factors in each of the disposition categories:

(i) Factors affecting the "Direct Recovery" options"

a. Demand in the secondary market

b. Capability of third party

c. Buyer's need

d. Transportation cost to the destination

e. Demand in other units of the organization

f. Vendor's Annual Clearance agreement terms

g. Vendor's consignment agreement quantity

(ii) Factors affecting “Reprocessing” options

a. Quality of RTU

b. Infrastructure at the reprocessing facility

c. Contracts available for stakeholders

The cross – functional team will be required to figure out how each factor will be affecting the expected value recovery of the various disposition options.

The three parameters of the scoring model is vital to the successful selection of the disposition options. Especially, the third parameter is highly difficult. All the data should be documented so that it becomes handy for the next similar RTU. The challenge here is however to come up / forecast the expected value recovery parameter that might differ from time to time.

IG 2.9 Sum up the three parameters for a given RTU and for a given disposition option. Do the same process of fining the three parameters for the same RTU.

IG 2.10: This is the last step in the scoring model in which the disposition option with the least score is selected. The option is implemented.

As a side point, a feedback system that tracks the performance of the scoring system should be implemented. The feedback should include the percentage of savings from the implemented disposition option, the parameter, and the split ups of the various cost estimates of the parameters. This should give a picture of how well the scoring model performs and opportunities for improvement.

Goal 3

For the third goal in the methodology that deals with reducing the number of return items in the future, it is recommended that another sub – ordinate perform the task. The steps involve inter and intra organizational visits to explore the reasons for returns, to find out the initiator of returns and to ensure that the returns due to those identifiable / assignable causes are reduced in the future.

IG 3.1: This step involves identifying the various reasons that makes the "producer / manufacturer" to be the initiator of returns. The sub – ordinate should perform a "Cause – and – Effect" analysis like the one depicted below. In addition these identifiable causes, other causes should be documented.

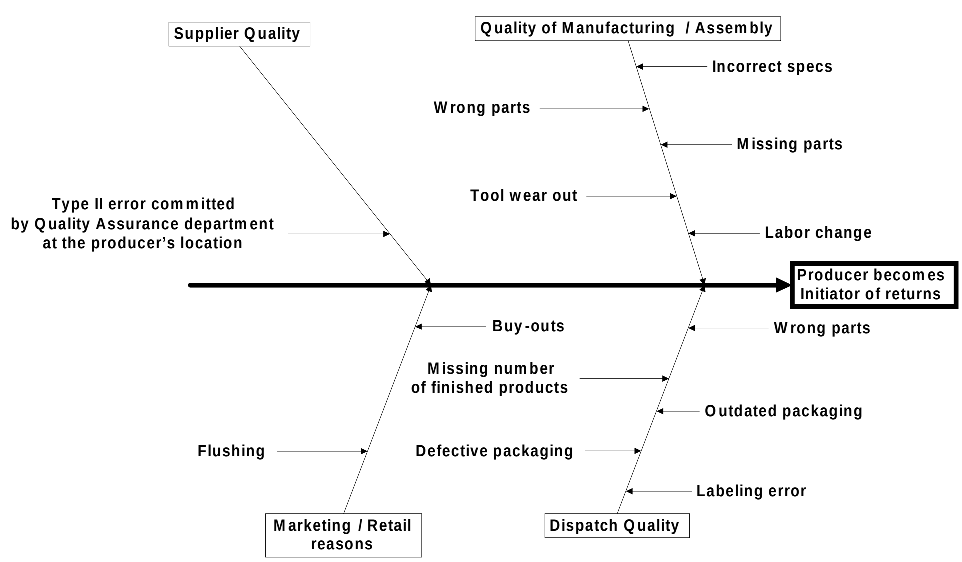


Figure D.7 Return reasons initiated by Producer

IG 3.2: After having identified the return reasons initiated due to the "producer", the sub – ordinates will be developing initiatives that curb the returns for the same reasons in the future. A "poka – yoke" system is highly recommended for this. The next step is to do a cost – benefit analysis for each of the suggested recommendation.

