



**T.C**

**YEDİTEPE UNIVERSITY  
INSTITUTE OF SOCIAL SCIENCES**

**REVERSE LOGISTICS, ACCEPTANCE AND MANUFACTURING  
OPTIMIZATION POLICIES**

**RAMAZAN CAN ÖZTÜRK**

**JANUARY 2017**



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**INTERNATIONAL TRADE AND LOGISTICS MANAGEMENT**

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OPTIMIZATION POLICIES**

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**Ramazan Can ÖZTÜRK**

## ABSTRACT

Reverse logistics involves effective flow planning, implementation and control activities of raw materials, semi-finished and final products, from the point of origin to the final destination for the purpose of capturing value, or proper disposal.

In addition, reverse logistics is a process that enables companies to become more environmentally efficient. Furthermore, many companies around the world have recognized the importance of reverse logistics in the economy and environment and have set this as their operating structure and mission.

A successful application of reverse logistics provides the company a competitive advantage by reducing the company's raw material asset costs, lower the risks involved with consumer purchase, shorten response time and fulfill the social responsibility whilst promoting a green image for the company.

In addition to the opportunities with environmental and cost-based deals provided to the businesses, reverse logistics have become a mandatory regulation within numerous countries. For this reason, the companies select the suppliers that work well in this context. This study has derived from an original equipment manufacturing businesses that aim to meet the needs of consumers who demand a single product. Original parts manufacturers use a hybrid system which consist of normal production and reproduction. Both of these methods are carried out on the basis of production orders. Unlike the returned products, the final products are kept in stock. The problem is addressed through the acceptance and production control within the production system whilst aiming to create the optimal policy structure.

## ÖZET

Tersine lojistik hammadde, yarı mamul, nihai ürün ve ilgili bilgilerin tüketim noktasından orijin noktasına doğru, değer kazanımı veya uygun şekilde yok edilme sağlamak amacı ile etkin akısının planlama, uygulama ve kontrol aktivitesidir. Bu açıdan tersine lojistik, firmaların çevresel açıdan daha etkin olmalarını da sağlayan bir süreçtir. Dünyada birçok firma, tersine lojistiğin hem ekonomik hem de çevresel açıdan önemini fark etmişve bunu işletme misyonlarına taşımış bulunmaktadır. İyi bir tersine lojistik uygulaması, firmanın hammadde ve materyal edinim maliyetini azaltarak, müşterinin satın alma riskini düşürerek, tepki süresini kısaltarak, sosyal sorumluluğu yerine getirerek ve 'çevreci firma' imajını iyileştirerek, firmaya rekabetçi avantaj sağlar.

İşletmeler için geçerli olan bu çevresel ve maliyete dayalı fırsatların yanında, tersine lojistik, artık birçok ülkede geçerli olan yasal düzenlemeler ile de zorunlu hale gelmektedir. Bu sebeple firmalar sadece kendilerini değil, çalıştıkları tedarikçilerini de bu bağlamda seçmektedir.

Bu çalışma, tek bir ürün talep eden tüketicilerin ihtiyacını karşılamayı amaçlayan bir orijinal parça üreticisi işletmeden esinlenerek ortaya çıkmıştır. Orijinal parça üreticisi işletme, normal ve yeniden üretimden oluşan bir karma üretim sistemi kullanmaktadır. Her iki üretim yöntemi de siparişe üretim temelinde yapılmaktadır. Geri dönen ürün stoğu tutulmasına rağmen son ürün stoğu tutulmamaktadır. Bu problemde, üretim sisteminde gerçekleştirilen kabul ve üretim kontrolü ele alınmaktadır ve optimal politika yapılarının oluşturulması amaçlanmaktadır.

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## ABBREVIATIONS

<b>1PL</b>	: First Party Logistics
<b>2PL</b>	: Second Party Logistics
<b>CLM</b>	: Council of Logistics Management
<b>LODER</b>	: Logistics Association
<b>SCOOP</b>	: Scientific Computation of Optimum Programs
<b>SOLE</b>	: The International Society of Logistics
<b>UKAD</b>	: International Air Cargo Association
<b>UNMAD</b>	: Association of Contractors and Agencies
<b>UTIKAD</b>	: International Transport and Logistics Association

## INTRODUCTION

At present, it is important for businesses to adapt the constant change of economic conditions and competitive environment through a customer-oriented operation of enterprises. Businesses aim to provide a competitive advantage in the market more effectively in order to present efficient operations and low-cost alternatives through developing different production and distribution system alternatives to provide maximum customer satisfaction.

Recently, one of the main system which businesses highly emphasize on is “Logistic Management”. Throughout the delivery of product from its starting point till the end user, the increasing value of logistic concept targets to minimize the cost of products, maximize profit, minimize risk and maximize benefit. Activities involving reverse flow in order to ensure efficiency in logistics are also involved in this concept. Alongside the movement of goods, whilst the product reaches the end user, the consumers used products and materials are also taken to be recycled.

Another important concept within logistic management is the reverse logistics. The arise of reverse logistics is caused by the lack of raw materials due to the constant increase of global population. For this reason, recycling is required to achieve production of materials that could be used in replace of raw materials. One of the main factors that cause the environmental problems is that natural resources are regarded as infinite and free of cost. The recycle and re-use of resources that have completed its life cycle have become very efficient during periods where there has been an increase in demand and consumption of limited resources

In the past recent years, reusable products have become increasingly important whilst manufactures have been imposed with more liability over products that have reached the end of its life cycle. Overtime, landfill is minimized and which has caused the companies to become highly interested in the reduction of waste materials.

Businesses are required to focus on reverse logistic activities for its for economic incentives, which have increased environmental factors, introduced legal requirements and

have improved the value of recycled products through increasing the re-use of these resources.

Besides the conservation of natural resources, for various reasons, such as less material and resource consumption makes significant recovery. In addition to this, the protection and reduction of consumption of natural resources has significantly raised the value of recycling. On the other hand, reverse logistic activities have gained significance through the rise of consumer awareness, the expanding number of eco-friendly manufacturers and successful projects based on social responsibilities.

Normally, Logistics face events that take the product towards the consumer. However reverse logistics are involved in activities where the resource goes at least one step back in the supply chain. For example, the goods move from the customer to the distributor or manufacturer.

Reverse logistics requires producers to be responsible for their products beyond the point of sale, by involving the removal and elimination of the product. This responsibility of reverse logistics requires the manufacturers to behave and work systematically for the work to be done correctly and efficiently, whilst they are under supervision for certain period.

Research identifies that reverse logistics-related academic studies have first been published by the employees within the sector. This recognizes the importance of reverse logistics to Manufacturers and businesses. In the last twenty years, this area has become the point of interest for the employees of this sector, which has also become a point of interest for many research and studies by academics.

The increased accountability of businesses and manufacturers with the products they produce has been supported by the increasing environmental awareness as well as the new laws that has been passed to support this awareness.

As reverse logistic gains significance with the increase of consumer perception and recognition of appropriate regulations, the steps of strategy and objective must be clearly identified for manufacturers to follow in order to effectively and efficiently handle their products. The combination of strategies should be well designed and innovation friendly for firms to follow. Management of logistics is a costing process. Businesses must bear all

the additional costs that are not taken into account. The process of reverse logistics requires systematic steps and approach to be taken by businesses whilst drawing the additional costs to minimal to manage challenges.

Regulatory pressures, sustainable environmental concepts, ecological and social responsibility of businesses, customer demand and economical factors enables businesses to take back their products and values of recovery through these systematically reverse logistic activities.



# 1. THE OUTLINE OF LOGISTIC CONCEPT

## 1.1. Scope and concept of logistics

The origin of the term logistics is ancient and has been explained in different ways by many various individuals and organizations. In the late 1840's the term Logistic has been found by the French: *Logistique*, meaning the art of moving, quartering and supplying troops. Others attribute a Greek origin to the word Logistikos, meaning to be skilled in arithmetic calculations. Over time, Logistikos has come to be used in Latin European languages (Sezgin, 2008:26). Logistic at the root of the word is Latin. Logic and statistics was formed by the merging words, in which the united meaning is logical statistics (Günay, 2005: 3).

Logistics was first used in the military field, then due to the change of conditions, the term has been used in various fields. Below, is the definition of logistics by various different people.

The military definition of logistics, " The science of planning and carrying out the movement and maintenance of forces". Within the civilian field, logistics is defines as "The two way flow of resources, information and service from the manufacturer to the final point of delivery" (Cengiz, 2006: 5). Webster College Dictionary defines logistic as "The branch of military science dealing with the procurement of equipment, movement of personnel and provision offacilities". As the term logistic does not only apply to the business sector, various definitions of Logistic management can be applied to business activities of companies engaged in the private and public sector (Sezen, 2001: 24).

In marketing vocabulary, the term logistics has been recognized following on from a widely known organization within the logistic sector of the United states in 1963, called The National Physical Distribution Committee (CPDM). In 1985, CPDM has changed its name to The Council of Logistics Management (CLM) (Polat, 2007: 3). As a result, the definition of logistics had been modified: "Logistics is the process of plan, implementation, and administration for the efficient and beneficial movement and safekeeping of raw

materials, semi-products and related information from production location to consumption location to satisfy customer's requirements." (Akçay, 2005: 33).

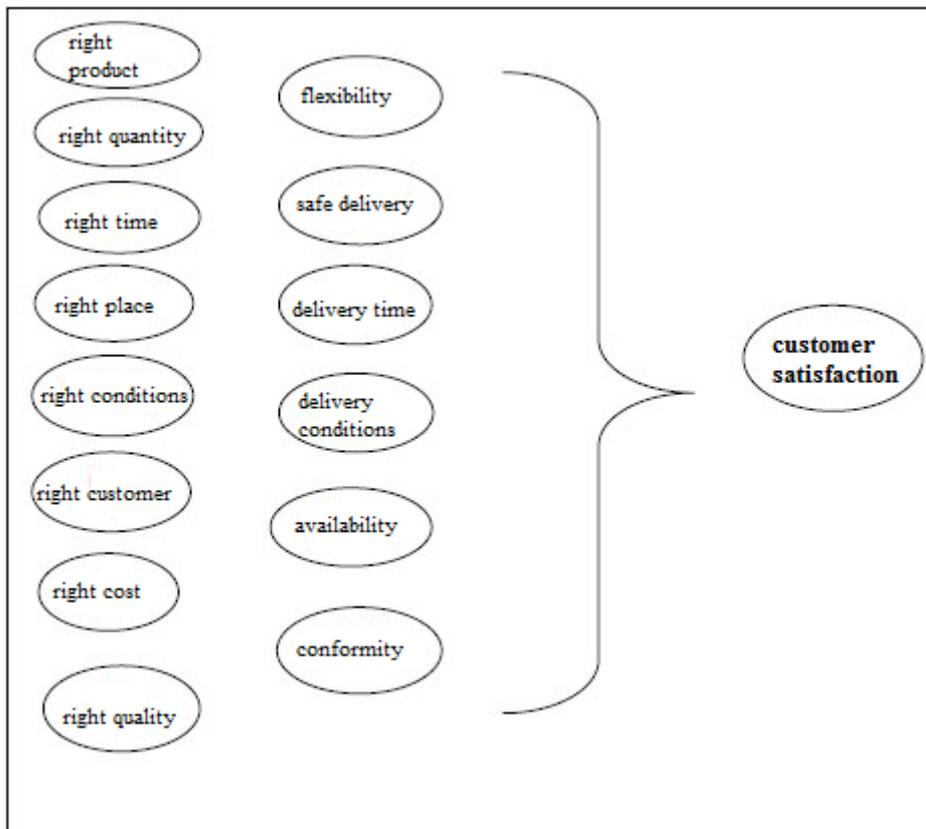
According to SOLE, every facility that has an impact on cost in logistic management is taken into consideration. One of its main important role is to make the product conform to customer requirements. It also involves efficient integration of suppliers, manufacturers, warehouses and stores and encompasses the firms' activities at many levels which are from strategic to the operational level (Sezgin, 2008: 27).

Kasilingam (1998) believes that "Management of transportation determines whether the goods are transported efficiently or inefficiently". The speed at which the goods are moved from one point to the next is determined by the way the transportation process is managed and the techniques used to deliver the goods (Oluk, 2006:1).

According to these definitions, logistic is an economic activity that involves transportation of products from the point of production to point of consumption. The space and time given to the product, adds value to the product (Sheen & Tai, 2006: 331). Also logistics represents the relation time has with the supply chain management and the status of the resources (Waters, 2003: 4).

According to the definition of Group Seven D, the main aim of supply chain management of Logistics is the continuous supply of materials through delivery of the right product, at the right quantity, the right quality, the right time and the right place, at the right price to the right consumer (Günay, 2005:5).

This situation is represented in the figure 1.1 below



**Figure 1.1. Basic Operations of Logistics (Günay, 2005:5)**

According to the International Transport and Logistics Association (UTIKAD), logistics is:

- Is a function that involves the management of resources and aspects of physical distribution
- Management of stock that are stored and on the move
- The recycle of used and waste materials, the handling of products and materials throughout the supply chain as well as the storage and shipping of the products, to finally the process of planning and putting this plan into action (Meriç, 2005: 5).

In reference to a definition of cost factors, logistics; “Aim to increase business profit through a strategic management of stock that involves a good control and flow of materials, resources and finished goods through creating a managerial responsibility (Akçay, 2005: 34). As a result, a successful logistic will reduce the operating costs, accelerate jobs and improve customer service.

In terms of inventory management, logistics: Is the effective management of stock control of raw materials as well as resources that are under production (Polat, 2007: 4). This highlights the importance of inventory management.

Overall logistics is described as "The supply of goods and services as desired by the target customer, at the right location and time". These activities include transporting, warehousing, in-process inventory, order processing, effective flow of materials, packaging and information processing. As long as there is a difference in between the point of production and the point of consumption for the purpose of recapturing value or proper disposal (Tunç, 2006: 4).

The major objectives of logistics is to maintain the company's viability through managing its own internal resistance to change. These marketing changes involve costs and quality of materials (Alkusal, 2006:21). In addition, improving customer service and creating a competitive advantage through optimum use of resources (Sancaklı, 2006: 7). As a result, logistics have become the key element towards competitive strategies of the international companies (Visser, 2007: 214).

The main mission of logistics is to deliver value effectively to its customers and suppliers through the provision of the right products and services at the right time (Güven, 2005: 4).

In addition, logistics is the planning of product and supply procurement, organization, management and supply of goods and services (Bilgisu, 2007: 5).

It is observed that some researchers use the concept of physical distribution instead of the logistics concept. At most points, these two concepts can differ from each other. Logistics is highly involved in the process of supply, material management, customer satisfaction and distribution of the entire process. On the other hand, logistics management is a process that manages material, physical distribution and life cycle (Kurtuluş, 2007: 7).

Moreover, logistics involves the flow of all activities in between the two points of (logistics service providing-customer) information based on the goods, services and knowledge.

The relation between the service providers and manufacturers is called “Inbound logistics”. However, the relationship between the manufacturer and the consumer is called “Outbound logistics”. This is represented in the Figure 1.2 below.

inbound logistics periods	production periods and material management	outbound logistics periods
➔	➔	➔
physical supply	internal transactions	physical supply
supply systems raw materials/semi-manufactured/manufactured material supply/purchasing programs inbound warehouse warehousing	production systems process planning production programming manufacturing inbound forwarding	distribution systems unmanufactured products outbound warehouse warehousing distribution chain target marketing and customer servicing

**Figure1.2. Logistics process(Kurtuluş, 2007: 8)**

According to the Figure1.2, Inbound logistics involves the process of physical supply and distribution. For production, resources such as raw materials and semi-finished products are transported and stored. Once these materials are ready for production it enters the process of production and management. The manufacturing system enters the process of outbound logistics after the completion of production and several other programmes.

As a result, Logistic activities are carried out under two main activities which are inbound and outbound logistics. These two activities are also linking process of business logistics as presented in detail below.

### **1.1.1. Inbound logistics**

Inbound logistics involves the collection of raw materials from suppliers, the storage process and regulation of these activities within the framework of supply chain management (Yavuz, 2006: 102).

The main purpose of physical supply, also referred to as the inbound logistics does not aim to separately maximize the suppliers and manufacturers profit margin after each exchange they do, instead it aims to mutually benefit from the exchanges made and maximize profit together (Vatansever, 2005: 3).

Physical supply is responsible of linking suppliers to the business process (Ozen, 2006: 34). Planning the movement of elements (raw materials, semi-finished, ready-made parts, etc.) involves determining where, whom, quantity and timing (Karagöz, 2007: 25). In addition, it is also involved in logistic research, design, development, manufacturing and production. Material requirements, business maintenance materials and stocks, the requirements in relation to the concept is supplied based on the system whilst creating activities based on.

The required and business maintenance materials are supplied according to the concept of stock needs-based system and create procurement activities (Çakırlar, 2009: 34-35). The elements of the physical supply, which involve supply systems, raw materials, procurement of semi-finished ready materials, purchasing programs are delivered to and stored at the warehouse.

The raw materials which are delivered for operation are turned into final products that meets the customers' needs, wishes and expectations, subject to the procedures for the management of semi-finished and ready parts. If we're at this point, outbound logistics will be on the agenda (Vatansever, 2005: 4).

The process of inbound logistics can be seen schematically in Figure 1.3.

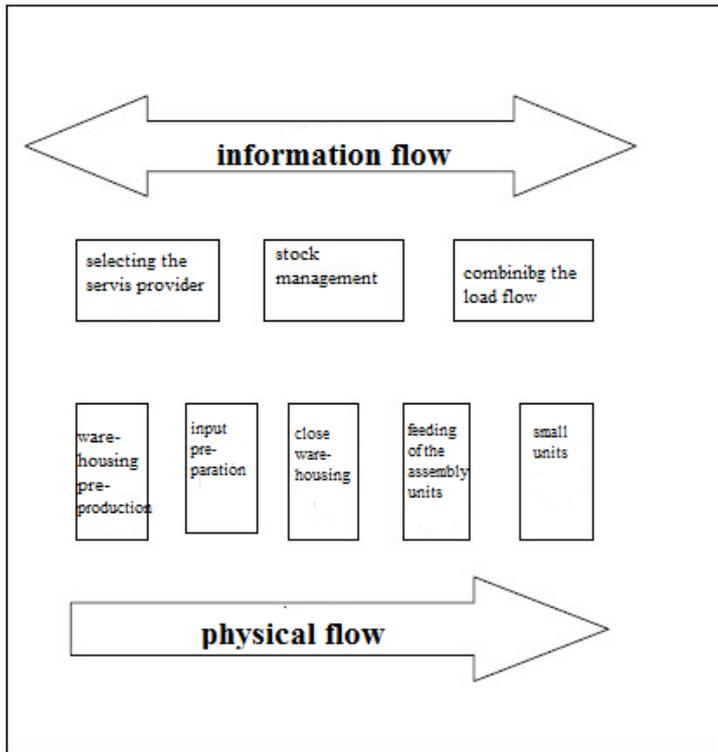


Figure1.3.The Process of Inbound Logistics (Özdener, 2010)

As seen on Figure 1.3, the inbound logistics occur from physical procurement. The raw materials which are needed for production can cover operations e.g. supply, the actualisation of production procedures, kinds of transport and execution of storage services. After all these activities, these materials, which are ready to meet the customers' needs, are incorporated into the 2<sup>nd</sup> stage (i.e. the process of outbound logistics).

### 1.1.2. Business Logistics

Business logistics can generally cover issues such as storing, distributing, transporting, maintaining, using materials and removing them from inventories (Özdener, 2010: 19). At the same time, it also consists of all types of activities, like selecting which goods and services need to be stocked, time, quantity and number of stalls in a warehouse ready for use in a service-providing market, and making a movement from supply sources to consumers via distribution channels (Yavuz, 2006: 90).

According to Donald J. Bowersox, business logistics is the process of managing all services related to the movement of raw materials/spare parts/finished products' inventories from sellers (supply sources and/or producers) to customers and applying strategic moves between business facilities (Akın, 2006: 109). Operations such as transferring materials found in inbound warehouses to workstations within the manufacturing environment and shipping their conversions into finished products to outbound warehouses, by providing the circulation between the divisions, are carried out (Özen, 2006: 35). Expressed in this concept, the result of a logistics activity is the process of completing the production of an obtained product and delivering it to a customer or user. In this process, research, design and development are incorporated (Çakırlar, 2009: 37).

The simple goal is providing that the right material is in the right place and time, in the required quantity and at the lowest cost. The logistic activity is responsible for ensuring that the materials are ready in production sites. Within the business, the procedures of the actualisation, planning and control of materials and information flow is contained (Kapkın, 2006: 13).

