GALATASARAY UNIVERSITY
INSTITUTE OF SOCIAL SCIENCES
DEPARTEMENT OF BUSINESS ADMINISTRATION

REVERSE LOGISTICS: THEORY AND PRACTICES – WITH FOCUS ON REMANUFACTURING APPLICATIONS

Master Thesis

Ezo Evrim HARSA
06111030

Director of Thesis: Prof. Dr. Mehmet Şakir ERSOY

MARCH 2010

ACKNOWLEDGEMENTS

In the course of my studies for this thesis, I have had the support of many people, without which, the completion of this work would not have been possible.

I would like to thank in the first instance Professor Dr. Mehmet Şakir Ersoy, for kindly agreeing to be the director for my thesis, his interest in my works and his guidance.

I am also deeply indebted to Assistant Professor Dr. Aslı Gül Öncel, for her thorough advisory suggestions enabling me to complete my thesis; to Associate Professor Dr. Orhan Feyzioğlu, for his support during my researches and to Professor Dr. Gülçin Büyüközkan Feyzioğlu, for her advisory contributions, in particular with regard to the case study.

I would further like to express my gratitude towards Mr. Mahmut Ulak from TATKAP A.Ş. for providing me with most of the critical data required for the case study section of my thesis.

Finally, I would like to give my special thanks to my dear family, and especially, to my husband Tulû Harsa, whose patience and constant support have enabled me to complete my studies.

TABLE OF CONTENTS

II. SPECIAL FOCUS ON REMANUFACTURING AND ITS INDUSTRIAL APPLICATIONS

ABBREVIATIONS

APRA : Automotive Parts Remanufacturers Association
ASR : Automobile shredder residue
CFC : Chlorofluorocarbon
CRC : Centralized Return Centre
DC : Distribution Centre
DOD : Department of Defence
EDS : Electronic Data Systems
ELV : End of Life Vehicles
EPA : Environmental Protection Agency
EU : European Union
HFC : Hydrofluorocarbon
HVAC : Heating Ventilating and Air Conditioning
IT : Information Technologies
OEM : Original Equipment Manufacturers
PBB : Polybrominated biphenyl
PBDE : Polybrominated diphenyl ether
PDAs : Personal Digital Assistants
PEP : Printer's Environmental Program
PET : Polyethylene terephthalate
pg. : Page
RoHS : Restriction of Hazardous Substances
R3 : Reduce, Reuse, Recycle
WEEE : Waste Electrical and Electronic Equipment

LIST OF FIGURES

LIST OF TABLES

RESUME

Les questions environnementales deviennent de plus en plus importantes et nécessitent des nouvelles approches de la part des sociétés d'aujourd'hui, non seulement en ce qui concerne des fonctions de production, mais également pour des fonctions de la supply chain.

Aujourd'hui, personne n'a le luxe d'évacuer comme déchet les articles en fin de leur cycle de vie ou les produits défectueux ; même le recyclage devrait être considéré comme l'option ultime de disposition ; puisque recycler un produit annule complètement la valeur supplémentaire créée pendant sa fabrication.

La fonction de rétrologistique, avec la multitude d'options de disposition qui l'accompagnent, peut être la solution pour la protection de l'environnement et des ressources naturelles.

La logistique est une partie de la supply chain et porte sur le contrôle du flux et du stockage des marchandises ou des services, et de l'information y afférentes, à partir du point d'origine, jusqu'au point de la consommation. La supply chain entoure toutes les activités liées au flux et à la transformation des marchandises et de l'information, à partir de la phase initiale de matières premières, jusqu'à la remise à l'utilisateur final, et la gestion de supply chain est la coordination de la production, de la gestion d'inventaire, et du transport pour réaliser la meilleure combinaison de réactivité et de l'efficacité, tout au long de la supply chain.

La rétrologistique est le processus de planification et de contrôle des flux de matières premières, d'inventaires, des produits finaux et de l'information, partant du point de consommation jusqu'au point d'origine. C'est une fonction de gestion de supply

chain, avec les activités du reconditionnement, du recyclage, ou de la réutilisation des produits retournés après qu'ils aient atteint la fin du cycle de vie.