Table D.4 Producer's matrix of suggestions and costs-benefits

REASONS	**SUGGESTIONS**	**COSTS**	**BENEFITS**

1.*Supplier Quality*
(Type II error committed by the Quality Assurance department at the producer's location)
	• Switching to better sampling plan
	• Increase education and training of the organization personnel
	• Promote industry cooperative efforts
	• Improved technologies
	    • RFID
	    • Bar coding
		• Sampling costs
		• Investment infrastructure in education and technologies
			• Reduction in COGS
			• Reduction in RL cost
			• Reduction in type II error

2. *Quality of Mfg /Assembly*
• Incorrect specs
• Missing parts
• Wrong parts
• Tool wear out
	• Lean, 5S,
	• Poka-yoke
	• Visual representation techniques
	• 6σ training
		• Investment infrastructure costs in
		    • Labor
		    • Technology
			• Reduced process variability
			• Reduced manufacturing returns

Table D.2 Continued

• Labor change		• Training • Education	

3. *Dispatch Quality*
• Labeling error
• Defective packaging
• Missing # of products
• Wrong parts
	• Improved packing technology
	• Optimized packing*
	• Final packing list check up against an ERP software output
	• Poka – yoke
	• Visual representation techniques
		• Investment infrastructure costs in
		  • Packing technology software
		  • Machines
			• Reduced labor costs
			• Reduced shipping errors
			• Better customer perception of the organization's product

Optimized Packing*: It is important to figure out the correct carton size for the packing. An under-sized carton will make the packer to squeeze in the final products which may lead to defective packaging. Or the packer might loose time in getting the correct carton size that adds to the productivity loss. An over-sized carton might not be cost-efficient. It can also lead to packing voids that leads to "damaged goods in transit". This can be rectified by figuring out the correct packing size. There are many types of software available in the market to do this. The organization can invest in them or could possibly a packing algorithm to be integrated in its shipping process.			

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IG 3.3: The sub – ordinate will have to work in tandem with the transportation provider if it has any. If it has more than one transportation provider, then each one of them will have to be considered. Typically, the number of external transportation provider is not too much. If not, then they will have to work with the logistics department / shipping department who does that function. The task here is to nail out the possible / plausible return reasons that can be initiated by the transporter. The following cause and effect diagram depicts some of the commonly identified return reasons with respect to the transporter. In addition these, the sub – ordinates will have to work to identify any other return reasons.