This concept brings forward the concept of internal and external customers. The internal customer concept covers business logistics; this is explained briefly below.

#### **1.1.2.1. Internal customer**

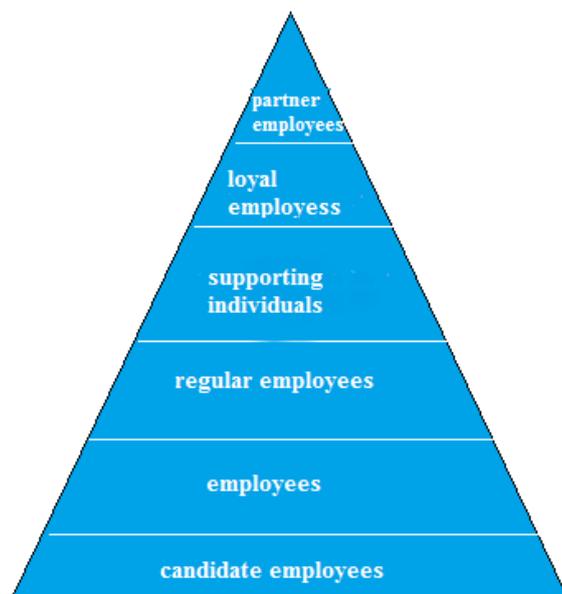
In an establishment, in the continuing processes that start from suppliers to external customers, an internal supplier is the name given to a body that provides goods and services to one another, and an internal customer is the name given to a body that receives these goods and services. This product is either in one group or a section/group that was handed over from another section (Akın, 2006: 1-2). Every unit in an organisation is in a position of a customer in a preceding level (Doğan ve Kılıç, 2008). In a workplace, a process is based on accepting the customers in the preceding process as their own customers in the next process (Ceylan, 1997).

In another definition, the internal customer is expressed as all business employees who directly/indirectly contribute to the production of the goods and services in question and delivery to external customers. They fulfill the work and tasks which are connected to each other in the business (Erk, 2009: 8-9).

If everyone, from the person in the highest level to the new recruit in the lowest level perform work and tasks related to each other in order to meet the expectations of the external customer who works in the same business i.e. the final user of the product, they are defined as each others' customers (Pekmezci, Demireli, ve Batman, 2008).

All individuals working in the business create internal customers (Ada, 2010:33). The concept of internal customers is concerned with relations in both inside the process and between the process, because the processes within the business would use the other processes' outputs as inputs, then produce outputs for other processes (Pekmezci, Demireli, ve Batman, 2008).

The internal customer can be classified as shown below.



**Figure1.4.Internal Customer Hierarchy (Doğan ve Kılıç, 2008)**

As seen on figure 2.4, the candidate who is in the nature of being an employee of the company in the future is called a “candidate employee”. The “employee” is a newly recruited person who does not yet know much about the business. A “regular employees” is an individual who is accepted by the business, and typically found in the business, in a constant relationship with other employees, but has a neutral attitude towards the business. An individual who is satisfied and loyal to the business, but passively supports the business against other business is called a “supporting individual”. Individuals who recommend the business to other employees, reflect the positive attitude about the business environment and support the business are “loyal employees”, and those who consider the business interests as their own interests and consider the company as their partner are called “partner employees”.

### **1.1.3. Outbound Logistics**

The second stage applied in the actualisation of logistic activities is outbound logistics. Outbound logistics covers services such as the distribution between companies and customers, cargo vehicle tracking, delivery and returning of the products (Eker, 2006: 19). It starts with the products ready for usage being released from the operational boundaries, and finishes with the product being delivered to either the seller or the final user. Because of the delivery of the product being the last link as well as the point where it provides the closest contact with customers, outbound logistics can be described as an important section of logistics (Çakırlar, 2009: 38).

Throughout this process, the aim is to pack and label the products at the end of the production line, continued by storage of the product, then making some services for the customer service that provides the preparation of orders and lastly granting services after distribution, such as unpacking the goods for customers and placing the goods on shelves in some cases (Özdener, 2010: 14).

One large section of outbound logistics is formed of physical delivery services. Physical distribution allows meeting with clients in terms of goods being competitive at affordable prices (Eker, 2006: 10). Physical distribution is responsible for a quick, safe and

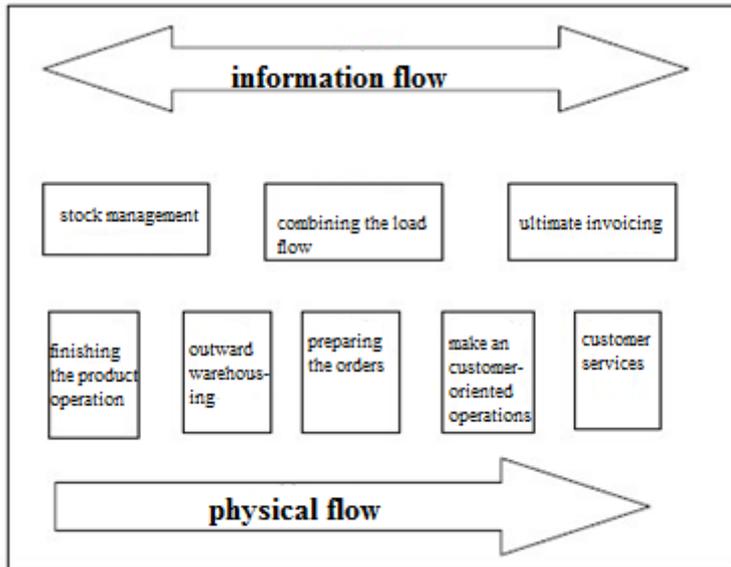
economical delivery of the goods belonging to the business towards customers (Özen, 2006: 35).

Operations in the manufacturing sector are a process which covers the chain starting from forwarding to the relevant workstations and workbenches after inbound logistics activities i.e. transport and handling within the factory, and ending at distribution channels and customers from outbound warehouses (Kapkın, 2006: 14).

If analysed from another angle, outbound logistics is responsible for the movement of output. The contents of the chain of complete products' distribution (wholesalers, brokers, dealers, retailers, etc.) is a process of reaching the recipient by enabling the sending quickly and cost-effectively (Özen, 2006: 35).

The process of outbound logistics consists of three stages. The first stage is moving a product to its shipping point. In order to take advantage of the transport which is to be made at a large scale, it includes the products' movement by freight and truck. The second stage is services at transfer points. Partial changes either in the product or the preparation of shipping orders occurs from activities such as producing, packaging, etc. The last stage is delivering the finished product to the final customer. This is also known as activity after shipping. At this stage the product is delivered to the point where they meet up with customers with smaller carriers (Sezgin, 2008: 39).

Like in inbound logistics, the diagram showing the process which has occurred around basic operations, described as physical and information flow, can be seen below.



**Figure 1.5. The Process of Outbound Logistics (Özdener, 2010)**

According to Figure 1.5, in the process of outbound logistics, activities, such as making the movement of materials which will be on sale, various order transactions and the delivery of products to customers, occur. This also enables the products to be delivered from production sites to consumers.

It would now be appropriate to refer to the concept of external customers in outbound logistics. This concept is briefly explained below.

### **1.1.3.1. External customers**

The external customer is a customer who provides the payment of employee wages and uses the company's products for their own personal interests by buying the introduced goods and services (Erk, 2009: 10). In other words, they are customers who consume products produced by internal customers (Doğan ve Kılıç, 2008).

External customers, though not members of the business, are aware of the goods and services produced by them, and are likely, or already bought, these goods. That means they are people who are affected by the company's products (Pekmezci, Demireli, ve Batman, 2008). External customers are those who are supported by their purchasing power as well as wanting the maximum benefits of a product, providing that it is high quality (Doğan ve Kılıç, 2008).

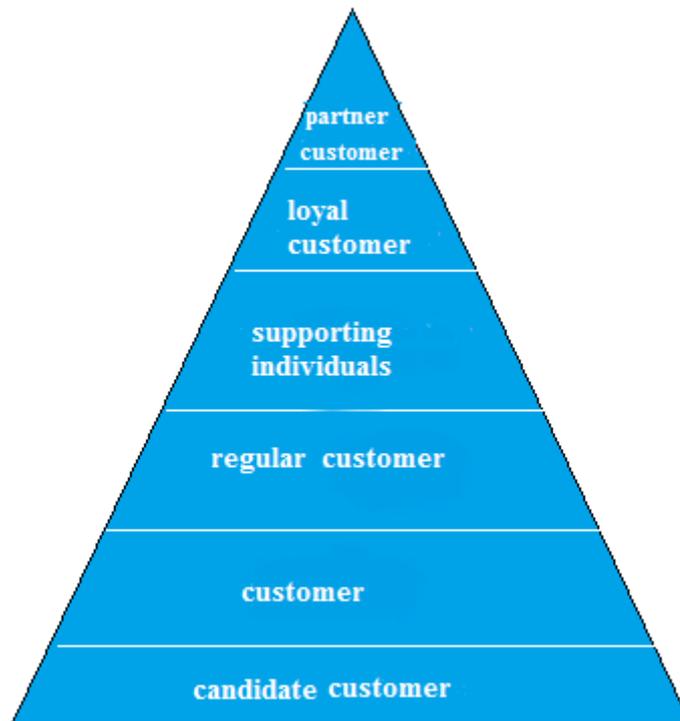
In another definition, an external customer is somebody who enables the business to exist on the market by buying products made by the organisation (Akçay ve Okay, 2009). The reason why these businesses exist is because of the external customers who are offered goods/services by the business. At this point, the external customer satisfaction will enable those companies to continue their assets (Özgüven, 2008:659).

External customers are grouped amongst themselves like the ones down below (Akin, 2006:2):

- Available customer
- Potential customer
- Old customer
- New customer
- Lost customer
- Target customer

The external customer takes more care of how he/she reflects upon him/herself, being perfect and accurate, being satisfied or dissatisfied, the extent to suit the needs and expectations and to what extent the promises are fulfilled, than a good or service's process and what tools were used to make this product (Erk, 2009: 10).

The external customer can be classified as shown below.



**Figure 1.6. External customer hierarchy (Polat, 2007: 6)**

In figure 1.6, a “candidate customer” is a buyer who is expected to qualify as a candidate to become a customer of the business in the future. They can be also described as potential customers. A “customer” is an individual/group who buys a good or service from the business at least once. A “regular customer” is an individual who generally has a relationship with the business, but has a neutral attitude towards them. An individual who is satisfied and loyal to the business, but passively supports the business against other business is called a “supporting customer”. Individuals who recommend the business to other consumers, reflect the positive attitude about the business environment and support the business are “loyal customers”, and those who consider the business interests as their own interests and consider the company as their partner are called “partner customers”.

Despite the fact that a moulded definition about logistics, as understood from these definitions/statements about logistics, is not found, every definition corrects one another and approvals are made in a logical framework (Polat, 2007: 6).

## 1.2. Historical Development of Logistics

Over the years, the concept of logistics, which was first used in military areas, was implemented in different areas through the various stages. Over time, activities like increasing production in order to enter the businesses' competition, and delivering these products to customers, have become the elements of costs. From this angle, business began to focus on the logistics concept in order to profit economically. As a result, the concept of logistics, which expanded their field of application, has gone through several processes.

The 15<sup>th</sup> edition of the *Encyclopaedia Britannica* states that the origin of the word "logistics" comes from the Greek word "logistikos", meaning "the knowledge of calculation". In the Roman and Byzantine armies, the officer in charge of administrative affairs was called a "logista". The French word for the accommodation of soldiers, "loger", also comes from the same word origin. The book "Summary of the Art of War", written by officer Antoine-Henri Jomini (the baron of Jomini), who is considered an expert on Napoleon's battle management, defined logistics as "practical art related to the movement of the army" which includes the accommodation jobs of engineering and exploration (Kapkin, 2006:3).

Logistics is more of an old concept which developed and had its contents changed over the years, than a new concept (Polat, 2007: 3). According to Kent and Flint (1997), the concept of logistics is passed as physical distribution in the early 1900s as an academic literature (Demir, 2005: 7).

The services in the supply chain applied into logistic management was performed all over the world since prehistoric times. Before settlement, operations like the delivery of hunted animals, collected fruits and other goods, drying of these goods for consumption, storage and reshipment of these goods were performed. After settlement, the transportation of the produced food and supplies, protection of these goods in various ways and storage have become the subject of these services. The different production techniques, which started specialisation and brought advantages of division of labour and geography, have been developed, as well as initiating operations such as production, delivery and storage for

exchange and trade that is beyond personal and local consumption. Merchant countries have prospered, sea routes have gained importance thanks to newly-discovered continents, highways have been improved, and huge ports and wide storage warehouses have been constructed (Kurtuluş, 2007: 4). After steam-powered engines like steamboats and steam locomotives, activities involving delivery and storage, thanks to the electric motors' contribution to the land, sea and rail transport, has observed a natural increase in speed and capacity (Akçay, 2005: 38).

During the World Wars, the logistics concept in the military sense has started to form, and the importance of optimisation and control of delivery, storage, distribution has become apparent. The basic principles of the logistics management, like delivering goods faster, storing them as much as necessary, preparing them in times of need, preventing them from losing shelf life and the provision of their return, emerge. The people who used the concept during World War II started to question the principles of the logistics management in their jobs during peace-time. Logistic services, in various forms and written and card systems, has been controlled by the USA, a new country especially in world history that became the war's victor (Sezgin, 2008: 23).

In a 1905 article written by US army major Chauncey B. Baker, logistics was known to be used in order to identify a military function in the style of "*The art of war is the science related to the supply of military movements and requirements*" (Polat, 2007: 3). Therefore, logistics was first used in a military area, not a trading area. Thus, armies have complex, and sometimes contradictory, needs. These requirements are spread over a wide range, from tanks, planes and ammunition, bakers, bureaucrats, carpenters, cashiers, to the funeral directors, and social consultants, besides the requirements of well-trained, mobile and flexible war movements and providing intensive support services. For all these requirements, planning, application and control of the activities like shipping, storage and packing can only be fulfilled by the logistic process (Akçay, 2005: 38).

During the last days of 1940, the SCOOP (Scientific Computation Of Optimum Programs) project, created by the US Air Force on behalf of George Dantzig, conducted the first study of linear programming, and developed methods for the optimisation of an objective function that was specified before solving the logistics problems related to the Berlin airlift

under resource constraints. This project first introduced card systems, then computers for the inventory control of the spare parts system in the Air Force (Yıldırım, 2006: 6).

Logistics is a concept that has acquired an important place in today's business world as well as military literature. Logistics was first used as a concept in the early 20<sup>th</sup> century despite entering the literature of trade in the 1960's.

The concept was understood during World War II, and scientifically analysed and finally applied into logistic activities after the war (Günay,2005: 13).The rapid developments and increasing competition in the world has created needs for the raw materials to satisfy consumer demand, the inventories in the process, the end product or relevant information, and the ability to deliver effectively from the exit point to the point of consumption, as well as cost-effectively. The solution to meet this need is defined around the logistics concept (Yıldırım, 2006: 4-5). The logistics concept, developing on a daily basis, has added demand forecast, customer service, and the activities of delivery, packaging and distribution of both final products and raw materials inside or outside outside the business into its structure (Vatansever, 2005: 2).

The result of favouring consumption in the production and consumption balance in the recovery of the economy during the transition period has led to an increase in the completion of grabbing shares in the market between companies, and the occurrence of global competition due to international firms entering the foreign markets via exports. During this period, businesses begin to shift towards the marketing concept after realising that the classic sales approach which they followed is now inadequate. In these years, it appears that they primarily focus on long-term demand forecasts and budget plans as a marketing strategy followed by companies (Karakadılar, 2007: 3).

After the 1950's, technological and economic needs have changed rapidly, and between 1950 and 1965, the concept of integrated logistics has become clear. The 1958 recession, due to the decrease in profits, it was revealed that a research on an environment of a more effective cost control system in internal environments has started. Many businesses began

to feel the need to work in a coordinative and careful manner in logistic and physical distribution activities (Dostsever, 2007: 3).

After the industrial revolution, the high goods capacity that occurs in the market as a result of mass production in the US, the needs related to logistic activities by avoiding the distribution function has been put into the agenda.

When physical supply activities and physical distribution activities were dealt with separately until the 1950's, with the effect of the transition from the concept of classical management (the one that requires a system approach) to the concept of modern management and cost reduction efforts, signs of integrated logistics have emerged (Akçay, 2005: 40).

From the 1960's to the beginning of the 1980's, it wasn't possible to argue that enough work was done in the field of logistics. The main reason was that the increase in interest in logistics was parallel to the prevailing quest for quality that lasted from the 1960's to the 1970's, which then was left to price-based competition. Price-based competition has urged administrators to seek ways to create cost advantages, and has prompted them to turn to the logistics that's known as one of the most important cost item (Meriç, 2005: 12).

The 1970s formed the basis of modern logistics concept that we know today. During these years, companies handled the logistics management and worked for making logistic activities less costly and perform well (Kurtuluş, 2007: 5). On the other hand, logistics-related software is developed along with the spread of personal computers. With the help of progress and the development of communication in the data processing technology, every acquisition, processing and distribution of information in businesses has become easier (Eker, 2006: 13).

The reflections relating to logistic sector, which has seen an important progress in international markets, has been seen in Turkey's economy, and has made logistic services more known every passing day. Consequently, organisations in sectors were made, and in 1986, the International Association of Contractors and Agencies (UNMAD), formed of 30

companies, was established. UNMAD, which worked in order to keep the companies, who were responsible for the organizing of transport operations, under the same roof, merged with the International Association of Air Cargo (UKAD) in 1995 to form the 162-member Association of International Forwarding and Logistic Service Providers (UTIKAD) (Önder, 2007: 24-25).

### **1.3. Logistic Applications**

A number of concepts closely related to logistics management are described below and are as follows:

#### **1.3.1. E-Logistics**

Every day a new round of information technology is added due to the intense competition in the economy. These developments are reflected in the business world, and many businesses attempt to adapt to these innovations.

As a result of changes in the business world, new structures and insights in the logistics sector have occurred, and led to adaptation of technological developments. Thus, the e-logistics concept came into question (Bamyacı, 2008: 48).

E-trade closely affects businesses, suppliers, customers and technology. It shapes the businesses' organisation structure, their use of information technology, trade structure and the actualisation environment, supply processes and customer attitudes and desires (Gülenç ve Karagöz, 2008: 78).

E-logistics is an advanced form of traditional logistics that offers more information and service, i.e. it is the underlying system of Internet technologies with traditional logistics processes (purchasing, warehousing, customer service, etc.) (Gülenç ve Karagöz, 2008: 78). It is the business of forwarding information regarding delivery and storage quickly and safely and benefits customers electronically through various means (Bamyacı, 2008: 48).

In short, e-logistics is the method of operations regarding activities that are based on logistics management as quickly as possible and giving customers the best possible service.

E-logistics are activities that are performed by using logistic activities in businesses as external sources. It is performed by a separate organisation outside the operation of a number of activities related to logistics.

In other words, e-logistics is an operation in which the activities that are used for delivering a good, product or raw material from sources to the user in its final form, performed by third-party or other institutions (Bingöl, 2006: 13).

Third-party logistics are given to third-party logistic companies who are able to administrate some elements in the supply chain business and activities such as customs, warehousing, order processing, distribution and international transport within the business (Aydın, 2005: 136). According to Lieb, other companies must fulfil the logistics functions performed within the third party logistics organisation (Marasco, 2007: 128).

### **1.3.2. Fourth-party Logistics**

Fourth-party logistics, essentially, is the name given to the duties of consultation and consultation or coordination that are in-between the third-party logistics duties. It manages the process of coordination and integrity of both product and information flow. Fourth-party logistic companies fulfil business on behalf of the logistics activities of the company with customers and operations of planning, conducting monitoring and measurement together with business management (Barlan, 2009: 67-68).

Unlike the third-party logistics concept, the fourth-party logistics' subject is the status of organising business processes with the help of external sources. By taking of information, experience and technology from external specialist firms, the processes can develop by redesigning (Hubar, 2006: 28).

### **1.3.3. Integrated Logistics**

The use of external sources in all countries, in parallel with developments in the business world, is becoming more widespread.

The research results show that logistic services should be carried out in an integrated manner in order to ensure efficiency in the use of external sources (Alkusal, 2006: 1).

Integrated logistics is a set of activities like the inclusion of planning, budgeting and functionality control mechanisms, aiming to meet the performance needs of the system and including the provision of long-term support at optimum prices. It provides the incorporation of elements of technical logistics, in order to identify and plan essential needs for the support of the system. Integrated logistics, in the style of basic management functions, make design and support infrastructure compatible with system components, with the main purpose being to support the system components (Milli Eğitim Bakanlığı, 2011: 18-19).