L'importance croissante du courant entreprise citoyenne et de son impact potentiel sur la fidélité du client encouragent les sociétés pour la libéralisation des procédures de retour, de même que les pressions concurrentielles et régulatrices forcent les sociétés à prolonger leurs chaîne de distribution afin d'inclure les produits finaux, puisque les entreprises se voient obligées de transformer leur produits –utilisés- en produits ou matériaux recouvrables, sans nuire à l'environnement.

Des raisons des retours peuvent être classifiées comme suit : (i) les retours par consommateur, (ii) les retours de marketing, (iii) les retours des actifs, (iv) des rappels de produit et des (v) retours environnementaux.

Les retours par le consommateur peuvent résulter de l'une des six raisons suivantes: le produit ne répondrait pas aux besoins du client ; le client ne comprendrait pas correctement comment le produit doit être utilisé (des défectueux dits non-défectueux) ; le produit est défectueux ; le produit est retourné pour être remanufacturé ou pour une disposition appropriée, ou, le client abuserait d'une politique de retour libérale.

Les retours de marketing concernent les produits retournés par un acteur situé en aval dans la supply chain, et particulièrement s'agissent des renvois par les détaillants, souvent en raison des dégâts subis par le produit en transportation ; du dépassement da la date de péremption ; d'un remplacement du produit ou d'un retirement du produit du catalogue ; de la terminaison d'une saison de vente pour les produits saisonniers ; d'un excès de stock du détaillant, ou d'une interruption des affaires du détaillant.

Les retours des actifs visent la reprise et le replacement des actifs. Des produits soumis à ce genre de retours sont typiquement caractérisés comme des articles que la gestion veut voir retournés.

Les rappels de produit sont une forme de retour habituellement lancés en raison d'une question de sûreté ou de qualité. Les rappels peuvent être volontaires ou imposés par une agence gouvernementale.

Les retours environnementaux visent la disposition des matériaux dangereux ou à assurer une conformité aux règlements environnementaux.

Sous la forme la plus commune, les activités de la rétrologistique sont des processus par lesquels une société rassemble à partir de l'utilisateur final, les produits utilisés, endommagés, indésirables, ou périmés, aussi bien que les matériaux de l'emballage et de l'expédition.

La collecte est la première étape dans le processus de recouvrement, où des types de produit sont choisis. Les produits sont ensuite situés, récupérés, et, s'il y a lieu, transportés aux centres de traitement pour la reprise et le remanufacture.

Le contrôle de l'accès aux flux de retour (*gatekeeping*) est l'activité de sélection permettant de décider quels produits seront admis dans le système de rétrologistique. Cela consiste en un triage au point d'entrée de rétrologistique, pour déterminer les produits défectueux et de retours indésirables et s'agit d'une étape critique pour rendre les flux de retour gérables et rentables dans leur globalité.

Le triage est l'étape de décision où le sort de chaque produit est décidé. Cette étape peut intervenir au point et à la période de la collection, ou après celle-ci. Les articles rassemblés ont besoin généralement d'une classification détaillée et cette étape exige une compétence dans le domaine de la classification de produits utilisés.

La disposition est simplement l'envoi des produits à leur destination désirée.

Le prétraitement peut être sous forme de classification, ségrégation, démontage partiel ou complet ou réparation mineure et des activités de réhabilitation.

L'emballage peut être défini comme des produits faits de tout matériau et de n'importe quelle nature, utilisé pour la retenue, la protection, la manipulation, la livraison et la présentation de toute sorte de marchandises (des matières premières jusqu'aux produits finaux), par un producteur.

Des activités de rétrologistique portant sur les produits finaux et l'emballage peuvent se résumer comme suit :

Les détaillants renvoient les produits au fournisseur en raison des défauts, des retours de marketing, de l'obsolescence du produit ou d'un excès de stock.

Si le produit retourné n'a été ni utilisé, ni ouvert, le détaillant peut le revendre comme neuf.

Si le détaillant a trop de stocks, le produit retourné peut être vendu par des magasins d'usines ou discounts.

Quand une société ne peut pas vendre un produit et le renvoi aux fournisseurs ou la vente par des magasins d'usines ne sont pas des options viables, des produits peuvent être revendus par l'intermédiaire du marché secondaire dont les opérateurs se spécialisent dans l'achat des produits de surplus ou de fins de séries.

Si le produit est encore utilisable, mais avec quelques défauts superficiels, les détaillants ou les fournisseurs peuvent décider d'offrir ces produits à des organisations caritatives.