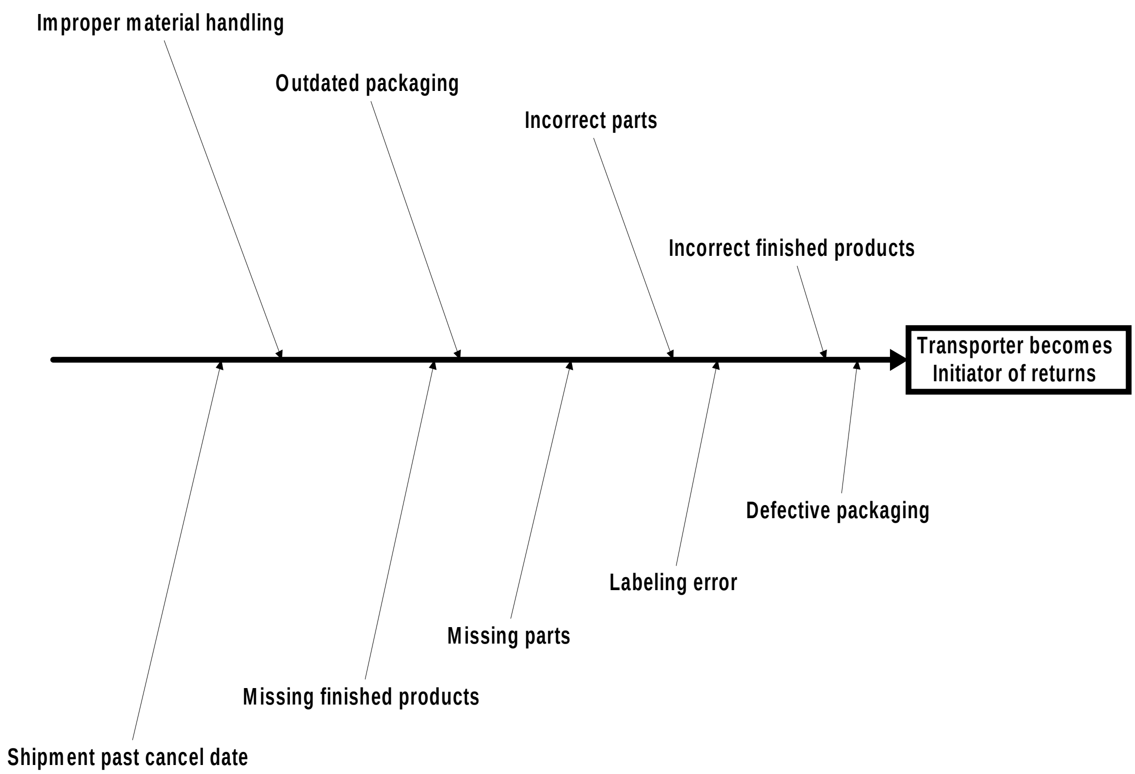

Figure D.8 Return reasons initiated by Transporter

IG 3.4: After having identified the return reasons initiated by the transportation function, now the sub – ordinates will have to develop improvement initiatives that curb the returns due to the identifiable reasons. For doing this, the sub – ordinate will have to work with various departments including the logistics, accounting, finance, sales and marketing and operations. The recommendations will have to be approved by the Project Champion after thorough analysis. Some of them are given below which the sub – ordinates can possibly make use of.

(ii) Investment in travel optimization softwares,

(iii) Labor and resources scheduling methods

(iv) Updating the EDI system within the transporter organization to reflect the latest and dynamic of scenarios.

The sub – ordinate will have to make sure that their organization has answers to the following questions before offering any contract to a 3PL. The answers to these questions will have to be used as valuable inputs in the selection criteria.

(i) What is the maximum number of carriers that can be added?

(ii) What is the maximum number of drivers that can be added?

(iii) What additional mode of transportation would be necessary?

(iv) What special storage requirements would be needed in the warehouse?

(v) How often do we need the automatic sorting and collection equipment?

The sub – ordinate will have to work with the transporter to ensure that the transporter checks a checklist each time in a chronological order is given so that the transporter does not become the initiator of returns. Some of the checklist points include:

(i) Check for the correct parts

(ii) Check for the correct number of parts

(iii) Check for the correct finished goods product

(iv) Check for the correct number of finished goods product

(v) Check for correct packaging

(vi) Check for the labels against the product to eliminate labeling error

(vii) Check packing list before shipping

IG 3.5: The task is to figure out the various return reasons that are initiated by the seller. Now the issue here is to choose which sellers among the multitude of them to proceed with the cause and effect diagram. One method is to choose the sellers for which the volume of returns is high. This is a subjective decision based on some quantitative judgment. A "Pareto" analysis of the various sellers return volume could be done for the manufacturer's products. This, however, requires a lot of collaborative initiatives across organizational boundaries (a higher degree of supply chain integration).

The "Project Champion" will be responsible for making the improvement initiatives across the organization to maintain the corporate image. Once it is done, then the sub-ordinates will work with the seller's representatives to nail out the problems. A typical cause – and effect diagram is outlined below that could be utilized by the concerned parties.