### **1.3.4. Spherical Logistics**

Spherical logistics is the management of the system that controls, plans and applies material flow, inward or outward, within a company operating in the international market, in order to achieve common goals, at the level of the minimum total cost (Dostsever, 2007: 28). In other words, spherical logistics is the creation and management of the system that controls the flow of goods and information worldwide (Gür, 2009: 45).

Spherical logistics aims to deliver logistic activities to the international stage. With the most important point of spherical logistics being the creation of the process of information sharing, it is required to plan, implement and fulfil the whole process of carrying out the logistic activities in different countries in the business. It is important to control the process, especially when the right information is given at the right time (Gür, 2009: 45).

### **1.3.5. Green Logistics**

With this concept being new, the issue has been raised with the development of environmentally conscious consumers. Buyers want their consumed materials to become eco-friendly each passing day and they put pressure on this issue. With the situation being brought by global competition, our country has begun to show sensitivity on this issue. Therefore, green logistics, works to measure all the negative effects on the environment of all activities and minimise them, in order to perform the logistic activities such that it causes minimum damage to the environment (Tulgar, 2012).

### **1.3.6. Reverse Logistics**

Reverse logistics services start as soon as a faulty product owned by the customer is sent back to the company for replacement, and finishes when a the newly-repaired or replaced product is sent back to the customer. The concept of reverse logistics from this point of view is more important than customer satisfaction (Hubar, 2006: 29).

According to Carter and Ellram (1998), reverse logistics is a process that is more environmentally efficient by the reduction of the number of materials, recycling and re-using (Kayabaşı, 2007: 77).

A more detailed explanation of this topic will be included in the 3<sup>rd</sup> part.

### **1.3.7. Closed Loop Supply Chain**

The closed loop supply chain includes processes of return and refund unlike the forward supply chain (Özkan, 2010: 22).

Reverse logistics forms a relationship between the second-hand product market and the new product market. If these two markets form a conflict between each other, it is called the closed-loop supply chain. The closed-loop supply chain not only includes advanced supply chain operations, but also includes supply chain activities (Özkan, 2010: 23).

In the systems with the closed-loop supply chain, the final products that have emerged from the advanced supply chain network are collected from customers, and repeatedly included in the process of being recycled without departing from the loop(Paksoy, 2012:9).

#### **1.4. The Relationship Between Logistics and the Supply Chain Management**

The logistics concept and the supply chain management concept are practically defined as the same thing frequently. However, these two concepts are separated (Eryürük, 2010: 27). Logistics is a section that plans, applies and controls the flow and storage of information related to goods and services, which start from the starting point and finish at the production point, effectively and efficiently, in order for the supply chain processes to meet the customers' needs. From this angle, the understanding of the supply chain expresses an upcoming understanding of the events from a wider perspective (Kurtcan, 2009: 11).

The supply chain includes firms who perform all functions, with the inclusion of supply, manufacturing, transportation, storage, sales, after-sales services, in the moving chain that starts from the existence of a product's raw material and finishes at the activities performed after the goods reach the consumer. The name given to something which regulates the management of the relationship and understanding of the dependence of mechanism in the chain is called the Supply Chain Management. Logistics, on the other hand, includes the management of risk and information found as a flow and product along the chain, and all operations that make a product move or stop along the chain (Eryürük, 2010: 27).

The supply chain management is the merging of activities such as the supply of materials, transportation of semi-finished and final products, and delivery to the consumer. Logistics plays an important role in the supply chain management (Lin, 2006: 257).

Logistics is a huge important part of the supply chain, despite not being the whole of it. Logistics affects the features of ability to give a quick response, the success of supply chain management and the efficiency of logistics management (Yaman, 2009: 29).

## **2.REVERSE LOGISTICS**

### **2.1.The concept and content of reverse logistics**

The concept of reverse logistics is described in various ways in literature.

First descriptions were made by Lambert and Stock (1981). Accordingly, reverse logistics is the role of logistics in recycling of products, source reduction, recovery, substitution and reusing of materials, waste disposal and incineration, repair and reproduction (Bulut and Deran, 2007: 327). Traditionally, reverse logistics can be expressed as the process of recycling of products (Krumiede and Sheu, 2002: 326).

According to the description of Flieschmann (2001), conventional supply-chain must get value again in reverse direction and destroy properly. For this reason, reverse logistics is the process of storing by-products and planning, applying and controlling of them for the chain to perform effectively ( Özkan, 2010:13)

Reverse logistics is the activity of planning, applying and controlling of effective flow in order to ensure appreciation or to destroy properly of raw material, semi-product, final product and data relating to this from the consumption point to the source point (Kaymak, 2010:23)

According to Dowlatshahi, reverse logistics is “the process of retrieving systematically from the consumption point so as to apply one of the operations of manufacturing plant like before-transferred product or recycling, remanufacturing or disposing (Özgün, 2007:14). Reverse logistics is related to how common information flow and recurrent products’ flow are managed effectively.

Another description states: reverse logistics includes shattering, going into production environment and then operating. In doing so, products of no-use in consumer markets or in organizational markets are recycled and have no harm to the environment. Reverse logistics which adds a third- dimension to the logistic activities, is the movement, storage and handling of returned products from the last customer to the service provider.

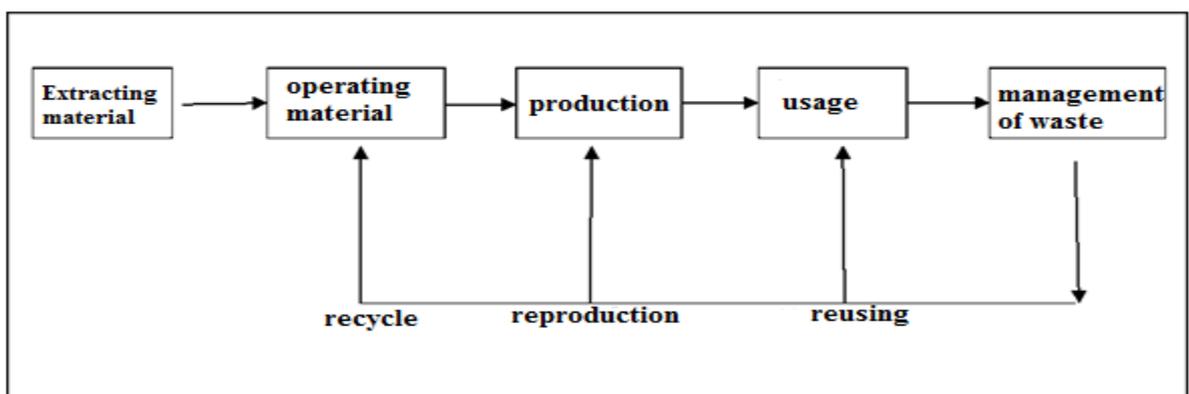
According to the description made by The Council of Logistics Management (1990), reverse logistics is stated as the process of planning, applying and controlling productive flow of raw materials, ongoing inventories, stockouts and the information about these so that they can be recovered or be disposed properly from the consumption point to the production point.

The Council of Supply Chain and Management Professionals describes “reverse logistics” as the process of planning, applying and controlling network topology so that inventory processes, final products, used materials and related data can be recovered or be disposed properly from the consumption point to the beginning point.

The most common idea about reverse logistics is the physically transfer of used products from the last consumer to the producer.

Reverse logistics is known as environment- friendly logistics in that it is evaluated to recycle unwanted materials (sewerage, box, bottle, paper etc.) and bring them procurement again.

*The table of the content in waste management of reverse logistics as follows:*



**Figure 2.1 the Content of Reverse Logistics in Waste Management(Kaçtıoğlu ve Şengül,2010: 91)**

Figure 2.1 states the content of reverse logistics with regard to waste management. Used-products undergo a process of sortation after gathered in different ways. The parts that can

be used are determined and integrated into reproduction. In this manner, the damage of wastes to the environment is minimized.

In parallel to all these situations, reverse logistics is the reverse flow from the consumption point to the production point. By this way, various products or materials that completed their life cycles are brought in to the usage, damage to environment is minimized and thirdly, natural sources are preserved.

As a result of economic factors, the importance of reverse logistics has increased. Because the activities of reverse logistics provides additional income to companies due to decreasing of raw material consumption, the additional value to regained materials and decreasing of waste materials.

## **2.2.The Development of the Content “Reverse Logistics”**

The products that completed their lifetime are left to environment in various ways and cause a great deal of destruction in terms of environment. In time, waste capacity of lands gets full and damage to environment increases day by day.

Over the years, human beings have consumed a lot of sources first by making them usable in order to fulfill their needs and reach the best ones. This cycle, over time, has caused the consumption of natural sources and the destruction of environment. In these days, a sustainable development is needed without threatening the existence of ecologic and social system.

The appearance of the term “reverse logistics” dates back to old times. Making a distinction with precise lines in naming this terms is highly difficult. Although reverse canals appeared in 1970s in scientific merit, they were mostly used as recycling.

The recovery and reuse of used products have gained importance along with efficient usage and increasing consumption level in an environment especially where sources are

insufficient. Consumption of waste lands and growing capacity day by day has made abatement of wastes and reproduction process the most important fields of interest.

“Reverse Logistics” content was born due to the need of recycling the materials that would be used instead of insufficient raw materials. Besides, recovery activities has gained popularity due to the factors such as environmental concern, economical reasons, rules, institutional and social responsibility, sustainable development, conservation of natural sources, less consumption of material. This situation has also brought along the need for proper logistic structures that enable used and reformed products’ flow to regain the products.

### **2.3.The Importance of Reverse Logistics**

One of the important trends in Supply Chain Management is to realize strategical importance of reverse logistics operations.

Reverse Logistics activities have become a function that grows in importance continuously. That’s because natural sources began to be used efficiently, used products were recycled and reformed, and the damage of wastes to environment was minimized.

Reverse logistics is a process that enable companies more efficient in terms of environment. The aim is to benefit from the products that will be recycled in a maximum level or ensure their destruction.

A good reverse logistics practice decreases company’s acquisition cost of raw material and supplies. Also, it reduces customer’s risk of buying and shortens reaction time. In addition, it performs social responsibility and provides the company competitive advantage. If reverse logistics system is organized and managed in an appropriate way, it provides customer satisfaction, increases profit by decreasing the cost.

Reverse logistics is also needed when a product is returned for repair after sold or the returned product is sent to the service. The product is returned due to a mistake made in a

phase of the production process. In these circumstances related to the product, reverse logistics is applied (İpekçi, 2012). An effective reverse logistics activity focuses on the flow of materials from consumers to producers when maximum profit of product recycle is intended or their disposal is done properly (Autry, 2005: 749-750).

Nowadays, returned products are given great importance. For the disused products, manufacturers are held responsible. That the capacity of waste lands is becoming narrow day by day has made reduction of wastes an outstanding concern for companies (Demirel and Gökçen, 2008: 904).

If there is a product that moves on supply chain network or there are any factors, products materials, semi-products or spare parts that are found defective or demoded by customers, taking them to the storage and making examination of them in terms of functionality, convenience, repair, quantity and quality are important matters for companies recently (Karadoğan, 2011).

The concept of “reverse logistics” which is a systematic figure of taking back and recycling products has taken its place in literature as one of the processes of supply chain and it has been gradually emphasized (Bulut and Deran, 2007: 326-327). In this regard, activities such as collecting end-of-life products, approving or refusing them after examined, processing the approved products and reusing them have an important position in the reverse logistics process (Baki, 2003).

Reverse logistics which is an important concept in terms of customer satisfaction enables to recycle inefficient and unused products in consumer or organizational markets. Then, these waste products that are not harmful to the nature are reutilized by being taken to production (Derinalp, 2007: 14).

## **2.4. General Features of Reverse Logistics**

Reverse logistics activities generally focus on used products that are collected from consumers. Making properly the return flow of products that will be collected has an important position in reverse logistics processes. Besides the uncertainty of products' quantity, when these products will be returned is also indefinite. For this reason, features of reverse logistics must be determined well.

The features that make managing and planning of reverse logistics process difficult are as follows (Özgün, 2007: 32-33):

- Uncertainty of material flow: Generally, firms are not able to know the quantity of returned products, when they will be returned or disposed of.
- Indefinite quality and variety of returned products: the return flow of products vary.
- Customer engagement: return of products depends mostly on final consumer or final user.
- Criticality of time: material routes are indefinite. The active value of the returned product coming for regulation must be regained immediately.
- Demand of indefinite market: the demand and cost of secondary markets are not definite. Reverse logistics activities must support flexible capacity in order to provide facility, transport and other related services for returned materials.
- Value enhancement: new markets are needed so as to maximize capital value which arises during returns.

## **2.5. Constituents of Reverse Logistics**

Various constituents must be available to be able to practice reverse logistics activities. They are as follows (Tuzkaya, 2008:9):

- Constituents of Advanced Supply Chain: Suppliers, producers, wholesalers, retailers
- Expert Reverse Logistics Providers: wholesalers, recovery experts

- Constituents that use an opportunity: Charities, foundations.

Each factors creating reverse logistics constituents has different responsibilities. While some are responsible for reverse organizations, others are responsible for the practice of duties in this process. For example, while producers make the resale of wholesalers' products, they can also lead off recycle work to inhibit putting low prices. In addition to this, assistant works that can be carried out by sender, receiver and costumers are also available. Including customers, any party can be sender or receiver. Constituent groups in reverse logistics activities such as collecting and operating are; some intermediate staffs, recycle companies, reverse logistics service providers, municipalities working in collecting wastes and public or private institutions that work in recycling (Tuzkaya, 2008: 9-10).

## **2.6. The Importance of Reverse Logistics for Companies**

The efforts of improving reverse logistics have been seen since 1980s (Stock, 2001). Reverse logistics has gained importance due to the retrieval potential of the used products' value (Pokharel and Mutha, 2009). Ecologic and economic reasons have sparked analyst's and employee's interest to returns and reverse logistics. Control of wastes and disposal costs give producers the task to retake of products from consumers. By the way, it is realized that positive economic value can be obtained from the returned products with various recovery methods. After returned products are separated, they can be used as constituents inside of new products or can be sold as spare parts in services (Minner, 2001).

EU has financially supported various research projects in order to bring reverse logistics into prominence. Branches of industry has also realized the importance of reverse logistics. As a significant signal, various reverse logistics associations have started to publish journals (de Brito and Konings, 2008).

The questions needed to be asked in order to understand reverse logistics:

- Why is recycling made?
- What is recycled?

- How will recycle be carried out?
- Who will carry out recycle?

Reverse logistics provides a huge potential in terms of lowering the cost for the companies managing the process well, increasing incomes and supplying additional profit (Wu and Cheng, 2006).

There are numerous studies done about the importance and economic effect of reverse logistics. These studies are as below:

**Table 2.1. The Importance of Reverse Logistics and Academic Studies on Its Economic Effects**

Researcher	Research Year	Economic Influence Area	Value
Rogers and Tibben- Lembke	1998	The value of total logistics and reverse logistics costs in USA economy	Total logistics costs-10.7% and nearly 4% of total logistics cost is reverse logistics cost
Robbins- Gentry	1999	The amount of returned products	6% of average sales, 15% for wholesalers, 35% for catalog salers and doing e-commerce
Meyer	1999	The value of reverse logistics costs for American companies	0.5% of gross domestic products- 35 billion \$
Pogorelec	2000	The reasons of returns and returned products in USA.	The return potentials of online sales' 50% and in 1999 in USA returned products' value is 62 billion \$ and its 10-15 billion \$ is due to seller's mistake
ReturnBuy (Dowlatshahi, 2010)	2000	Transportation cost of returned products	Totally 40 billion \$
Jedd	2000	Advantage of reverse logistics to advanced retailers	6 million \$ saving in 1 billion \$- sale
Trebilcock	2001	Product value in retails	The amount of returned products is more than 100 million parcel packets and its economic value is 150 billion \$
Stock	2001	Reverse logistics in USA	Per year 35 billion \$, 4% of total logistics costs and nearly 6% of sold products are returned.
Daugherty vd.	2001	Rates of returns and costs of reverse logistics (with empirical study)	20% of returned products' sales in companies making catalog sales and 5-6% of reverse and total logistics costs for production and retail sectors.
Rogers	2001	Reverse logistics costs	4% of total logistics costs
Guide ve Van Wassenhove	2003	Reproduction in USA	Sale amount of reproduced materials yearly is 50 billion \$
Hill (Dowlatshahi, 2010)	2004	The amount of returned products and expenses of reverse logistics	Generally 20% of sold products are returned and 5% of expenses is for reverse logistics
Prahinski and Kocabasoglu	2006	The study of Reverse Logistics Management Council and Reverse Logistics in USA	The costs of transportation and disposal of returned products are yearly 35 billion \$ and reproduction cost is 50

			billion \$
Gecker and Vigoroso	2006	Reverse Logistics for Companies	For 60%, reverse logistics is important, but it fails to satisfy
Skapa and Klupalova	2009	Reverse Logistics in Czech Republic	61% of companies is on research about negative effect of reverse logistics on stability and 83% is researching costs and benefits of reverse logistics

Source: (Rogers and Tibben-Lembke, 1998).

The importance and influence of reverse logistics have been changing depending on the sector and the position of distribution channel. For some sectors, reverse logistics is quite a critical activity. Especially in the companies where the product's value is high or the rate of returned products is too much, reverse logistics process must be improved (Rogers and Tibben-Lembke, 1998). Reverse logistics is an important issue especially for branches of industry such as automotive, electronics and press (Wu and Cheng, 2006).

Companies which have no strategic vision about reverse logistics will probably have trouble in future. Especially in the sectors that have high return rate, companies possessing no substantial reverse logistics programs such as catalog and electronics will stay out of competition (Rogers and Tibben-Lembke, 1998).

Rogers and Tibben-Lembke determined the strategic role of returned products in the study they did in 1998. The strategic role of returned products and effecting rate are shown in Table 1.4 below:

**Table 2.2. The Strategic roles of Returns**

Role	Percent
Competition	65.2%
Distribution Channel Cleanliness	33.4%
Legal Disposal Reasons	28.9%
Regaining Value	27.5%
Asset Recovery	26.5%
Maintaining Profit Margin	18.4%

Source: Rogers, D.S., Tibben-Lembke, R., (2001), "An examination of reverse logistics practices", *Journal of Business Logistics*, 22/2, 138.

*Competition:* Companies know that satisfied customers are more important than protecting products. One way of satisfying customers is the retake of the products which customers do not want. Customers care about unconditionally retaking back the products they want to dispose. Companies having reverse logistics network and potential to succeed in this

provide competitive advantage. If one of the competitors has a strong return policy, other companies will need to strengthen their policy to protect market shares. In addition, reverse logistics is used as a part of useful social responsibility projects for some firms.

The important point of some campaigns which firms use such as “Bring your old goods, we shall give them to needers!” is created by reverse logistics activities. Managing this kind of flow is expensive. However, it increases the company’s brand value and purchasing of products.

*Distribution Channel Cleanliness:* The possibility of customers’ buying new products has been increasing thanks to removal of unnecessary products. For various reasons, retaking of the products remaining in distribution channel staffs enhances the ability of customers’ managing their inventories. Taking back unwanted products decreases the financial stress on customers. This leads customers to purchase products and leads an increase in customer satisfaction.

*Maintaining profit margin:* maintaining profit margin is closely related to distribution channel cleanliness. Taking back old or unnecessary products from customers increases the possibility of them to buy new products. This helps the company to maintain profit margin by creating demand.

*Legal Disposal Reasons:* The legal disposal of dangerous materials has gained importance. There are even punishment related to this. These circumstances are seen by firms as factors enhancing strategic importance of reverse logistics.

*Regaining value and asset recovery:* It is proved that high level of profit is obtained when asset recovery programs are applied in companies.

By practicing reverse logistics, companies get recovered and obtain some prices from returned products. This matters a strategic importance for companies.

Main features of reverse logistics process are as follows (Blumberg, 1999):

- *Uncertainty*: In the process of reverse logistics, producers are not informed about when the product will be returned or about the features of the returned product.
- *Customer Orientation*: It is important to be aware of customers' expectations because the products flow from customers to the producers. And it is also important to keep continuity and order of the flow.
- *Timing*: A quick process is needed in order to reuse or dispose of convenient materials.
- *Value Development*: Reverse logistics process aims to maximize the value of returned products through scrap, recovery and resale.
- *Flexibility*: Reverse logistics must have a flexible capacity so as to maximize the rate and flow of returned products in storage, process and transportation phases.
- *Multilateral Coordination*: One of the most important difficulties of reverse logistics is that many stakeholders are within the process to be conducted. To get maximum output from the process, parties must work in coordination.