Avant de décider que le produit ou l'emballage est une perte complète et d'opter pour le recyclage, la plupart de sociétés essayent de réparer, réhabiliter ou remanufacturer le produit concerné, ce qui implique le reconditionnement ou une rénovation du produit.

La réhabilitation et le remanufacture diffèrent en ce qui concerne le degré de rénovation et la quantité d'effort requise pour améliorer le produit : le remanufacture implique un effort plus important.

Quand la société ne peut pas vendre le produit au marché secondaire, et les autres options ne sont pas réalisables, et si le recouvrement de l'emballage est impossible, l'option finale est l'élimination. Normalement, l'objectif d'une entreprise est de recueillir la valeur la plus élevée ou de disposer du produit en question en subissant le moindre coût possible.

L'excellence environnementale commence pendant la conception initiale du produit et du processus de production. La philosophie de « conception pour l'environnement » peut être réalisée pour les produits neufs et dans la modification des produits existants, quand les produits sont remodelés pour éliminer les déchets, ou encore, afin d'enlever le contenu dangereux dans la mesure du possible ; pour augmenter la durée d'utilisation et la longévité de produit ; pour réduire la pollution pendant l'utilisation ; ou pour réutiliser les matériaux recyclés.

Par ailleurs, dans la mesure où les règlements environnementaux deviennent répandus, ceux-ci peuvent provoquer une modification de certains structures et systèmes industriels.

Les règlements européens au sujet de la réutilisation, le recyclage, l'utilisation des sites d'enfouissement, de l'utilisation des substances dangereuses et de la responsabilité pour disposition en sont de très bons exemples.

Le remanufacture est, tout simplement, le processus de modifier un produit utilisé et périmé pour lui redonner une condition aussi similaire à un produit neuf que possible. Il s'agit d'une série d'opérations pour réclamer la valeur ajoutée au matériel quand un produit a été fabriqué la première fois. Le remanufacture permet une réduction du coût en énergie et en matière premières, et de ce fait, du coût de production.

Un produit est considéré comme remanufacturé si ses composants principaux viennent d'un produit utilisé.

- Le produit utilisé est démantelé jusqu'au degré nécessaire pour déterminer l'état de ses composants.
- Les composants du produit utilisé sont complètement nettoyés afin d'éliminer toute trace de rouille et de corrosion.
- Tout les pièces absentes, défectueuses, cassées ou périmées sont reconstituées à l'état fiable et fonctionnelle, ou sont remplacées avec des pièces nouvelles, remanufacturées, ou des pièces utilisées mais fonctionnelles.
- Pour mettre le produit dans en bonne état, des opérations supplémentaires sont effectués, au besoin.
- Le produit est rassemblé et des tests sont réalisés afin de s'assurer qu'il fonctionnera comme un produit neuf.

Il y a cinq principales étapes de remanufacture :

- démantèlement complète du produit ;
- Nettoyage complet de toutes les pièces ;
- Inspection et triage de toutes les pièces ;
- Reconditionnement des pièces et/ou complémentation par de nouvelles pièces, au besoin ; et
- Remontage de produit.

En Turquie, il existe très peu d'entreprises engagées aux activités de remanufacture. Ceci étant, les travaux de TATKAP, dont les activités se concentrent sur les produits de pneumatiques sont particulièrement intéressants. Dans le cadre de nos travaux, nous avons essayé de déterminer, par une analyse de régression construit sur les donnés obtenus de la société TATKAP (qui renouvelle les pneus usés par voie de rechapage) et de l'Institut Turque des Statistiques, les effets sur le nombre des pneus rechapés par TATKAP, des facteurs que nous avons adopté comme des variables dépendantes, comme : le nombre total des pneus rechapés par les entreprises actives

dans ce domaine, la quantité des pneus neufs vendus en Turquie, les prix des pneus neufs, et le nombre de camions immatriculés en Turquie.

L'Information numérique disponible concernant les entreprises actives dans le monde entier et dans des différentes industries, témoignent de l'importance des activités de remanufacture pour les entreprises. Ce fait est corroboré surtout par les efforts déployés pour le développement et la propagation de ces activités d'une manière globale.