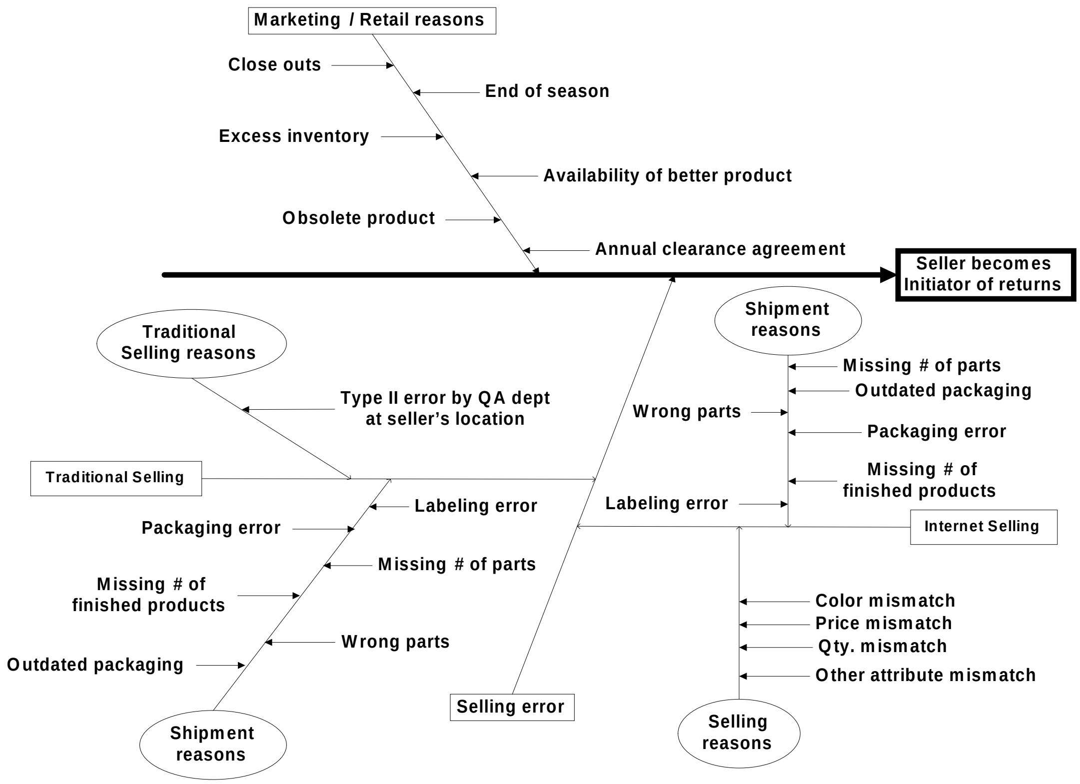

Figure D.9 Return reasons initiated by Seller

IG 3.6: After identifying the return reasons, now the sub – ordinate and the representative from the outside organization will have to collaborate on the process improvement initiatives. The sub – ordinate will have to take some of the success stories in his firm to check for practicality across the other organization. For e.g., the improvement initiatives due to traditional selling can be checked for validity in the sellers' place. A lot of supply chain integration should be considered in this regard. For all the return reasons due to internet, proper remedial procedures should be devised that is mutually beneficial. The key word is "mutual" because it involves more than one organization in the supply chain network.

IG 3.7: The task is to analyze the return reasons initiated by the customer. Most organizations now have mechanism that classify and code the return reasons at the appropriate place in the supply chain. These reasons serve as inputs to developing the cause and effect diagram for the return reasons initiated by the customer. The sub-ordinate should identify key sellers where there is high degree of end customer interaction. A "Pareto Analysis" to identify where the majority of end customer returns happen can be one way to identify the sellers. Typical examples include retail locations and their corresponding e-tail locations. For the selected sellers, the sub – ordinate will work in the similar fashion discussed in the "seller's" section except that their efforts will now be targeted to identify the return reasons initiated by the customer. A sample cause and effect diagram is shown below:

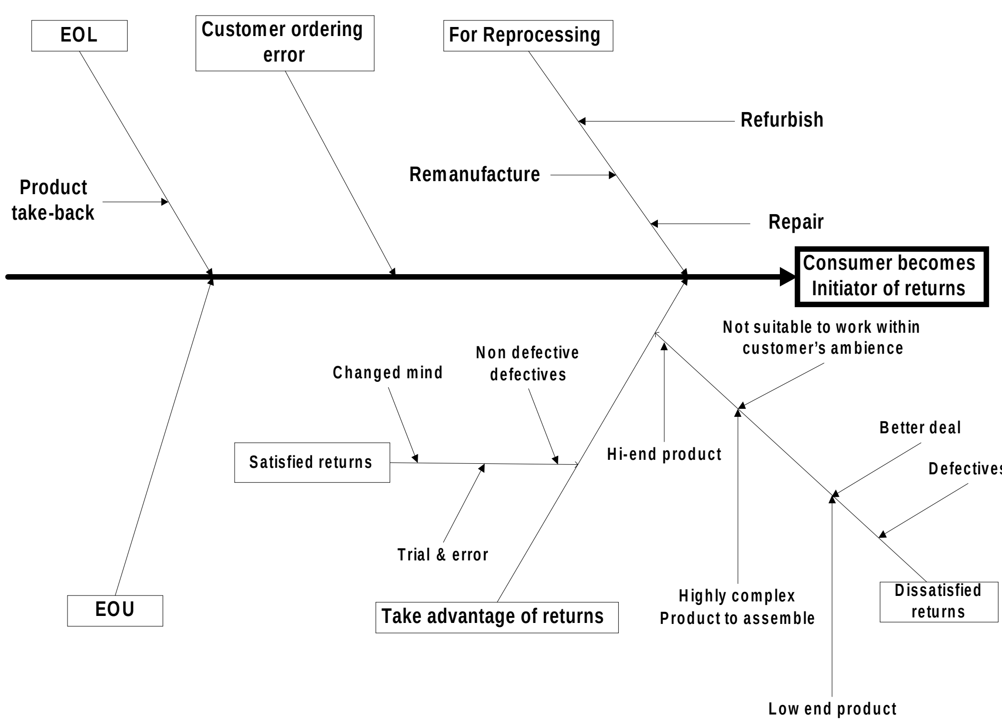

Figure D.10 Return Reasons initiated by Consumer

IG 3.8: The task in this step is to develop improvement initiatives to reduce the returns due to the identified reasons. To do this however, there should be a meeting among the cross functional design of the manufacturing concern followed by inter organizational meetings with the sellers' representatives to discuss the issues with returns, possible remedies, cost – benefit analysis etc. Both the organizations can think of options like (i) allowing free trial for all possible products before purchase (ii) Double checking the product attributes if the sale is through internet and (iii) Publicizing the option of allowing the upgrading feature. There are many solutions that can be developed for the same problem. It depends on the specific instance under consideration. All these remedial procedures will have to be carefully considered because it deals directly with the end customers. Any mishaps will have a serious beating on the corporate image. On the flip side, doing a good job translates itself to a competitive advantage to all concerned parties in the organization

The implementation guidelines given require a lot of supply chain integration between the various supply chain actors. It takes a strong "Project Champion" to steer the cause to take the organization to the next level. A lot of planning and coordinating sessions will be required. The sub – ordinates will have to really adept at reverse logistics operations, cost accounting and administrative tasks. It takes a determined and continuous commitment from all the departments in the organization and all the major influential actors in the closed loop supply chain to achieve success in this.

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He worked as a logistics engineer in Lakshmi Machine Works Limited, Coimbatore, India for 1 year before embarking his higher studies in the U.S. He had completed a couple of Engineering Interns in automotive industries. In the U.S. he worked for the Texas Manufacturing Assistance Center in Fort Worth, Texas in developing a Master Production Scheduling algorithm for an interior decoration industry. He focused himself in “lean techniques” and “process improvements” in supply chain and logistics.

His research interests include reverse supply chain design, third party logistics management and performance measures in supply chain management. He aspires to be a teacher at a later part of his career after gaining considerable experience in the U.S. corporate supply chains.