The most encountered products during reverse logistics process are high valued technological products, “green” products, packages and industrial wastes (Blumberg, 1999).

With proper reverse logistics process, important gains are obtained (Carter and Ellram, 1998). A proper reverse logistics process increases companies' competitive potential (Amini, vd., 2005). In addition to environmental and financial benefits, reverse logistics both provides regularity compliances proactively and influences the image of company in a positive way (Carter and Ellram, 1998).

Managing of end-of life products is different in developing countries than in EU or other developed countries. For these countries, end-of-life products couldn't arouse attention of environmental authorities. Therefore, any legal frameworks or plans about managing these products couldn't be carried out (Cruz- Rivera and Ertel, 2009).

Management of returns gains much more importance in the circumstances below:

- If the amount of returned products is higher than the products that can be operated or disposed of
- Due to numerous returned products, areas and costs of storage increase
- Returns that cannot be determined or managed
- Long- operating processes
- Unidentified costs
- Loss of customer's trust

Various reasons that emphasize the importance of reverse logistics are stated below by Prahinski and Kocabasoglu (2006).

- The rate of returns reaches 50% in some sectors
- Sale options emerge in secondary and global markets as a result of obtaining value from disposed products before
- In EU and USA, regulations about end-of-life products and their retake increase quickly. So companies need to manage the whole life of products effectively.
- Customers force companies to take responsibility on the disposal of harmful waste products
- The capacity of scrapheaps becomes limited and expensive. Also, it is realized that recovery options like reproduction are more effective and convenient.

## **2.7. Reasons Bringing Reverse Logistics into Prominence**

The importance to reverse logistics has been increasing beginning with the years 2000s. Reverse logistics has begun to catch the attention of both researchers and companies. Reverse logistics which was ignored before by many firms has now become crucial for them (Rogers and Tibben-Lembke, 1998). Nowadays, product returns has become widespread in all product categories. Return rate rises to 20% in some sectors.

The most important reasons for becoming crucial of reverse logistics are implemented regulations, increasing environmental awareness (social responsibility and social reasons) and also the fact that firms can benefit from reverse logistics (economic reasons).

### **2.7.1. Regulations**

Implemented regulations are norms that firms are made to respect by governments. Especially in Europe, the responsibility of producers about the production they made expanded for the lifecycle of the production. “Expanded producer responsibility” has brought the obligation of retake the products and materials after the consumer used.

Regulations implemented in Holland, Belgium and Italy, divide the responsibility of returned products among all producers, importers, distributors, suppliers, government and customers. While the regulations in Sweden and Switzerland encumber the responsibility of end-of-life products to the producers, the ones in Denmark hold the government responsible. With German Waste and Packaging Regulation implemented in Germany in 1991, producers, distributors and retailers have become responsible for returns of package wastes. This regulation began to be enacted also in EU countries in 1992. With the regulation “Waste Electrical and Electronic Equipment” implemented in USA in 2003, accumulation of electrical and electronic wastes is prevented. Reuse and recycle of these wastes are supported (Nakıboğlu, 2007).

Worldwide, with regulations effectuated, end-of-life products’ responsibility is given to designers, producers, recyclers and governments. Some regulations brought the firms the obligation of the responsibility to retake the product and to obey the rules of recycle quota and packaging. Local authorities in USA practice various programs for the producers to minimize wastes and usages of source. Regulations suggested in Europe hold responsible producers, importers, distributors, retailers, governments and customers. EU supports to enact regulations promoting ecologic view. The purpose of legal regulations is make the materials be used for longer, to research how the material usage and production can be more effective and to make the products more suitable for the nature.

Environmental regulations led producers to increase the usage rate of parts used as raw material in the production process in many countries. This raised the importance of secondhand markets in which used products are recovered.

### **2.7.2. Environmental Awareness**

Increasing environmental awareness raised the importance given to recycling activity, therefore to reverse logistics (Wu and Cheng, 2006). The environmental aspect of reverse logistics is critically important (Autry, 2005). Environmental social responsibility is also called as “expanded responsibility”. It aims sustainable development environmentally and socially. World Commission on Environment and Development has explained, without endangering the ability of future generations to meet their needs, sustainable development as development to fulfill the needs (Nakıboğlu, 2007).

Reverse logistics activities mostly provide positive environmental benefits even if it is done for cost and service efficiency (Stock, 2001). Global companies such as IBM, Hewlett- Packard, Xerox put development including suppliers and distributors to forefront (Sheu vd., 2005).

### **2.7.3. Economical Reasons**

Companies have realized that returned products have an economical value and reverse logistics contributes to themselves. Thus, the importance that companies give to reverse logistics have been increased (Blumberg, 1999). A well-developed reverse logistics system is a significant strategic asset for firms (Wadhwa, vd., 2009).

The economic effect of reverse logistics have been understood by many companies. With effective and productive management of returns, firms can gain value again from products. An effective reverse logistics is conducted with increase in firm’s outputs. Effective reverse logistics management is useful for firms by decreasing source investment and costs. Activities of reverse logistics such as reproduction, repair, recovery and recycle show their effects financially as cost or income with regaining value or loss in firms (Autry, 2005).

Although reverse logistics constitute a little percent of firm's costs, it provides an important competitive advantage to the firm (Stock, 2001). The effective management of reverse logistics activities provide firms high profits by decreasing the costs of transportation, inventory and storage (Ilgin and Gupta, 2010). Reverse logistics directly brings income to the firm by lowering raw material usage, revaluing of the recovered material or decreasing the costs in waste management or disposal (Cruz-Rivera and Ertel, 2009). Companies are able to make savings in the rate of 40-60% from reproduction costs thanks to reverse logistics (Biehl, vd., 2007).

Decreasing raw material sources is also a factor that increases the importance of reverse logistics for firms (Ilgin and Gupta, 2010). Source amount is highly decreased by reproducing the returned products (Rogers and Tibben-Lembke, 1998).

With the activity of recovery, reverse logistics provides minimization of costs, increase in profitability and an economical power for companies. Besides profitability, it also contributes to development of organizational image, creates competitive advantage and obedience to regulations. Additionally, it enables to guarantee future of the company and future incomes (Álvarez-Gil, vd., 2007).

Reverse logistics is practiced by some firms as organizational social responsibility project. It is used for a positive image of firms within the society to be formed and supported (Wu and Cheng, 2006, Skapa and Klapalová, 2009).

It is a part of sustainable development for companies because it creates an opportunity to decrease the costs and to gain value.

Marketing, competition and strategic reasons are also other factors that increase the importance given to reverse logistics by the companies (Cruz-Rivera and Ertel, 2009).

Consumers' changing behaviors for purchasing and their expectations increased the significance of reverse logistics. Firms also make use of reverse logistics in order to create customer's loyalty. Developed returned product policies provides firms competitive

advantage by supporting customer's satisfaction and loyalty (Skapa and Klapalová, 2009). Not accepting to retake the products leads the risk of the loss of customers in today's world in which many firms accept to do so (Pogorelec, 2000).

**Table 2.3 Competitive Advantages Reverse Logistics Provide**

Financial Advantages	Non-financial Advantages
Regaining value of used products gives the chance of investment return and new markets for the used products.	Well-intentioned returns develop the organizational image of the company in a positive way.
While offering "green" products catches the attention of consumers and employees being sensitive to the environment, making greener products causes less responsibilities, insurance rates and disposal costs	Feedbacks about returned products provides information about uncertainty in reverse flow and possible markets for various recovery activities.
Returned products can provide detailed data about commercial activity, product performance, customer expectations and product profitability.	It is advantageous in terms of opportunities created by information obtained from returned products to sellers and suppliers.
Policies such as long return periods, choice of return point, transportation and quick repayments have an increasing importance in both online and conventional shopping.	It provides opportunity to evaluate customers' reaction, view and satisfaction about physical features of returned products.

Source: Skapa, R., Klapalova, A., (2009), "Reverse Logistics in the Czech Republic: Outcomes of the Preliminary Research", Proceedings of ICABR 2009 Malta, s. 1259.

With the direct effects above, revenue to the firms is supplied. Advantages provided with indirect effects are evaluated not financially but through marketing equipment.

Globalization and internet has also brought reverse logistics into prominence (Lau and Wang, 2009). In firms making electronic commerce and catalog sales, the return rate of products is nearly 20%. This rate is 6% in conventional companies. Quickly- increasing electronic commerce that have high rate of returns has also brought significance to reverse logistics (Skapa and Klapalová, 2009).

Time shortening of products' life is also another factor. This reduction in time increases the number of unsold products, returns and wastes (Lau and Wang, 2009).

Another reason for gaining importance of reverse logistics is the increase in the use of electronic products (like computer or mobile phone). So, the amount of end-of-life products becomes higher. Electronic wastes include toxics like bromine and mercury, thus

damaging environment. Evaluating electronic wastes as garbage is not a proper solution against the possibility of reobtaining value. This situation leads electronic goods producers to give their attentions to reverse logistics (Lau and Wang, 2009).

## **2.8. Reverse Logistics Networks**

Reverse logistics network can not be expressed as easily as forward logistics (Sezer, 2010: 46). Reverse logistics network is a structure including product flow that follows many different routes after the products are taken from customers (Köse, 2009: 35). Reverse network is related to used products and materials (İlgün, 2010: 26). Reverse logistics network sets up the connection between new product markets and used product markets (El-Sayed, Afia, and El- Kharbotly, 2010: 423).

While determining reverse network, the type of returned product, recovery function that will be used and legal obligation in this field are important issues. At the same time, the work must be economical (Şengül, 2010: 55-56). Some questions such as “Which products will be returned? When will they be returned? Where will they be sent? What must be the reverse flow strategy to gain ultimate profit?” are matters that should be taken into consideration for reverse logistics network (Köse, 2009: 35).

Reverse logistics networks are divided into different sections considering recovery activities, profit that it will provide to the firm and regulations. Types of reverse logistics network is explained below:

### **2.8.1. General Reverse Logistics Network**

They are networks that local governments set up in frames of laws to decrease wastes. Activities such as storing, disassembly and recycling are used. Used products or materials are collected from customers in order to be operated. As a example, waste batteries, bottles and glasses, plastic and paper materials are sent to recycling centers after being stored. General reverse networks are pushing system (Şengül, 2010: 56).

### **2.8.2 Private Reverse Logistics Network**

Private reverse logistics networks are pulling systems. It works on end-of-life products or wastes products recycle of which is economical. The costs of recycling and transportation are paid by producers. Profit margin is quite important, hence the product must be at a specific size for recycling to be economical (Şengül, 2010: 77).

### **2.8.3 Reverse logistics network for the products compulsory to be retaken.**

These are networks set up due to regulations for harmful wastes to be collected by producers. Companies pay attention to decline of costs in order to set up these compulsory networks. Therefore, instead of setting these networks, companies use logistics service suppliers or recycling firms to retake the used products. Besides, by cooperating with municipalities' waste product drop points are also used (Şengül2010: 56-57).

### **2.8.4 Reuse Network**

It is the network that is set up for materials, products and constituents to be distributed and sold after collected from production area. In consequence these operations, a decline in the value of the basic product emerges (Paksoy, 2012:7). Either little value or no value is attributed to the tool (Özgün, 2007: 23-24). Recollected products can be either directly used or subjected to reoperation processes such as cleaning or small-scale repair (Şengül, 2010: 57).

### **2.8.5 Reproduction Network**

The aim of this network is to make the used product convenient to quality standards that are applied to new product. The product is totally separated and its parts are passed through control. Demoded parts are changed with new ones (Bulut and Deran, 2007:334). Automobile parts, copiers, scanners, printers and telecopiers can be given as examples (Şengül, 2010: 57).

### **2.8.6 Recycle Network**

The purpose of recycle network is to make the materials forming used products and their constituents reused. Products and constituents collected for recycle lose their features and functions (Demirel and Gökçen, 2008: 905).

### **2.8.7 Repair Service Network**

It is set up in order to meet customer's service needs and repair faulty products. In repair service network, the aim is to make returned products working and usable (Şengül, 2010: 77-78).

## **2.9 Reverse Logistics Errors**

In reverse logistics, to be able to get low cost and competitive advantage, it is important to do right things in the right way. Many errors may occur because reverse logistics includes numerous wide-ranging activities such as returns and changes, warranty and repair, recycle, reusable containers, recalls, bartering and product updating, reproduction and waste disposal (Stock, 2001). Absence of a specific reverse logistics policy is the biggest obstacle against the success of the system (Autry, 2005).

7 basic problems in the phases of planning, practicing and controlling of reverse logistics are below:

- *Not being aware of that reverse logistics provide competitive advantage:* in settings where competition exists intensively, it is quite difficult to create competitive advantage. Companies have to search new opportunities that will provide competitive advantage. Cost saving and service development which will be provided with doing product returns well have been beneficial for firms. A right reverse logistics practice is differentiating for firms and advantageous in markets.
- *After the product is sent to the customer, it is believed that firms' responsibility of the product is over:* firms' responsibility about the product continues in all life cycles of it due to the life cycle approach. In the situations when the life of product ends in customer

or it must be returned because of not satisfying the customer, firms must take all the responsibilities and satisfy the customer.

- *Not correlating internal and external systems and processes within the context of reverse logistics:* Even though the transportation in forward and reverse flow, storage and inventory control activities show similarities to each other, they are not the same. There occur problems in reverse logistics because logistics process in firms are organized considering forward flow. For reverse logistics to be practiced, forward flow must be organized in the way that it will include reverse flow.
- *Less effort for reverse logistics will be adequate:* Little effort made doesn't generally ensure the best outcome. A firm's managing forward flow well doesn't mean that it will also manage reverse logistics well. Firms need to use necessary time, money and employees in order to get effectiveness and productivity in reverse logistics activities.
- *It is believed that product returning process is too variable and too long:* Although product return process has a structure with multiple variables, management of process in the right way decreases the uncertainty of system, hence decreasing also the costs.
- *By spending time on product returns as much as product delivery, believing that the system will operate:* Transportation and storage of returned products are different from the ones of operated products. While the products that will be sent to the customer are easy to control as inventories thanks to packages, this is not seen in returned products. Returned products don't generally have packages, even if they possess, it is a common situation that the product and package don't match. Therefore, a little time is needed for the product to be defined in the areas where returned products are collected.
- *Not caring about the cost, value and possible advantages of returns:* Returned products impose serious costs to companies. However, the benefits that they can provide shouldn't be ignored. All assets have a value. The value of returned products should be determined as of other products.

Strategies that can be applied in order to prevent these errors are as follows (Stock, 2001):

- Allocating adequate resource for reverse logistics
- The process of reverse logistics must be determined and turned into flow schema for its constituents and connections to be understood easily
- Applying programs that provide necessary training to customers, sellers, suppliers and process partners
- Believing applicability of reverse logistics and environmental programs in scale economies
- Reverse logistics is resulted in a better way with the attendance of many organizations, therefore cooperation and relations should be cared
- For tracing the performance of the system, performance measurement system should be developed

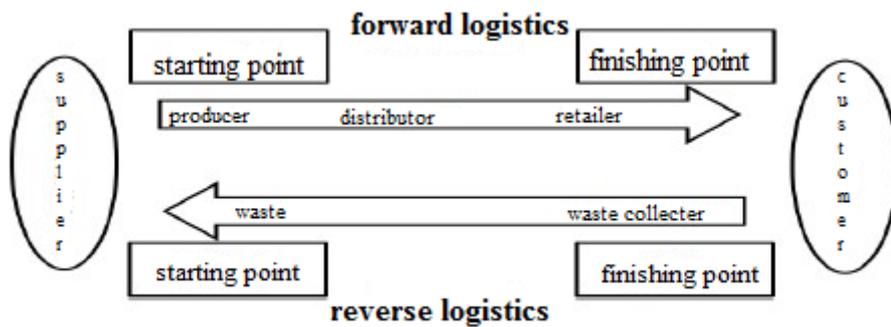
The most important reason for the inadequacy in management of reverse logistics is trying to manage the process by just one company. Also, not approaching reverse logistics with a total point of view. With the total viewpoint, as in forward logistics, cooperation of several companies must be ensured (Lau and Wang, 2009). If needed care is given to reverse logistics and necessary sources are supplied, its contributions to companies, environment and economy is obvious.

### 3. THE PROCESS OF REVERSE LOGISTICS

Reverse logistics processes are the ones that a company uses for damaged, unwanted or used products and also packages and transportation materials to be collected from the last user or seller.

Reverse logistics is a process of used product's physical movement from the customer to the producer. Also, it is a process of producing usable products with the rise in value of used products and of transportation of these products to customers (Koban and Yıldırım Keser, 2007).

It is possible to illustrate the reverse logistics process as in the shape 3.1 below:

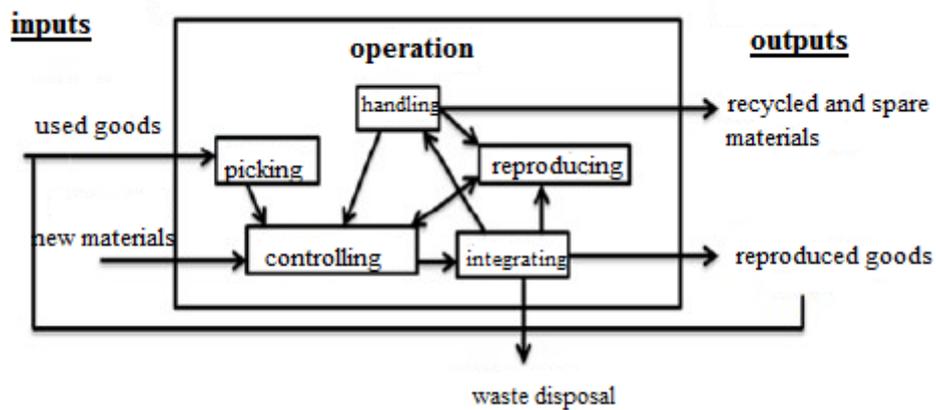


**Figure 3.1. Process of Reverse Logistic**

**Source:** Koban, E., Yıldırım Keser, H., (2007), *Dış Ticarete Lojistik*, Ekin Basın Yayın Dağıtım, Bursa, s. 86

In forward logistics, the movement of the product beginning with suppliers, continuing with producers, distributors, sales point and finally ending with customers becomes opposite in reverse logistics. So, the process ends with customers or even suppliers.

Reverse logistics system consists of inputs, process and outputs. The reverse logistics system is illustrated in Figure 3.2 below:



**Figure 3.2. System of Reverse Logistic**

**Source:** Pokharel, S., Mutha, A., (2009), "Perspectives in reverse logistics: A review", Resources, Conservation and Recycling, 53, s. 177

The inputs of reverse logistics system are created by used products, recycled materials and new items. Returned products are collected in specific recycling centers or in sellers. They are classified according to their qualities after passing through control. According to this classification, returned products are either disposed of or separated for reproduction or for other petty operations. The outputs of the system are reproduced goods, recycled materials and separated items.

In reverse logistics, flow of materials is categorized as external product returns and internal product returns. External returns are originated from the compulsion that producers have to retake the products they sold as required by laws. Except for the disposal of returned products, they are used in production with various recycle methods after they are separated. In internal returns, during production, many subsidiary products also emerge beside the basic products. These subsidiary products are put into the production again after passing through various operations (Minner, 2001).

### 3.1 Reasons for Product Returns in Reverse Logistics

Reverse logistics is the reverse flow of products from customers to producers. Product return from customer to producer is the beginning point of reverse logistics. Products, constituents, materials, equipment and technical systems move backwards in logistics system (de Brito, vd., 2001).

Skapa and Klupalova (2009) determined returns in reverse flow as unsaleable goods, recalled products, end-of-life products, recycled subsidiary products, production turns, commercial turns (damage, seasonal reasons, overstock and scrap), packages and containers.

An important rate of product returns is created by returns from customers. The rate of returns from customers is 6% in retails (Rogers and Tibben-Lembke, 1998). According to the research of Reverse Logistics Executive Council- RLEC), the rate of returned products is 8.46% (Wadhwa, vd., 2009).

Rates of returned products differ depending upon the current sector. For some sectors, product return rates are as in Table 3.1 below:

**Table 3.1 Occasional Return Rates For Some Sectors**

<b>Sector</b>	<b>Return Rate</b>
Magazine Publishing	50%
Book Publishing	20-30%
Book Distribution	10-20%
Greeting Cards	20-30%
Catalog Sellers	18-35%
Electronic Commerce	10-12%
Computer Producers	10-20%
Printer producers	4-8%
Massive Producers	4-15%
Automotive (item)	4-6%
Electronics	4-5%
House chemicals	2-3%

**Source:** Bulut, E., Deran, A., (2008), "Reverse Logistics and Its Effects on Firms' Management of Costs. Economical Approach Journal.

In companies that work by electronic commerce, the returned product rates in the fields of electronics, book and greeting card are more than the ones in other fields (Stock, 2001). Zieger (2003) has emphasized the sectors in which returns are critical, consumer electronics, publishing, catalog sales are available and also emphasized that returns in these sectors have the power to affect operating incomes (Nakıboğlu, 2007).

Returns in reverse logistics are divided into 2 main fields as product or package returns (Rogers and Tibben-Lembke, 1998). In the Table 4.2 below, it is shown that return reasons for the products or packages in reverse logistics generally according to return points.

**Table 3.2 Returned Item Types with Reasons and the Relation between Return Points**

	Return Point	
	Supply Chain Factor	Last User
Product	Stock Balancing Marketing returns The end of expiration date/ end of season Transportation damage	Defective/ Unwanted Product Warranty Returns Recall Disposal due to environmental reasons
Package	Reusing Transporting to multiple points Disposal	Reusing Recycle Disposal

**Source:** Rogers, D.S., Tibben-Lembke, R., (1998), *Going Backwards: Reverse Logistics Trends and Practices*, Reverse Logistics Executive Council Press, s. 13

Products should be put into reverse logistics process by the customer because defective products may not be wanted by the customer. Other reasons are need for service, recall by producers or sending back the products to the producer for material recovery or disposal. The reasons for including products into reverse logistics by any supply chain are overstocks, products obtained from promotional activities. In addition, ending of product's life before getting at last user and damages emerged during the flow of product in supply chain are other important factors. Packages also should be put into reverse logistics processes by supply chain members in order to be reused, recycled and disposed of.

Product returns can be originated from the production; they can also be originated from production errors or overproduction, and marketing; other reasons are sending wrong products, not determining the demand properly and allowing returns of redundant products (Stock, 2001).de Brito and Konings (2008) explained the reasons of product returns as inoperative product or no need for the product.

Brito, Flapper and Dekker (2002) classify product returns as the moment they occur in the production process as follows:

- Production returns,
- Commercial returns,
- Product recalls,
- Guarantee returns,
- Service returns,
- Expiration returns,

- End of life returns.

The returns that emerge from both product and raw material overstock contain returns to production area.

Commercial returns contain retaking of products with the consequence that sold products don't meet the expectations of customers or the consequence of agreements made by other staff in distributional channel.

Product recalls are gathering back defective products that are put on the market by producer. The products that are recalled at firms are divided into three categories. The products in the first category threaten the health of users severely. The products in this category need to be recalled and turned to the producer as soon as possible. The products in the second category are unhealthful for consumers but the harm dimension is not serious. Recalling of these products is important but it requires less urgency than the first category. The products in third category have no harm for consumer's health. Nevertheless, they are products that need to be recalled because of the mistakes made (wrong labelling, illegal, etc.).

Warranty and service returns are product returns occurring to repair breakdowns during using the product.

Used products returns are returns occurring when customer's need for the product is over. End-of-life product returns are return activities for disposing the product in a proper way.

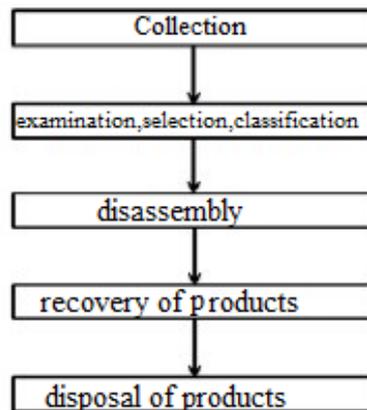
In their study in 2006, Wu and Cheng stated the reasons for product returns as follows:

- Positioning product marketing in a wrong way
- Quality problem
- Design defects and connection errors
- Wrong demand forecasting
- Unreasonable pricing

- Slow information flow
- Absence of marketing support
- Weak sale function
- Bad store presentation
- Absence of logistics support
- Absence of transportation support
- Absence of control on the quantity and sequence of returned products
- Late delivery due to the difference between order and demand amounts
- Long return process
- Returned products that are various but in small quantities
- Cash flow problem
- Not choosing product mix properly
- Paradox between expected returned products and emerged returned products
- Long distribution channel
- Increasing returns resulted from promotion activities
- Different consumer preference in different geographical regions
- High transportation costs resulted from difficulty of determining transport order in advance
- Absence of a specific order for stocking
- Presence of numerous distributors

### **3.2 Steps of Reverse Logistics Process**

Determining practicing steps in reverse logistics in companies brought formality to the process and made planning, organization, coordination, management and control of the system easier. The current sector, regulations and quality of returned products affect this process. Steps of reverse logistics explained by Mulder and de Brito and Dekker are illustrated in Figure 3.3 below:



**Figure 3.3. Process of Reverse Logistic**  
 Source: Mulder and de Brito and Dekker

### 3.2.1 Collection

The first step of reverse logistics is collecting the products that will be returned. Collection is bringing the products to recycle points after taking back from customers (de Brito and Dekker, 2004). For reverse logistics to be active, there must be product flow from the consumer to the producer (de Brito, vd., 2002). In the phase of collecting, the activity of retaking back the products from customers is done. In retaking phase, products are carried physically from the customer to the producer (Koban and Yıldırım Keser, 2007). Many producers take back their products to provide competitive advantage, to obtain social value with the contracts made during sales or on request.

That firms develop effective policies to obtain product in reverse logistics is important issue due to uncertainty of quantity, quality and timing in reverse logistics. There are two product acquisition systems: waste flow system and market-oriented system. In waste flow system, companies take wastes as required by regulations. In market-oriented system, companies obtain used products from customers with financial reinforcements. Applicable financial reinforcements can be as in the form of deposit systems, disbursement according to quality level or discount for the new product (Pokharel and Mutha, 2009).

The success of reverse logistics system is closely related to used products collecting strategies.

### 3.2.2 Product Collecting Channels

The structure of product and the current market cause collecting channels to become different. The collection method of a car and the collection method of a glass bottle differ from each other. This situation causes forming of various collecting canals (Zikmund and Stanton, 1971).

There are 4 basic collecting canals (Zikmund and Stanton, 1971):

*From consumer to producer:* In this collecting form, used products, packages or wastes are directly sent from consumer to producer or the producer takes the product directly from the customer.

Modern consumers care transporting product, package or wastes directly to producer and they exert effort for this (Zikmund and Stanton, 1971).

*With sales points belonging to producer:* Sometimes, reaching producer directly is quite difficult and expensive. The producer possesses common sales point network. In these situations, consumers reach producers by sending their products to these points.

*With means not related to producer:* When the producer has no sufficient ability about collecting products, however, collection is useful for environment and economy, it is the method of collecting products with the efforts of corporations, municipalities or employee associations through collecting points and containers.

Indirect collection: It is the method based on sending back products that are wasted by customers and has economic value to producers for recycle.

For production flow to be started, some inducements that have economic aspects or not have been used by companies. The incentive factors for product retaking are as below:

- Deposit cost,
- Retaking option,

- Discount in new product's price,
- Payoff
- Not taking return costs
- Instead of old one, giving new one
- Rental contracts
- Providing easy provision
- Right and in-time information
- Regulations
- Provoking environmental awareness in consumer
- Provoking social awareness in consumer

### **3.2.3 Examination, Selection and Classification**

With the examination, the quality and convenience of products are determined after they are collected from customers. In line with the outcomes, products to which value regaining is applied are selected and classified according to methods that will be applied (de Brito and Dekker, 2004). After examination of returned products, the most suitable recycle operation is determined (Koban and Yıldırım Keser, 2007).

Examination, selection and classification are the phases in which the decision of product usability and its recovery method is made. These phases also include testing and storing activities (Fleischmann, 2000).

Examination, selection and classification can be practiced at the same time with collection according to collecting or producing points or can be carried out later (Srivastava and Srivastava, 2006).

While being examined, products are generally divided into 3 groups (Fleischmann, 2000):

- High quality products that can be recovered with minor operations
- Separable products having usable pieces
- Products that will be disposed of.

Critical factor for selection is profitability and manageability of product in reverse logistics process. The returned product can be in any quality level. It can be defective, damaged or just unwanted by the customer. It is needed to evaluate each product economically and to decide which strategy must be applied (Ji, 2006). While returned products are evaluated economically, production costs are taken into account. The cost for producing a new product and the cost for recovering products should be compared (Fleischmann, vd., 1997).

Classification is the activity that products examined and selected for recovery are sent either to separation or to proper production unit after grouped according to their features or activities.

### **3.2.4 Separation**

In the next step, the product is separated for recovery method decided after examination to be applied.

Separating is the most obvious phase that distinguishes the system based on recovering from conventional production. Separating is the loss of links in many materials. It is an activity having deep and consecutive steps (Fleischmann, 2000).

Separated items are divided into 2 groups as usable items and non-usable items. While recovery is feasible with usable items, with non-usable items, the disposal activity is done.

### **3.2.5 Product Recovery**

The method decided in value gaining step is applied. Then, maximum benefit is tried to be obtained. (Koban and Yıldırım Keser, 2007). The idea “second life” has led reusing materials and products instead of their becoming wastes. This idea is originated from decrease in production input sources and the need for storing increasing wastes (Wells and Seitz, 2005).

- Sending back to supplier

- Reselling
- Selling in outlet
- Making scrap
- Repairing
- Renovating
- Reproducing
- Regaining material
- Recycle
- Making waste

If repayment can be received after returned product is sent to supplier, this is the first alternative to apply. If the product is returned without any use, it can be sold to different customers and this sale can be done in outlets. If returned product has inadequate quality, then the product can be sold to other companies as scrap. If there is the possibility of offering the product as new product to the market, the alternatives “repairing, recovering or reproducing” can be applied. If the product can’t be reused in markets for various reasons, the alternatives “storing it as recycled material or waste or disposing it” can be applied.

If the returned material is package, applicable operations are as follows:

- Reusing
- Recovering
- Reobtaining material
- Recycle
- Making scrap

When the package is returned from customer, the possibility of reusing it is taken into consideration. If the returned package is damaged, necessary recovery operations are done before using it. If returned package is out of condition, recovery and recycle are applied. Then, the package is turned into scrap or waste.

### 3.2.6 Disposal

In the last step of reverse logistics, products or packages that have no technical and economic value are disposed with proper disposal methods.

Disposal is an activity that is applied when returned product can't be lowered to separation level, the efforts and costs for recycle is too high, recycled product has no marketing potential to satisfy company and the product is expired. Disposal includes transportation, waste burial or open waste storing and incineration operations (Fleischmann, 2000).

The hierarchy of operations applied in reverse logistics is shown below:



**Figure3.4. Hierarchy of Reverse Logistic**

**Source:** Carter, C.R., Ellram, L.M., (1998), "Reverse Logistics: A Review of the Literature and Framework for Future Investigation", Journal of Business Logistics, 19/1, s. 92

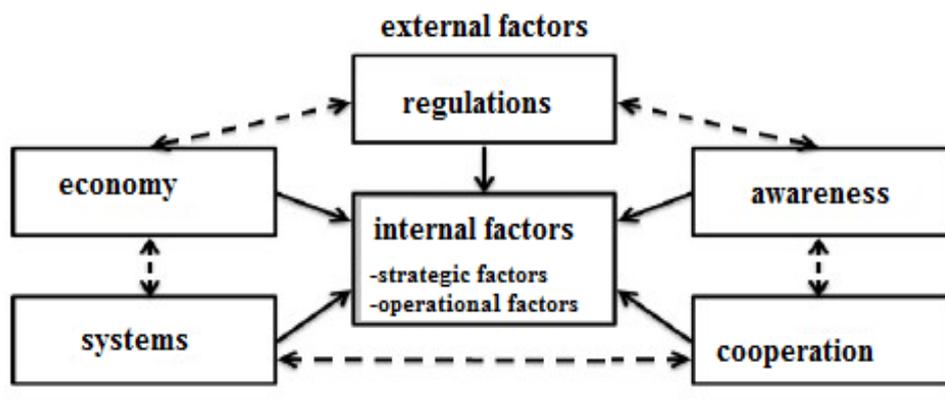
The main aim in reverse logistics is to decrease the sources that will be used in production. In the previous step, there is the phase "reusing" and the produced item is quite made use of. In the next step, there is the phase "recycling". With this phase, obtaining value from wasted materials is aimed at. In the last step of reverse logistics hierarchy, there is "disposal". Disposal is applied by, if possible, incinerating in the way that energy is obtained, if not, by burying or storing.

Transportation activity is also performed in each step of the process although it is not regarded as a step in reverse logistics process.

### 3.3 Factors Affecting Reverse Logistics Process

Reverse logistics process is affected by many internal and external factors. The existence of these factors makes easier the practice of reverse logistics process. The absence of these factors poses an obstacle for the practice (Lau and Wang, 2009).

Internal and external factors affecting reverse logistics system are shown in Figure 3.5 below:



**Figure3.5. Internal and External Factors Affecting Reverse Logistic**  
Source: (Lau and Wang, 2009).

External factors affecting reverse logistics system are awareness, regulations, economy, systems and cooperation. Awareness reveals the interest of society to environmental matters. It also forces producers to satisfy customers' expectations for competition and sustainable development. Regulations enable to protect environment, consumers and companies with the rules made by government. Economy is the existence of benefits that can be obtained with reverse logistics. Systems reveal the existence of necessary information system, infrastructure and technology. As for cooperation, it characterizes the existence of collaborators and competitors needed for the process. These factors affect the development of reverse logistics not just in operation level but also in industry level.

Internal factors affecting reverse logistics system are strategic and operational factors. Strategic factors are concerns of costs, quality, customer services, environment and regulations. Operational factors are cost-benefit analysis, transportation, storage,

procurement management, reproduction, recycle and packaging. In the phase “designing reverse logistics”, these factors should be taken into consideration.

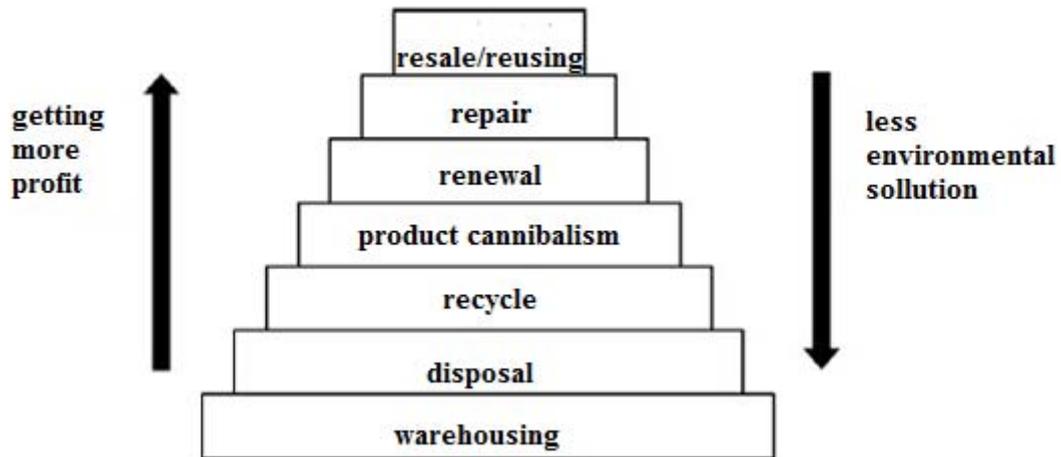
Rogers and Tibben-Lembke determined internal factors as the importance given to reverse logistics, company policies, strategic plans, executives support, resist to change, information and technology systems, financial sources, human resources, performance criteria and the quality of returned products.

As companies are, according to regulations, responsible for the period after products are used, the basic method they adopt is disposing the products. However, costs for disposal show that economic advantage must be obtained from this situation. With reverse logistics process, various recovery operations is applied to returned products according to their qualities, situations and structures. With recovery operations applied, life-period of products are prolonged, the need for input is reduced and it is started to obtain economic value.

In reverse logistics, it is proved that with the method “proper product recovery”, value of returned products is regained (Andel, 1997).

There are many product recovery methods. These methods aim to regain value from products with different technologies (Skapa and Klapalova, 2009).

In Figure 3.6 below, product recovery alternatives are illustrated:



**Figure 3.6. Pyramid of Recovery Alternatives**

The alternatives in the top step are much more when compared to alternatives in the bottom steps (Skapa and Klopalova, 2009).

Thierry vd. (1995) defined product recovery as regaining the economic and environmental value of returned product as much as possible and decreasing the amount of wastes by doing this (Wadhwa, vd., 2009).

Product recovery alternatives are as follows:

- Repair
- Renewal
- Reproduction
- Product cannibalism
- Recycle
- Disposal

### **3.3.1 Reparation**

The aim of reparation is turning the product back to its work order. The damaged parts are changed to obtain an operating product. Other parts generally stay the same. The quality of the repaired product may be lower than new ones’.

Reparation requires limited sortation and recombination. It is practiced at the customer’s place or at a repair centre related to the producer. Many producers of durable- consumer goods are closely interested in repair of their products.

Reusing is the use of the whole product again with its main aim. With reusing, the main physical structure of the material is preserved with little particle changes. Reusing provides not only economic benefit but also ecologic advantage. The used-product is put into the operating process again.

### **3.3.2 Renovation**

Renovation is bringing the quality of the product to the normal level with the processes “sortation” and “changing the damaged parts”. The aim of renovation is getting the used-product to the determined quality level. The aimed quality is lower than the new product. After the used product is dismantled, all critical parts are revised and repaired. Repaired parts are erected to the renovated product. Renovation includes updating technologically. The demoded parts in the product are shifted with current parts. Renovation enhances the product’s quality prominently and prolongs its lifetime. The service life gotten from renovation is shorter than the nwe product’s.

### **3.3.3 Reproduction**

Reproduction is sorting the used materials to the least level as much as possible, revising and changing the parts and then obtaining a new product. Reproduction tries to make the product better by changing the old parts, controlling the convenience for product standard and getting original product standard with quality-control tests. Reproduction includes needed renovation processes for the used product to be as qualified as the new one. During

reproduction, there are some changes of parts. The aim is to prolong the used products' lifetime by restoring them. There are some examples such as recycling of waste paper, returnable drinking bottle and filling print cartridge.

### **3.3.4 Cannibalism of Product**

Cannibalism of product is reobtaining little usable parts from the used products. It is used in many alternatives of recycling. It is also explained as reusing some parts of the product for another product to be repaired, revised and reproduced. The quality level of cannibalised parts depends on the period they will be used. The materials which will be used in reproduction process must be tighter and of better quality than the ones that will be used in revision and repair. Cannibalism of product requires sortation of the used materials in some level and examination of the potential usable ones. The rest ones are not used during cannibalism.

### **3.3.5 Recycling**

The aim of all the other product recycling activities is to maintain the features and functions of the used products as much as possible. In recycling, functions of the product and its constituents are destroyed. The purpose in recycling is reusing the product and its constituents. In recycling, the used product is divided into usable materials by various methods. Then, these materials are used in production of new product. So, recycling is obtaining material from the old product. Recycling gives a new structure to the product in both physically and chemically.

If the materials obtained in recycling are of high quality, they are used in production of new goods, if not, they are reused in other processes of production. Recycling begins with dividing of the used materials and constituents. These parts are grouped according to what they are made of. Later, grouped materials are used in productions of new parts. Recycling is applied to a large number of used products. For example, all metal parts of a junk car (approximately %75 of the car's weight) are recycled in Germany, England and USA.

### **3.3.6 Disposal**

Disposal is storing the used products as waste or incinerating them. The disposal of the old product and materials is practiced in 3 ways. The first one is incineration of wastes. The energy coming from burning can be useful for the plant if needed technology is provided. Another method is burying the wastes- especially the exposed ones that can be harmful to human health and environment. The last method is storing the wastes in open areas.

It is important to decide how the products are utilised in which phases and then how they will be disposed. The age of the product, the substances forming its constituents and their rates, its technology, the separation level of the product, the operativeness of reproduction process, demand and cost for the operated products are all important factors for making this decision.

### **3.4 Disguised Costs in Reverse Logistics**

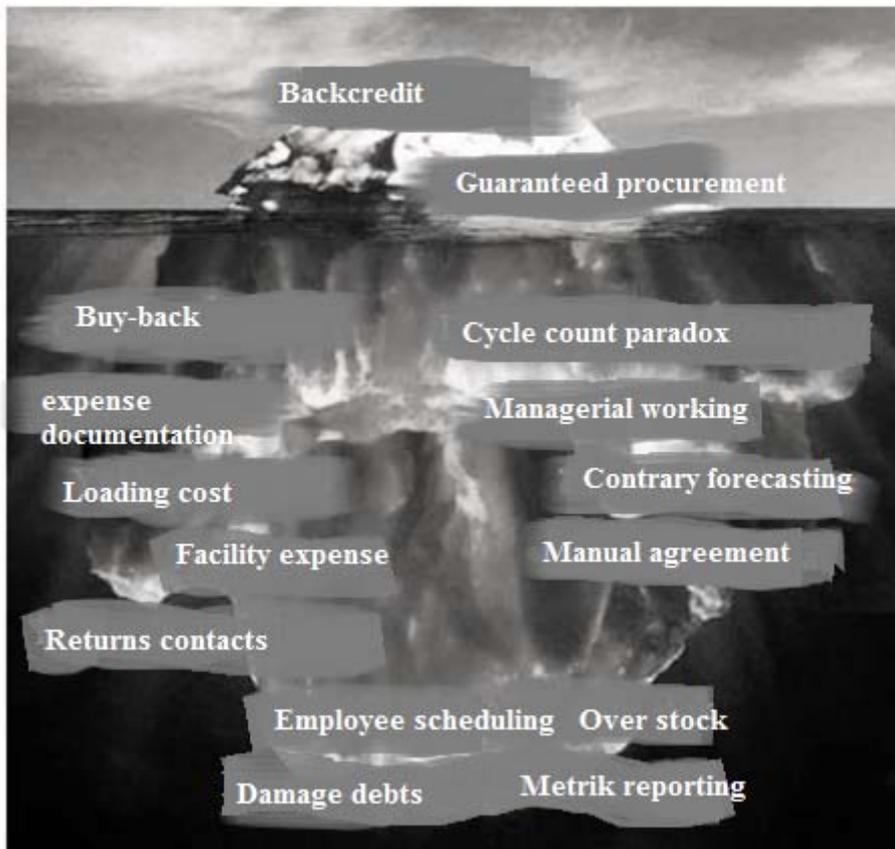
Today, primary activity of plants that have advanced supply chain management is to earn income by selling their products to ultimate users. However, increasing consumer awareness in recent years, legislative regulations, economic reasons and awareness of social responsibility have led managers to get the products that they sell from the market.

Quantity and quality of the products which turn to supply chain of plants affect incomes of the plants and countries significantly. For instance, that recycle ratio of industrial products in USA happens between 4-8 % affects total USA income about 52-104 billion dollars. Also, the fact that recycle ratio of computer and its hardwares is 8-20% affects total income of USA between 39-97 billion dollars.

Practicing successfully the activities of reverse logistics that affect incomes of countries can only be possible by using information and technology effectively. Today, firms do not much care information about management of operations within the scope of reverse logistics and technology used in this field. Lack of using information and technology in reverse logistics leads to a slightly increase in value of recycled products. This increase

happens slowly. Therefore, this situation causes a concealed loss in value in supply chain of firms. These concealed losses are expressed in literature as “disguised costs”.

These disguised costs that affect productivity in reverse logistics are shown in Figure 3.7.



**Figure 3.7 Hidden Cost of Reverse Logistics**  
Source: (Norman ve Sumner, Agis, 2015)

Shown in figure 3.7, disguised costs are possible to examine in headings following:

### 3.4.1 Disguised Labour Cost

If firms benefit from information and automation systems on a limited scale or do not benefit in any way, they have to be exposed to some disguised labour costs. The costs originated from the activities that firms practice are as follows:

- Labour costs resulted from activities such as product recycle policies applied in the scope of customer relations, the qualities of returned products, determination of credit time in credits made with customers and assessment of warranty applications,
- Labour costs resulted from activities such as marking of returned product and assessment of special needs in case of firms' applying warranty policy and service contracts, determining credit policies, changing returned products with new ones,
- Labour costs resulted from activities in the event that returned products are not under warranty
- Labour costs resulted from lack of care to new sales due to the fact that firms' sales representatives focus mostly on returned products,
- Labour costs resulted from lack of a specific procedure in terms of transporters' control, the situation of one-time shipment, damages while moving, controlling of returned products, collecting costs effectively and detection of transport route,
- Labour costs resulted from long-term storing because of the time for determining recycle programs and assessing returned materials,
- Labour costs resulted from the fact that activities such as repair, resurrection, reproduction and recycle are tried to be practiced by personnels who have inadequate informations.

### **3.4.2 Gray Market Costs**

Subventions made by consumers concerning the products that firms supply from gray markets can be both risky and expensive. That these products aren't under warranty and the operation of sorting from the original product is practiced potently leads to costs that firms have to endure. This situation creates another disguised cost in reverse logistics. Gray market is the sell of product by importing it individually from any country without reports of official importers.

### **3.4.3 Absence of Traceability**

The operations about returned products from consumers and absence of written instructions about when the products are repaired and sent to the customers cause failure in relations between consumers and firms. In addition, they lead additional communication costs.

### **3.4.4 Absence of Right Decision**

The fact that firms can not make right decisions about datas of returned products from customers within the scope of reverse logistics leads to employing redundant personnels, putting personnels to work too much and increase in overtime payment.

### **3.4.5 Loan Agreement**

That loan agreements made with customers about returned products from the firms selling on credit happens intensely may cause claim for refund, detection failure in accepted products' value and failure in matching with their bills. Firms have to put up with costs about loan agreement during these operations.

### **3.4.6 Poor Response Process and Negative Image of The Brand**

That firms traces claims for refund related to products returned from consumers intensely without using automation system causes delay in approval or refusal of claims. This situation leads to failure in communication between firms and customers, decrease in sails and more communication costs.

## **3.5 Approaches for Decrease in Disguised Costs**

Firms do have to put up with some costs as disguised and open costs during reverse logistics activities related to products returning to supply chains. For these costs to be lowered, the first action that firms must take is integrating information technologies to reverse logistics processes. Then, firms are able to lower the costs by using information

technologies during estimating and controlling recycle of sold products, determining the routes, tracing the process of collecting products and planning recycling activities.

One of the information technologies used for reverse logistics activities to be practiced well and for lowering the costs is web based Return Merchandise Authorization-RMA systems. Firms are able to directly reach data about returned products by integrating RMA system to ERP systems.

Consumers who sent their products to firms can reach RMA procedure from web pages of firms. By doing so, they can both examine their rights on the products and control the situation of their products with the help of RMA numbers.

Another system that firms use to lower reverse logistics costs is Enterprise Returns Management- ERM system. ERM is a new and an active system used to log in the orders of returned products, decrease failures and costs. In this way, firms can gain high profit margins. Besides, the costs of reverse logistics can be decreased by improving cost system that firms practice. For instance, firms enable to lower quality costs which are called total costs of repression, recycling and failure within the frame of total quality management. So, they can lower the costs of reverse logistics.

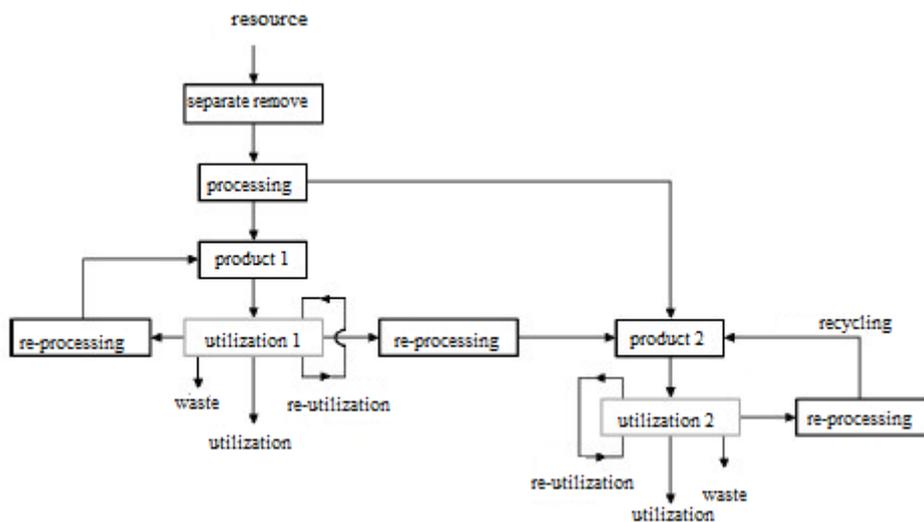
Firms also can lower the costs by practicing some strategies such as reducing returning of products, planning the quantity and time of returns, extending the products' lifetime and managing the lifecycle of these products. In addition to these strategies, managers can also hand over the activities mentioned to experts in the field of reverse logistics. Outsourcing during the process of reverse logistics is as follows:

### **3.6 Industrial Ecology**

Products can be used consecutively thanks to recycling. This is the main driving power of industrial ecology.

Industrial ecology is a frame of regimentation for many aspects of environmental management. It is seen as a natural system and a part of ecosystem and global biosfer. Industrial ecology is based on the main understanding that it is important to model industrial system and to get sustainable environmental performance.

Following Figure 3.8 shows industrial ecology.



**Figure 3.8 Industrial ecology: (consecutive use of materials and products)**

During the process of this system, materials and products are used or reused for the same or different purposes. Eventhough this procedure is often carried out successfully, the performance of products is much lower in reusing the products.

## 4. SITUATION OF REVERSE LOGISTICS IN TURKEY AND IN THE WORLD

### 4.1 Situation of Reverse Logistics in the World

Indeed, reuse of materials and products is not a new concept. It is practiced for a long time to collect scrap metals, to recycle waste papers, to do deposit practices for glass bottles and to reuse of packaging materials. Returning of products is economically more advantageous than disposal or reproduction. In Europe, the responsibility of collecting products like automobile and electronics is given to producers. EU Electric and Electronics Products Waste Legislation has increased the rate of recovery to 75% and the rate of reuse or recycle to 65% till 2006. With legal pressures, in many countries, there have been constituted national collecting and recovery systems. While in USA 20% of glass, 30% of paper products and 61% of aluminium boxes are recycled, every year 95% of cars and trucks is put into recycling and 75% of these vehicles is recovered for reusing. Firms have realised direct and indirect benefits of reverse logistics. So, they practice their strategies and long-term plans considering this. To give an example, the strategic aim of BMW is to design automobiles that are wholly recoverable in 21. Century. Reverse logistics is, apart from automotive industry, valid in many industries and markets including steel, electronics, computer, chemistry, medicine, online sales, catalog retailing, heavy equipment and medical devices. Among big firms that practice reverse logistics are BMW, Delphi, DuPont, General Motors, HP, Xerox, Canon, IBM, Ford, Phillips ([www.utikad.org.tr](http://www.utikad.org.tr), 10.06.2016)

Returned products that can not be controlled till the end of 1980s have become a separate management because retailers regard them as competitive advantage. Returning has recently increased with the effect of retailers' supporting product returns to create competitive advantage. Meyer (1999) is of the opinion that this rate rises to 30-50% in some products and situations.

Nowadays, the return rate in ever-mounting catalog and online retails vary by the type of the product. These sales are 5-25% of the total sales (Morphy, 2001). Meyer (1999) thinks that the number in online sales is 50% (Subramaniam, 2004). It is predicted that in 2005 online customers will return 90 million pencils costing 5.8 billion dollars (Moore ve Davis,

2001). According to the research that Rogers and Tibben- Lembke did in USA with 1.003 operations, rates of product returns for some chosen sectors are shown in Table 4.1

**Table 4.1.rates of product returns for some chosen sectors**

Industry	Percentage
Publishing journal	50%
Publishing book	20-30%
Distributing book	10-20%
Catalog retails	18-35%
Electronics distributions	10-12%
Computer producers	10-20%
CD ROM	18-25%
Printer	4-8%
Automobile Industry (item)	4-6%
Consumer Electronics	4-5%
House Chemical	2-3%

Source: Rogers and Tibben-Lembke, 1999

According to Gartner, only in USA, the process of managing product returns has reached 150 billion dollars (Frontline, 2005). Generally, it is thought that 20% of all the sold products is returned and 5% of logistics costs of firms is spent for reverse logistics (Hill, 2004). Returns have the power of effecting operating profit in many sectors such as consumer electronics, publishing and catalog sales (Zieger, 2003).

Recently, statutory regulations that appear with the increase of sensitivity to the matter also force the firms to practice reverse logistics activities. Extended producer responsibility (EPR) that increases with many statutory regulations has become a valid understanding. So, producers have been held responsible for their products till the end of the products' life. The purpose of all these regulations is to make the material to be used for longer time thanks to reusing and recycling. Another purposes are to learn how material using and producing can be more effective and to make the products convenient for nature with the help of product designation (Sundin, 2004). Due to regulations OEMs (Original Equipment Manufacturer) are responsible for the products and electronics they produce till the end of products' life. For example, if the user leaves the refrigerator he used to dump without extracting its parts or a child dies because of remaining close in it, then the refrigerator producer may be held responsible (Blumberg, 2004).

Besides regulations about environment has gained importance, especially EU quite pays attention to “Green Reverse Logistics: Importance and Practices in the world / 187 Development and Practices of Regulations” for environmental effects to be reduced or even removed totally. The main objective in these practices is Germany and Northern Europe countries in which environmental effects are seen as the most important problems. For instance, in 1991 within the scope of German Waste and Packaging law that is enacted in Germany, producers, distributors and retailers are held responsible for recycling of packaging wastes. Many other member states of EU also started to practice the law about packaging rules in 1992. Similarly, in many states of USA, laws like this began to be valid (Subramaniam, 2004).

EU published the instruction WEEE (Waste Electronic and Electrical Equipment) in January 2003. The plot of this guideline is preventing accumulation of electric and electronic products’ wastes and also supporting of reusing and recovering of these types of products. The general purpose of the guideline is to increase environmental performance of all shareholders such as producers, distributors, customers and firms that are responsible for the procedures at the end of the products’ life. According to this guideline, EU members are in the position of promoting designation and production of products in the way that they can be dismantled, broken down, recycled and especially reused (Sundin, 2004). With WEEE, producers are held responsible for the destruction of electric and electronic products. If supplier can’t take the product back, the last user is responsible not only for leaving the product to dumping area but also for annihilating it lawfully (Blumberg, 2004). WEEE regulations will have a huge impact on reverse logistics and setting up closed cycle supply chain. Both EU originated companies and many other multinational companies that make sales to EU will have to follow these rules.

Another important law in terms of product recovery and reverse logistics is ELV (End of Life Vehicle Directives) which is for automotive industry. According to this regulation, 85% of vehicles’ weight must be recyclable till the end of 2005. In accordance with ELV, vehicles’ rate of being recyclable is determined as 95% for the year 2015 (Bunger, 2004; NC3R). Subjecting automotive sector to regulations is quite necessary and logical because automobiles are among the most recyclable products. This is because 75-85% of a vehicle’s

content is recyclable (Lund, www.remancentral.com). The future strategy of automotive industry and companies involved in this industry is developed considering this concept. To give an example, the strategic purpose of BMW is to design automobiles that can be totally recovered in 21st century (Dowlatshahi, 2000). According to The Society of Motor Manufacturers and Traders, long-term success of automotive industry depends on the working ability of the sector in sustainable future. This ability includes both environmental and social responsibilities (Seitz).

#### **4.2 Reverse Logistics Activities in Turkey**

Reverse logistics activities in Turkey began to be carried out by various companies from the middle of 2000s. The facts that Turkey is developing country and there is lack of necessary regulations have delayed the implementation of reverse logistics activities. In developed countries like USA and EU countries, laws for collecting the products after use have been implemented from the beginning of 90s (Prahinski & Kocabasoglu, 2006). EU implemented regulations “Waste Electrical and Electronic Equipment” and “End-of-Life Vehicles” are examples of this. However, some of these regulations began to be practiced with the orientation period to EU in Turkey. For this reason, reverse logistics takes little parts in Turkey in terms of both real life practice and academic study.

It can be said that in Turkey, reverse logistics activities began due to the changes done in regulations for protecting environment. The fields of regulations that Ministry of Environment and Forestry enacted such as waste package, waste batteries, residual oil, waste plant oil, waste electric and electronic goods, building waste, end-of-life tire (ELT) can be given as examples. According to waste batteries and accumulator regulations enacted in 2005, battery producers have to collect and dispose of waste batteries (by counting the previous years' amount) in the rate of 15% (first year), 25% (second year), 30% (third year), 35% (fourth year), 40% (fifth year). In on-going years, ministry determines the rates. In view of the same regulations, accumulator producers have to recycle not less than 70% (first year following the implementation), 80% (second year), 90% (third year) of waste accumulators that are subject to deposit implementation, have to dispose and submit the related documents every year to The Ministry of Environment with deposit

references. In Turkey, These activities must be carried on by TAP (Taşınabilir Pil Üretici ve İthalatçıları Derneği) and AKÜDER (Akümülatör ve Geri Kazanım Sanayicileri Derneği).

According to waste oil regulations, waste oils in the first category can be used directly and the ones in the second category can be reused thanks to regeneration and raffination methods. 1. and 2. categorised- waste oils can be used by being added to available fuel in cement, plaster and lime companies or in clay drying and iron-steel blast furnaces. Petroleum Industry Association is authorised by Ministry of Environment and Forestry in the name of Petroleum Industry Association and Motor Oil Producers to gather waste motor oils. In the last 7 years, 123.627 tones of waste motor oil are collected by doing 96.780 services from 12.038 different waste - motor oil producers in 81 cities. Only in the year 2012, the amount of waste motor oil which is collected by doing 14.730 services to waste motor oil producers and submitted to licenced companies reached 18.545 tones. The number of companies attending the organisation is 84 from the end of the year 2012. The amount of motor oil which is put on markets in 2011 is 185.743 tones (PETDER sector report 2012).

Old and out of use electrical and electronic appliances such as refrigerator, television, washing machine, mobile phone and computer in houses and workplaces will also be utilized thanks to AEEE regulation that is made in 22 May 2012 and enacted beginning from June 2013. According to the regulation, the targets of recycling is given in table 3. Accordingly, it is intended that minimum 50%, maximum 75% of electrical and electronic appliances will be put into recycling in the year 2016. In view of the data of Environment and Urbanisation Ministry, 539 000 tones of AEEE occur per year in Turkey. Only 20.000 tones of these wastes can be recycled in keeping with circumstances. The most wasted appliances are televisions and computer monitors. The cities producing AEEE most are Istanbul, Kocaeli and Ankara. In Turkey, the production of AEEE per capita is nearly 7 kilogram. Dating from the end of 2011, the amount of AEEE that provides recycling in Turkey is expressed to be 8.200 kg and the number of licenced AEEE companies to be 21 (Environmental Protection and Packaging Waste Recovery and Recycling Foundation, 2013).

**Table 4.2. Target Rates of Returning Electrical and Electronic Equipment**

Electrical and Electronic Appliance Categories	Years				
	2012	2013	2014	2015	2016
	Weight (%)				
Big Household Goods (%)	50	55	60	65	70
Small House Appliances (%)	10	20	30	40	50
Information and Telecommunication Equipments (%)	15	25	35	50	65
Consumer Equipments (%)	15	25	35	50	65
Lighting Devices (%)	10	20	30	40	50
Gas Discharge Lamps (%)	50	55	60	70	80
Electrical and Electronic Appliances (%)	10	20	30	40	50
Toys, Entertainment- Sport Tools (%)	10	20	30	40	50
Monitoring and Controlling Devices (%)	10	20	30	40	50
Automats (%)	50	55	60	65	70

**Source:** BELBAĞ, Sedat. Optimization of Acceptance and Production in Reverse Logistics Management, Doctoral Thesis, Ankara, 2013.

Lastly, according to end-of-life tire regulation, tire producers are responsible for collecting 30% (in 2005 – the year the regulation was enacted), 35% (second year), 40% (third year), 45% (fourth year) and 50% (fifth year) of ELTs, also for recovering or disposing of the collected amount. While determining these rates, tire tonnage that is released to the domestic market is also counted. In on-going years, Ministry of Environment and Urbanisation determines the rates by taking the average tire abrasion rate into consideration. When tread depth of tyres declines to a specific millimeter, it poses a danger under the vehicle. Therefore, laws do not allow to drive on the street with these kinds of tyres. It is estimated that every year in Turkey approximately 180 – 200.000 ton ELT is formed. The whole ELT in Turkey is gathered by Lastik Sanayicileri Derneği (LASDER) and delivered to licensed recycling firms.

Reverse logistics activities have, even if just a bit, gradually increased thanks to these regulations that have entered into force. They are administered through third party firms as mentioned above because reverse logistics activities in Turkey are on the onset. Unfortunately, the firms in Turkey unlike firms abroad don't evaluate the option of building a facility which will implement reverse logistics activities in themselves due to various reasons.

The number of academic studies that have been carried out related to reverse logistics in Turkey is as limited as management practice. Two of them stand out among these studies which are too few in academic level. The study that has been carried out by Erol and others

(2010) is the first one to enlighten resource and level of reverse logistics activities in the sectors “auto, white goods, electronics and furniture” in Turkey. With this study, the authors are examining the studies related to reverse logistics of various firms that operate in four sectors in Turkey. As a result of the meetings carried out, the biggest obstacle of the firms taking part in these four important sectors in Turkey to implement reverse logistics activities is that sufficient legal and economic reinforcements aren't presented. Because of little reinforcement, the firms escape from required investment for necessary infrastructure and technology. Another important result is that business managers prejudge against reverse logistic activities. The managers think that the brand image will be damaged if the quality of products is lower than the new product during the reverse logistic activities. For this reason, implementing reverse logistic activities must be avoided.

Another remarkable study is forming potential reverse logistic network for a big white goods producer who operates in Turkey instead of fulfilling field research like Erol and others did (Tuzkaya, Gülsün, & Önsel, 2011). In this study, it is tried to determine the location of potential recollect storages and of potential recollect center with minimum cost for white goods producer. The importance of this study is that it is the first one carried out in order to form potential reverse logistics network for a firm in Turkey. In brief, reverse logistic activities are taken into consideration too late. However, it is inevitable that it will become an issue that can be examined more in next terms.

## **5.OPTIMAL RECEIVING AND PRODUCTION CONTROL MODEL IN REVERSE LOGISTICS MANAGEMENT**

As mentioned in the previous sections, reverse logistics has become a quite popular matter in terms of both companies and academic studies. The reason for the attention to reverse logistics is explained with various factors such as environmental awareness, legal and economic factors. Reverse logistics includes various methods to recover products returned to companies for any reason. However, it is the reproduction process that has the widest use of area among these methods. Besides, reproduction activity requires supportive logistics activities such as collecting, separating and stocking returned products, which brings companies extra cost burden. Even so, reproduction activity has become a preferred option for especially original-material producing companies because it provides savings in terms of input costs when compared to conventional production. Additionally, collecting returned products has a big importance with regards to both asset protection and effective control of production and reproduction activities.

Original material producing company uses a composite fabrication system consisting of both normal production and reproduction lines. Besides producing new product, this company collects products that completed their economic life or broke down and puts them into reproduction phase. It does not separate the reproduced products from the products produced by normal production activity and puts them on the market by giving the guarantee that “it is like new product”. Therefore, it is accepted that there is no quality difference between reproduced products and products produced in normal production way. The company should make a decision about returned products before it determines with which production methods it should meet coming demands. According to this decision, the company will either accept returned products, stock them to recover or refuse to take and put them into waste product category by removing from the system. Production procedure (whether normal production or reproduction) is performed in the base of production to order. In other words, production is done as customer demand arises. Otherwise, the production does not happen. Although the company has the stock of returned products, it does not have last product stock. For this reason, demand amount and with which production way this amount will be met has a great importance for the company.

A system quite similar to stated system is used by computer and electronic giant Dell. In this system operating as unreal outlet market, Dell sells its products such as laptop, desktop computer, screen and printer to customers. The products made in reproduction process has taken the same limited hardware and service warranty with the new products. In addition, they have a serious price advantage upon new products (Dell, 2013).

Based upon mentions above, in this study, receiving and production control problem in terms of a production system are taken into consideration. Optimal policy structure is aimed to be formed with regard to a solution to this problem. On the one hand, optimal policy gives decisions about the amount of products that must be accepted according to the number of available returned products. On the other hand, it also gives decisions about production method that should be used depending upon the amount of returned products and the number of customers in system. First, demands from customers are taken and then productions for orders are done in necessary amounts. For this reason, there is need for flexible production systems to meet the demands of customers in the production environment. Otherwise, failure of meeting the orders at the appointed time causes customer dissatisfaction in long term and decrease in sales. Customers' managing the amount of returned products in order to make productions for orders has a vital importance. This can only be carried out by making receiving control for returned products.

Receiving control means that various systems are controlled actively by decision-maker. Receiving control considers parameters belonging to arrival and service processes that can change dynamically in the system (Stidham&Weber, 1993). In this way, in necessary conditions, decision-maker can affect the structure of the system in the frame of specific rules. In receiving control, the amount of work and customer in the system is determined by arranging the determined arrival rate or refusing the customer according to arrival number. In this study, receiving control helps original item producers to make production systems meet the demands on time. Receiving control is generally used to check the processes "coming to the queue and service". The aim of receiving control in this study is to check over returned products taken into the system within the arrival process. In service

process, demand satisfaction happens by matching works and customers. By this way, either the system becomes inactive or it is passed into next service process.

### 5.1. Markov Decision Processes

In a decision process, randomization can emerge in various shapes. Sometimes, transitions between conditions are in the random quality. But sometimes, proceeds corresponding to conditions can be in the random quality. For this reason, necessary operations in solutions change depending on these. In addition, such problems are examined under the title of Markov Decision Processes in that possibilities of transition between conditions have the characteristics of Markov chain. So, its solution is done accordingly.

Markov decision processes consist of stochastic processes that affect and observe processes in time by selecting different movement types of decision makers. By this means, decision makers gain advantages depending upon both action types they prefer and the condition in which the system is. A Markov decision process mathematically consists of five basic elements and is seen as below:

$$\{TT, SS, AAss, pptt(. | ss, aa), rrtt(. | ss, aa) : tt \in TT, ss \in SS, aa \in AAss\}$$

Here, first, the term T shows the set including decided times. The times when decisions are made can be dashed. As they can be in finite numbers  $T = \{1, 2, 3, \dots, N\}$ , they can also be in infinite numbers  $T = \{1, 2, 3, \dots\}$ . In dashed time problems, the time in matter is considered by being divided into terms or phases. Each of the decisions is accepted to be made in the beginning of the related period. A Markov decision process is called as Markov decision process in finite time horizon or in infinite time horizon depending on the lowest major time limit's being finite or infinite. If Markov decision process takes place in finite horizon, any decisions are not made in the last decision period.

Secondly, the term S shows the set including all the possible conditions in which the system could take part. In each decision period, the system is present at a condition. The system stays in the same condition as a result of each process and action type or pass into

another condition. The system's action between various conditions is determined by the decision maker's action type.

Thirdly, the term "As" is the set showing all the possible action types that can be carried out when the system condition is in "s". Decision maker causes changes in the system conditions by making selections from available action types. Action types is assumed not to change depending on the time. They can be chosen as deterministic or stochastic. If the choice of action manner is stochastic, selection is made according to possibility distribution defined on As.

Fourthly, the term  $p(. | s,a)$  shows the possibility of in which condition the system will be in the next term based on possibility distribution. If the time is dashed, it should be determined in what way the condition of the system will transform in the next term. This function is called as transition probability function.

Lastly, the term  $rt(. | s,a)$  shows gaining originated from the system's passing to a condition in "t" time after each "a" action manner. This term indicates profit when it is positive and it indicates cost when negative. Which action manner the decision-maker will choose depends on what the value or expected value of this advantage is. For this reason, the value or expected value of the profit is known before the action manner and it isn't affected by the decisions that will be made.

In a Markov decision process, decision rule guides the decision-maker about what decision it should make in a specific decision period. Decision rules differs depending on the connection with past data and action manner choice. If a decision rule is based on only the present condition of the system, it is approached as the decision rule that have the feature of Markov. On the other hand, if a decision rule takes notice of current conditions and action manner decisions from the beginning to end, it is called as decision rule based on the date. A decision rule is classified as deterministic only when a specific action manner can be selected. However, it is classified as stochastic when action manners are selected according to a certain probability distribution. In this way, it can be said that there are 4

different decision rules as deterministic and stochastic that have the features of Markov and deterministic and stochastic based on the date.

A policy is a guide showing decision-maker which action manner it should choose for a possible condition in future. A policy consists of decision rules that are made for each session.  $\Pi = \{d_1, d_2, d_3, \dots\}$ . If the same decision rule is applied at each decision period, the policy is called as static policy. Static policies are also examined in two different groups as deterministic and stochastic. Sometimes, deterministic static policies are also called as pure policies. Static policies are seen as basic theory in terms of Markov decision processes in infinite term. Decision processes which all these notations form are called Markov decision processes. In these processes, utility functions and transition probabilities are affected from the current condition and the action manner is selected in this condition. The applied policy provides utility lines (cost, profit) at the same time. Decision problem is to choose the plan of maximum utility function before the first decision moment. However, Markov decision processes are the decision processes in which possible actions, utilities and transition probabilities are based on just current condition and action. In Markov decision process, the aim is to determine the policy that makes sudden and after-coming profit or cost become optimum. Therefore, in common criteria used, it is tried to make the average cost expected for unit of time minimum or the profit maximum.

## **5.2.Value Renewal Method**

Value renewal method is one of the solution methods used in Markov decision process analysis. Value renewal method is used in determining other values beginning from one value randomly. This method ensures value function be updated constantly. Thus, it provides great convenience in analysis of Markov decision processes in infinite term. A criterion should be determined in order for the mechanism to be over because the values of obtained value functions do not combine in the long-term. This termination criterion can differ depending on Markov decision process' being reduced or average cost.

In this study, Markov decision process which makes the average cost minimum in infinite term is described. For this reason, this criterion is about the highness of the value (when

compared to  $\varepsilon$  value) obtained from that the difference of maximum and minimum cost is divided into minimum cost. So, as long as the value gotten from these differences is lower than  $\varepsilon$  value, recursion will continue and end in the point that it gets higher. The phases of value renewal can be ranged as follows:

I. The value of value function in the first phase is taken as zero

$$V_0(i, j) = 0 \quad \forall (i, j)$$

II The value of “ $V_n$ ” is counted based on the value of “ $V_{n-1}$ ”

III.  $m_n = \min_{ij} [V_n(i, j) - V_{n-1}(i, j)]$  ve  $M_n = \max_{ij} [V_n(i, j) - V_{n-1}(i, j)]$ . The bounds are determined by calculating these values.

IV. If  $M_n - m_n < \varepsilon \times m_n$ , the process is stopped. Otherwise, it is turned into second phase and the process is continued until fourth phase happens.

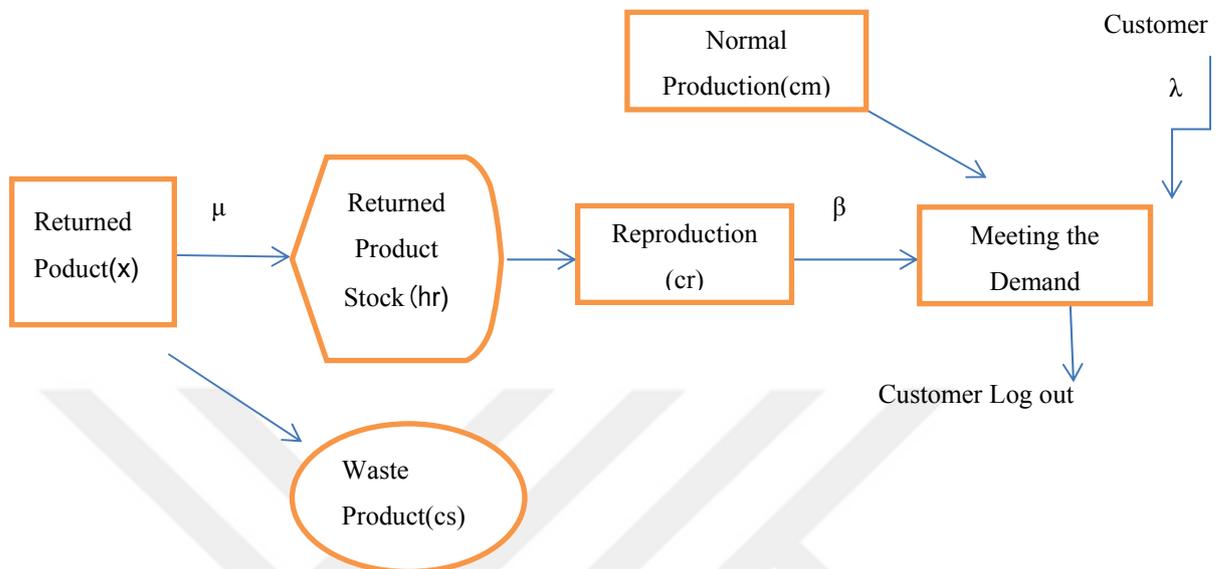
As seen, the practice “value renewal method” comes along as a pretty easy method. It is especially useful in that it is coded and analyzed with computer languages.

### 5.3. Model

In this study, an original material producing company that meets coming demands by producing new products or with reproduced products is discussed. It is accepted that there is no difference between reproduced products and the new ones. The products obtained from both production methods meet customer’s needs totally. Original item producing company works on the basis of production to order in both normal production and reproduction operations. And it does not keep last product stock.

Figure 5.1 illustrates mentioned production system. As seen, demand amounts are uncertain and come depending on Poisson distribution possessing  $\lambda$  ratio. Each customer demands just one product. Besides, the company recollect their used products due to various reasons such as legal obligation, social responsibility or asset protection. The amount of returned products is uncertain and the products come according to Poisson distribution having  $\mu$  ratio. In consequence of each operation, one returned product enters

to the system. Necessary time for the production of a new product or reproduction of the returned ones has respectively  $1/\alpha$  and  $1/\beta$  –averaged exponential distribution.



**Figure 5.1 Production and Receiving Control in Reverse Logistics (Stidham&Weber)**

The stock consisting of returned products is kept in order to meet the customer demands that may emerge in future. The company gives the decisions “keeping the returned products in stock or regarding them as waste products”. Each returned product kept in stock has a carrying cost up to “hr” at a unit of time. If the returned product is regarded as waste product and not put into production, the company will have to endure a charge cost. This charge cost shows the costs that the company has to put up with so as to destroy the waste product. As in the returned product, at any time, a customer can enter the system. Each customer in the system has waiting cost as “hc”. Therefore, the company wants to meet customer demands by normal production or reproduction as soon as possible. Otherwise, accumulation of customers in the system increases the costs gradually. Demands can be met with two different production methods as normal production or reproduction. Fair value (cm and cr) is the topic in terms of both normal production and reproduction. These costs emerge from normal production and reproduction activities which need to be endured so as to meet one unitary demand. The company prefers reproduction to normal production as much as possible due to the provided cost advantage. In the condition that demands from customers emerge, the company primarily looks at the

amount of the returned product stocks. If there is product in the returned product stock, the primary preference of the company should be meeting the demand by reproduction operation. On the other hand, if normal production costs are lower than reproduction costs, the company can prefer the normal one to reproduction operation. If there is no product in returned product stock, customer demand is met until returned product is found in returned product stock.

In a receiving and production control policy, a decision made at any time presents the condition of the system at that time. For this reason, only Markov policies are taken into consideration. A Markov policy will be an optimal policy because the system will not be affected from the decisions made in past- in other words, it has no memory- In this study, optimal receiving and production policy that can minimize the average cost per unit of time is looked for.

Examined optimal receiving and production control problem is formulized according to Markov decision process. Each condition is described as (x,y). These variants respectively show product number in returned product stock and the number of customers in the system. When this situation is taken into consideration, function  $t(x,y)$  is described as cost function and function  $g$  is described as the average cost per operation (returning of products, coming of customers, reproduction, normal production). By gathering all these,  $t(x,y)$  function is described as below:

$$t(x, y) = \frac{1}{\Lambda} [hrr * xx + hcc * yy + \lambda T1 t(x, y) + \mu T2 t(x, y) + \alpha T3 t(x, y) + \beta T4 t(x, y)]$$

Here, according to Lippman (1975) method, all proportions are gathered in the way  $\Lambda = \lambda + \mu + \alpha + \beta$  and it is resorted to normalization way.  $\Lambda \{hrr * xx + hcc * yy\}$  terms figured in equation represent expected carrying costs and waiting costs in every decision period. T1, T2, T3 and T4 condition operators in the function means changing conditions as a result of cases that the company will confront. In the next part, each operator is reported clearly. Operator T1 multiplied with Lambda ( $\lambda$ ) is related to returning of a product. According to this, the company either accepts the returned product, therefore increases its stock one

more or refuses the returned product therefore the amount of stock stays the same. The company prefers the least costly one between these two decisions. The operator T2 multiplied with  $\mu$  is related to a customer's entering the system. Along with the customer's entering the system, the number of customers in the system grows one more customer. The operator T3 multiplied with Alpha ( $\alpha$ ) shows meeting customer demands by performing reproduction. To be able to use this production method, both returned product stock and the number of customers should be higher than zero. Otherwise, with reproduction, it is not possible to meet customer demands. Lastly, the operator T4 multiplied with Beta ( $\beta$ ) shows meeting customer demands with normal production way. When the company cannot meet the huge demands of customers with reproduction, demands are met with the help of the products obtained from normal production. In this way, customer-holding costs decrease since not many customers will be stuck on the system. If there is no customer in the system, the system maintains its current condition.

#### 5.4. The Structure of Optimal Policy

In this part, the characterization of the examined model will be stated in terms of receiving and production policy. The basic problems for which the model looks solutions are:

- 1- In which conditions can a product be accepted to returned product stock?
- 2- In which conditions should production or reproduction be made?

In accordance with these questions, various descriptions below are needed for the policy characterization of the model. The model in this study, in dashed-time Markov decision period, describes  $t$  function defined to  $t(x,y): \mathbb{Z}^+ \times \mathbb{Z}^+ \rightarrow \mathbb{R}$  placed in an  $S$  state-space in  $\mathbb{Z}^+ \times \mathbb{Z}^+$  as below:

$t(x, y) = 1 \wedge [hr^* x + hc^* y + \lambda T1 t(x, y) + \mu T2 t(x, y) + \alpha T3 t(x, y) + \beta T4 t(x, y)]$  This defined  $t$  function differs depending upon the decision that will be made in consequence of each action manner. This function is explained below with the help of the operators T1, T2, T3, T4 and T by taking each condition into consideration:

$$T1t(x, y) = \min[t(x + 1, y), t(x, y) + cs],$$

$$T2t(x, y) = t(x, y + 1),$$

$$T3t(x, y) = t(x - 1, y - 1) + crx \geq 0, y \geq 0$$

$$t(x, y) \quad x = 0, y = 0,$$

$$T4t(x, y) = \min [t(x, y - 1) + cm, t(x, y)] \quad y \geq 0$$

$$t(x, y) \quad y = 0$$

,

$$TT(x, y) = 1/\Lambda[hr*x + hc*y + \lambda T1 t(x, y) + \mu T2 t(x, y) + \alpha T3 t(x, y) + \beta T4 t(x, y)]$$

The defined T1 operator shows the decision that may be made if one product is returned from the customer. The company may accept the returned product and increase carrying costs. It can either refuse to take and endure penalty fine because the products become waste. Between these two decisions, the minimum one is chosen. The operator T2 shows the inclusion of a customer to the system. In this way, while the returned product number stays the same, the number of customer in the system increases. The operator T3 indicates that reproduction is practiced only when both the numbers of returned products and customers are positive. Otherwise, the system stays the same. As for the operator T4, it shows that the company decreases the number of waiting customers by meeting the demands with production if there are too many customers. Or the company makes the customers wait by expecting returned product input. If there is no waiting customer in the system, the condition of the system stays the same because there is no need for normal production.

Besides condition operators which express mathematically the conditions that companies confront are defined, difference operators below also need to be defined for the characterization of optimal policy structure. For any defined  $t$  function placed in  $S$  state-space, difference operators are defined as follows:

$$D1t(x, y) = t(x + 1, y) - t(x, y),$$

$$D2t(x, y) = t(x, y + 1) - t(x, y),$$

$$D3t(x, y) = t(x - 1, y - 1) - t(x, y),$$

$$D4t(x, y) = t(x, y - 1) - t(x, y).$$

The function defined with the operator D1 shows marginal cost of keeping one more returned product in stock. D2 shows the marginal cost of keeping one more customer in service line. D3 shows the marginal income resulted from that returned product meets the customer demand with reproduction. Lastly, D4 shows the marginal income obtained from meeting one customer demand with normal production way.

If  $V$  is defined as a set involving the functions identified in  $S$  space, if  $t \in V$ ,

(i)  $D1t(x, y) \uparrow xvv \downarrow y$ ,

(ii)  $D2t(x, y) \downarrow xvv \uparrow y$ ,

(iii)  $D3t(x, y) \uparrow xvv \uparrow y$ ,

(iv)  $D4t(x, y) \uparrow xvv \downarrow$

Here the symbols  $\downarrow$  and  $\uparrow$  mean that operators are non-decreasing and non-increasing depending on the amount of returned products and customers placed in the system structurally. The conditions above show the features of the operators D1, D2, D3 and D4 defined on  $t$  function.  $D1 t(x, y) \uparrow x$  indicates that marginal cost increases gradually because one more returned product is added to the stock. So, the decision-maker will not want to keep  $x+1$  product while it has  $x$  returned product. This is because it will not be able to put the returned product into production process again in that the number of customer doesn't increase evenly.  $D1 t(x, y) \downarrow y$  indicates that the number of customer going into service line decreases the marginal cost while one more product is added to the stock. Such a result is not surprising when it is kept in view that returned product stock can be reduced only when reproduction is done for new customers.

Secondly,  $D2 (x, y) \uparrow y$  indicates that the marginal cost decreases as a result of increasing number of returned products while the number of customers in service line increases. The number of returned product provides a positive effect in that the number of customers in service line can be decreased primarily with the help of reproduction with a less cost. In the condition  $D2 (x, y) \uparrow y$  increase in the number of customers also raises the marginal cost of customer waiting. While the number of returned product doesn't increase, the number of customers going to service line. This situation causes the burden of extra cost.

Thirdly, in the condition  $D3(x, y) \uparrow x$ , increase in the number of returned products raises the marginal income resulted from that returned product meets the customer demands with the reproduction activity. That's to say, absence of sufficient returned product in stock will bring the reproduction to a standstill, therefore income will decrease because fewer customer demands will be met. For this reason, increase in the number of returned product affects the marginal income positively. In the condition  $D3t(x, y) \uparrow$  an increase in the number of customers going into service line raises the marginal income obtained from meeting the customer demands with the help of reproduction process. In this case, returned products will wait in stock and make incremental cost if sufficient customers are not in the service line although there are sufficient returned products. Therefore, entering service line of customers affects positively the marginal income.

Lastly, in the condition  $D4(x, y) \uparrow x$ , as the number of returned products increases, the marginal income that comes from meeting one customer demand with normal production also increases. Going to normal production way raises the cost because normal production is more costly than reproduction especially due to input expenses. For this reason, as the number of returned product increases, the cost coming from normal production will be reduced because much more reproduction will be practiced. In the condition  $D4t(x, y) \downarrow y$ , as the number of customers going into service line increases, the marginal income coming from meeting customer demands with normal production way decreases. With normal production, meeting customer demands for returned products when the stock amount is low has initially positive effect. However, as the number of customers increases, the marginal income decreases gradually because it will become less positive and more costly.

*Auxiliary Theory (Lemma) 1.*

If  $t \in V$ ,  $T1t$ ,  $T2t$ ,  $T3t$ ,  $T4t$  and  $Tt \in V$

Proof: The proof of auxiliary theory and all other theorems is given in Appendix.

Based on all these descriptions, the theorem below defines the optimal structure of receiving and production control model.

*Theorem 1*

- a. The optimal receiving policy is defined with a curve of conversion called  $a(y)$ . Accordingly, if  $x < a(y)$ , optimal policy will receive the returned product and include it into the returned product stock. On the other hand, if  $x \geq a(y)$ , optimal policy will not receive the returned product and will keep stable available returned product amount.
- b. The optimal production policy is also defined with a curve of conversion called  $p(y)$ . According to this, if  $x \leq p(y)$ , optimal policy is meeting customer needs with production activity. If  $x > p(y)$ , optimal policy is meeting customer needs with reproduction activity.

The structure of optimal policy belonging to a general problem mentioned in Theorem 1 is illustrated in Figure 7. Optimal policy structure consists of 3 sections according to the decision whether returned products will be accepted or not and the decision of preferred production methods.

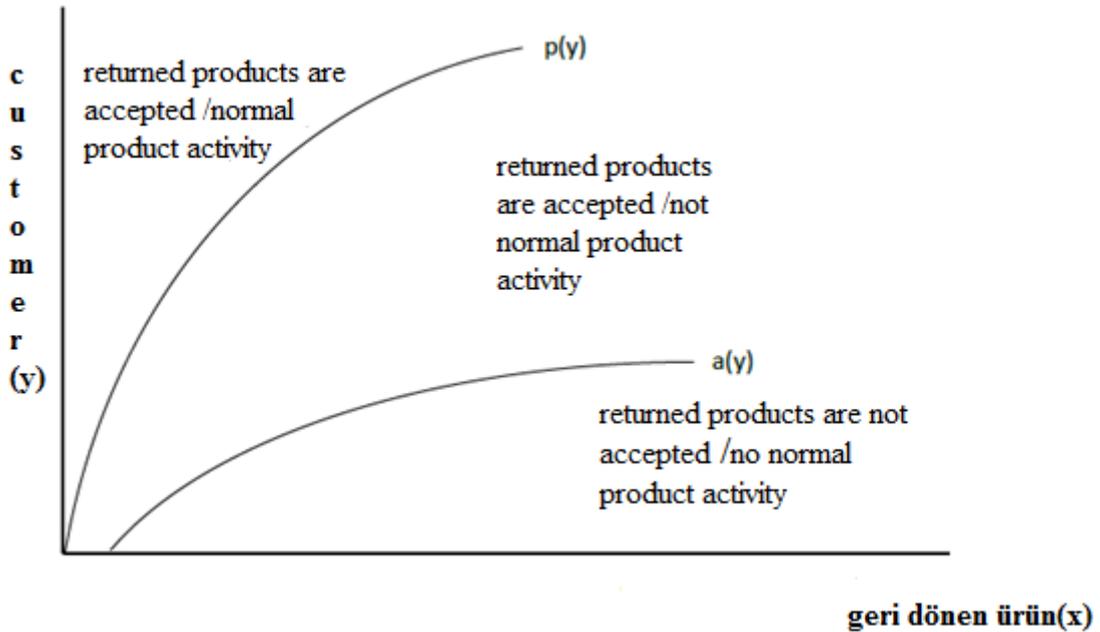


Figure 5.2 Optimal Policy Structure(Stidham&Weber)

According to this structure, it is seen that returned products are accepted in the first section and customer needs are met with production activity. In the second section (the one staying between the curves  $a(y)$  and  $p(y)$ ) returned products are accepted but residual demands are met by reproduction because sufficient returned product amount is obtained. In the last section, returned products are not accepted because they are large in number and customer needs are met by reproduction.

### *Theorem 2*

If optimal production policy has the intention of producing, optimal receiving policy acts in accepting the returned product. That is to say, the relation between optimal receiving policy and optimal production policy will always be  $p(y) \leq a(y)$ . Therefore, the company should accept each returned product if it practices normal production.

Theorem 2 involves very important results for the structure of optimal policy. Firstly, if optimal production decision is to make normal production for a condition, the optimal receiving decision in that circumstance will be accepting the returned product. Otherwise, the cheaper reproduction will not happen as sufficient amount of returned product is not obtained. Secondly, savings from the cost of both normal production and penalty fine is provided because  $a(y)$  lets more returned products be accepted.

### **5.5. Numerical Samples of the Model**

In the previous part, optimal control policy determined by Theorem 1 is in quite a complicated pattern. According to optimal control policy, the company should give the decisions about production and acceptance of returned products by evaluating curves of conversion. This can cause big problems in practice. In addition, it is another difficulty that both production and receiving decisions should be made simultaneously depending on the amount of returned product and the number of customers. Huge increases in returned products amount and in the number of customers affect reversely and make difficult optimal production and receiving decisions. These reasons make considerably difficult the applicability of the model. Thus, the structure of optimal policy will be compared to the

structure of a simple policy that is easier to be applied. In this way, differences between optimal policy and the other policy which is easier to apply will come to light.

Before making this comparison, an explanation for the simple policy is needed. Simple policy is determined with two integer parameters like A and P. While A indicates maximum returned product amount that will be received, the number P shows the limit of meeting the demands with production. Thus, if the company has P amounted returned product, the demand will be met by production activity, but if it is more than P, the demand will be met by reproduction activity. For any A and P value, a Markov chain that is quite easy to be calculated will be created. The rest is the determination of proper A and P values. For that, simple one or two-directional search is being done. This simple policy is quite an easy policy to describe and apply although it has difficulty in terms of being calculated.

After determining the simple policy, comparing it to optimal policy is necessary for evaluating working of the system properly. In order to make this, the values of parameters in the model are differentiated. Then, results of optimal policy and simple policy are obtained. Results from 32 different scenarios are gotten by determining the parameters of the model systematically. Table 7 and Table 8 show the formation systematic of data sets belonging to time and costs.

**Table 5.1 Time Parameters**

Customer	Returned Product	Reproduction	Normal Production
Fix	Slow	Fix	Slow
	Fast		Fast

**Table 5.2 Cost Parameters**

The cost of holding customer	Returned Product Stock Cost	Normal Production Cost	Reproduction Cost	Cost of Waste
Fix	Low	Fix	Low	Low
	High		High	High

Firstly, speed of customer's coming is fixed for each scenario. The speed of returned product's coming is taken as two different data as slow and fast. The speed of customers' coming to the system should always be higher than both slow and fast speed of returned

products' coming. Customer demands are assumed to be more than returned products because they are met by both normal production and reproduction.

On the other hand, the speed of normal production is assessed as two different parameters- slow and fast while the speed of reproduction is fixed. As reproduction requires less operation than normal production, it is practiced much more when compared to both slow and fast normal production. Reproduction can be done at a shorter time than normal production as it requires operations like changing obsolete parts or adding new parts on returned products.

In Table 5.2, unit cost of customer-holding is fixed and unit cost of returned products stock is taken as low and high. As returned products are assessed according to receiving policy, differentiating the unit cost of returned product stock is important for detecting how optimal policy is affected. Unit cost of customer-holding is assumed to be much higher than unit cost of returned products as losing customer demands has more risk. Normal production cost is fixed but reproduction cost is taken as low and high. In reproduction, products are already produced while in normal production raw material is supplied from scratch. For this reason, the cost of normal production is determined much higher than the reproduction cost. Waste costs are not wanted because they place huge burden on the company. Therefore, waste costs are determined as low and high in the way it will be especially higher than reproduction costs.

Table 5.3 shows the results obtained from optimal policy and intuitive method of 32 numerical examples formed according to mentioned systematic. As understood from the results, serious differences between the costs of optimal policy and the ones of simple policy exist. So, while the percentage difference between optimal policy and simple policy is 17, in 12<sup>th</sup> scenario, it reaches 73% in 6<sup>th</sup> scenario. Based on this, it can be said that optimal policy provides cost advantage at a serious rate when compared to the simple policy. Although simple policy is not advantageous in terms of costs, it is much easier to apply as A and P numbers are calculated just one time.

**Tablo 5.3. Comparison of optimal and simple policy**

No	M	$\lambda$	A	$\beta$	hc	hr	cm	cr	cs	Optimal	Simple	A	P	%Difference
1	1	0,6	1,5	1	4	1	50	5	25	12,474	22,219	30	20	43,86
2	1	0,8	1,5	1	4	1	50	5	25	9,405	18,002	14	13	47,76
3	1	0,6	1,5	1,2	4	1	50	5	25	7,134	13,717	30	17	47,99
4	1	0,8	1,5	1,2	4	1	50	5	25	5,652	10,521	14	11	46,28
5	1	0,6	1,5	1	4	2	50	5	25	9,490	26,934	18	16	64,77
6	1	0,8	1,5	1	4	2	50	5	25	7,329	27,453	8	11	73,30
7	1	0,6	1,5	1,2	4	2	50	5	25	10,082	20,972	15	15	51,93
8	1	0,8	1,5	1,2	4	2	50	5	25	6,198	16,583	8	10	62,62
9	1	0,6	1,5	1	4	1	50	10	25	10,120	18,130	30	20	44,18
10	1	0,8	1,5	1	4	1	50	10	25	7,775	28,132	13	13	72,36
11	1	0,6	1,5	1,2	4	1	50	10	25	11,212	12,974	28	17	13,58
12	1	0,8	1,5	1,2	4	1	50	10	25	8,593	10,361	13	11	17,06
13	1	0,6	1,5	1	4	2	50	10	25	11,216	34,038	15	18	67,05
14	1	0,8	1,5	1	4	2	50	10	25	9,404	30,105	8	11	68,76
15	1	0,6	1,5	1,2	4	2	50	10	25	8,915	20,522	14	15	56,56
16	1	0,8	1,5	1,2	4	2	50	10	25	7,372	14,079	10	7	47,64
17	1	0,6	1,5	1	4	1	50	5	50	10,055	16,494	30	13	39,04
18	1	0,8	1,5	1	4	1	50	5	50	6,174	10,661	19	17	42,09
19	1	0,6	1,5	1,2	4	1	50	5	50	8,877	12,247	30	11	27,52
20	1	0,8	1,5	1,2	4	1	50	5	50	5,673	10,797	19	18	47,46
21	1	0,6	1,5	1	4	2	50	5	50	9,469	21,363	22	11	55,68
22	1	0,8	1,5	1	4	2	50	5	50	9,275	33,762	11	15	72,53
23	1	0,6	1,5	1,2	4	2	50	5	50	10,615	18,687	21	15	43,20
24	1	0,8	1,5	1,2	4	2	50	5	50	6,190	16,703	10	9	62,94
25	1	0,6	1,5	1	4	1	50	10	50	8,976	17,108	30	20	47,53
26	1	0,8	1,5	1	4	1	50	10	50	7,000	13,027	18	13	46,27
27	1	0,6	1,5	1,2	4	1	50	10	50	6,843	29,429	30	18	76,75
28	1	0,8	1,5	1,2	4	1	50	10	50	7,208	16,408	14	10	56,07
29	1	0,6	1,5	1	4	2	50	10	50	11,443	26,463	21	18	56,76
30	1	0,8	1,5	1	4	2	50	10	50	11,406	19,110	11	10	40,31
31	1	0,6	1,5	1,2	4	2	50	10	50	10,137	18,623	20	15	45,57
32	1	0,8	1,5	1,2	4	2	50	10	50	7,934	19,644	10	10	59,66

Firstly, when 1<sup>st</sup> and 2<sup>nd</sup> scenarios that just differentiate at the coming speed of returned products are examined, it is seen that the optimal policy cost obtained from 2<sup>nd</sup> scenario is lower than the cost from 1<sup>st</sup> scenario. This is because the speed of returning in the 2<sup>nd</sup> scenario is higher. More products will be available in returned product stock due to high returning speed, therefore more reproduction will be done. Although this increases the cost from returned product stock, it has a positive effect for the costs as the cost from reproduction is higher. All the parameters in all other scenarios are the same. When there is a differentiation in only returning speed, costs in fast returning decreases, which supports the mentioned information. If we look at the costs of just 1<sup>st</sup> scenario that differentiates in terms of normal production time and the costs of 3<sup>rd</sup> scenario, the optimal policy cost of the 3<sup>rd</sup> one is better. The reason for this can be explained as enduring lower unit cost of customer-holding thanks to doing normal production faster.

When we look at 3<sup>rd</sup> and 11<sup>th</sup> scenarios that differentiate in terms of production costs, it is seen that the optimal policy cost of 3<sup>rd</sup> scenario is lower than the cost of 11<sup>th</sup> scenario. As a natural consequence of increase in the reproduction cost, average cost also increases. In the same way, the optimal policy cost of 12<sup>th</sup> scenario is higher than the cost of 4<sup>th</sup> scenario. Finally, if 9<sup>th</sup> and 25<sup>th</sup> scenarios that are different from each other in terms of penalty costs are to be examined, it is seen that the optimal policy cost of 9<sup>th</sup> scenario is higher than the one of 25<sup>th</sup> scenario. Penalty cost's being high requires the company to accept more returned products. Although the cost of returned product stock increases, keeping more stock is preferred because enduring penalty cost causes bigger burden. Consequently, this leads decline in costs.

Even though the results from simple policy is worse when compared to the ones of optimal policy, it shows consistency with optimal policy. As an example, simple policy results of 1<sup>st</sup> and 2<sup>nd</sup> scenarios show parallelism with the optimal policy results. Likewise, as the number of returned products increases, it can be observed that the cost decreases. There are other matters to observe like "A" that is determined by simple policy and has the limit of accepting returned product and "P" which determines the limit of normal production and reproduction. When A and P values in first scenario are examined, it is seen that they are 30 and 20. That's to say, they are quite high values in terms of both the number of accepted returned products and the limit of normal production. In the second scenario, A and P values are respectively 13 and 14. As seen, increase in the number of returned products cuts the bounds that simple policy chooses almost in half. Observing the same condition in other pairs of scenario shows that frequency of returned products affects seriously the limits that the company should determine.

Apart from that, simple policy determines the limit of returned products as a higher value for production threshold due to cost advantage in most of the scenarios. This situation has become vice versa in only 6<sup>th</sup>, 8<sup>th</sup> and 14<sup>th</sup> scenarios. In addition, in the scenarios in which production limit is lower, lower cost emerge because there are more reproduction opportunities.

## CONCLUSION

That ecological balance are destroyed gradually and therefore individuals, governments and civil institutions want precautions has caused both increase in legal regulations and social awareness. Desire to protect the natural balance has enabled precautions to be taken. It has also led the companies to adapt these and follow new production strategies. Receiving the products has become a necessity for whatever reason they return. Doing this systematically-with reverse logistics activity- has now become one of the defined processes of the supply chain management. The companies need to take necessary steps for reverse logistics and product recovery, enable the product to be received by starting from the phase “product designation” and choosing proper options. Lastly they need to set this system depending on the product’s feature. This situation provides important advantages to the companies in terms of making the image “environmentalist company”, obeying the laws and additionally making business opportunities that reverse logistics offers profitable.

In today’s improving economy, setting new centers depends on different decision factors. Opening of new centers in supply chain can be associated with setup and transportation costs that will influence the total cost. In reverse logistics system, as used products are collected from customers, this factor is also included into the model. Generally, solutions reflect two important characteristics of reverse logistics problems. These are collecting used products from customers then operating them and transporting them to customers again. As seen, many factors affect the phase of designation. Therefore, designating a model that includes all these factors enables to obtain realistic results.

Production recovery is very important for companies due to economic factors, environmentalist laws, the “green” image’s becoming an important marketing label, satisfying customers, governments’ environmentalist programs, social responsibility, products’ responsibility belonging to producers till the end of the product’s life. It is not a new situation to collect products and materials and then reuse them. Collecting metal scraps, waste paper recycling and deposit practices for glass bottles have been applied for a long time. However, pressures on the company brought along the need to follow systematic ways for receiving the products. This will only be possible by the company’s

being awareness of reverse logistics activities and doing necessary regulations to support this reverse flow in the processes.

This study emerged from a reverse logistics system of an original-material producer company that meets customer demands with one type of product. This company uses a hybrid production system formed of both normal production and reproduction. Hybrid production system is done based on the production to the order. This study analyzes receiving and production control model of the mentioned company. Moreover, an optimal policy structure is aimed to be formed concerning the solution to the problem. With the help of optimal policy, the control of the company in two different strategic decisions is provided. The first one of this is about receiving returned products. In the second one, when customer demands are met with normal production or reproduction is determined.

The most important difference of this study from available production and stock control literature is making hybrid production system for just orders. In all of the studies in literature, there are two different stock points for returned and last products. However, this study analyzes the production system of a company that works entirely based on production to order by not keeping last product stock.

On the other hand, reverse logistics is a subject that is hardly ever treated in receiving and production control literature. Only one study is done in this field (Kim, Song, Kim, & Jeong, 2006). However, also in this study, both production systems do production to the stock. As in production and stock control literature, there are two different stock control points as returned product and last product stock. This study is the only one which takes hybrid production system based on the production to the order and therefore considers just one stock point (returned product stock).

This study forms a model making optimal policies to solve receiving and production control problem of the mentioned company. The model calculates the average cost in infinite period by using Markov decision processes. Additionally, “optimal receiving policy” that controls returned product amount of the company and “optimal production policy” that determines production method are also important results of the model. The

assessment of the model has been done to measure its performance under 32 different scenarios obtained with changing the parameters systematically. Its comparison with a simple policy that is easier to apply has been done because the model which gives optimal results

is quite demanding to practice. It has been observed that for each scenario, the model that gives optimal result provides better results than simple policy does.

Finally, in this study, it is mentioned that the company has receiving control for just returned products. Another receiving control that controls participating of customers to the system may be added to the model in future studies.



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