Les données concernant le remanufacture des automobiles et des moteurs sont une indication claire de l'importance (en volume) et de la propension annuelle de croissance de ce secteur. Au fur et à mesure que les consommateurs deviennent plus conscients, la demande pour des pièces remanufacturées augmente, et les retours (pour le remanufacture) des produits en fin de leur cycle de vie ou des pièces endommagées ou réutilisables, aux producteurs, deviennent de plus en plus fréquents. En outre, les sociétés établissent de divers systèmes et coopèrent pour le retour des produits éligibles, annonçant ces systèmes aux consommateurs. Ils soutiennent la croissance de ce secteur, en se souscrivant aux normes statutaires, devançant les délais prescrits par la règlementation.

Les progrès technologiques réalisés par les fabricants des produits de copiage et d'image sur la réévaluation des pièces réutilisables et remanufacturable empêchent le traitement comme déchets des tonnes de produits. Un certain nombre de systèmes de retour ont été développés et mis en application ; et des partenariats ont été établis au niveau de supply chain, pour permettre des retours des pièces réutilisables et remanufacturable par les consommateurs, aux producteurs. De surcroit, l'adoption et la mise en œuvre de la philosophie de « la conception pour le remanufacture » de la part des sociétés permettent une croissance de ces activités dans ce domaine.

Tous les ans, les entreprises d'industrie d'informatique et de téléphones portables récupèrent des tonnes de produits encore utilisables, par le biais de divers programmes et de la coopération mutuelle. En vertu de ces efforts de recouvrement, beaucoup de pièces et de matériaux de valeur et qui, de plus, sont réutilisables, sont récupérés.

Toutes ces différentes données concernant des différents secteurs permettent d'arriver à la même conclusion : les activités de remanufacture ne commencent pas au moment du retour d'un produit, mais plutôt, dès l'étape de la conception. Dans la mesure où remanufacture des composants est pris en compte pendant la conception d'un produit, les activités de remanufacture peuvent être exécutées de façon beaucoup plus efficace. Les sociétés peuvent, en outre, augmenter l'efficacité de leurs activités de remanufacture en mettant en place des processus de coopération.

ABSTRACT

As environmental issues become increasingly evident and important, they require new approaches from today's companies, not only in regard of manufacturing activities, but also, for the entire supply chain functions.

In today's world, no one has the luxury of sending to landfill the end-of-life or defective products; even the recycling should be considered as the ultimate disposition option, since recycling a product completely annuls the added value created during its manufacture.

Reverse logistics function, with its multitude of disposal options, can be the solution for the protection of environment and natural resources.

Logistics is a part of the supply chain and controls the flow and storage of goods, services, and related information from the point of origin to the point of consumption. The supply chain encompasses all activities associated with the flow and transformation of goods and information from the raw materials stage, through to the end user. Supply chain management, on the other hand, is the coordination of production, inventory, location, and transportation to achieve the best mix of responsiveness and efficiency throughout the supply chain.

Reverse logistics is the process of planning and controlling the flow of raw materials, inventory, finished goods and related information from the point of consumption to the point of origin. It is a function of a supply chain management, with the activities of the recovery, recycling, or reuse of returned products from the end user after they have reached the end of their useful life.

The increasing importance of corporate social responsibility and its potential impact on customer loyalty encourage the organizations for relaxing returns polices, in the same way, competitive and regulatory pressures force the firms to extend their distribution channels with an aim to include the final products for disposition, since organizations eventually need to transform used products into new products or materials that can be disposed of, without harming the environment.

Reasons of returns can be classified as follows: (i) consumer returns, (ii) marketing returns, (iii) asset returns, (iv) product recalls and (v) environmental returns.

The consumer returns can be categorized under one of the following six reasons: product doesn't meet the costumer needs; costumer doesn't understand correctly how the product must be used (non-defective defectives); product doesn't work; product is returned to be remanufactured or for proper disposal or customers' misuse of liberal return policies.

Marketing returns consist of products returned from a subsequent step in the supply chain, especially from retailers, often due to damage in transit, expired date code, product being discontinued or replaced, product being seasonal, retailer inventories being too high, and retailer going out of business.

Asset returns aim at recapturing and repositioning of an asset. Products subject to this kind of returns are typically characterized as items that management wants to see returned.

Product recalls are a form of return usually initiated because of a safety or quality issue. Recalls can be voluntary or mandated by a government agency.

Environmental returns either aim at the disposal of hazardous materials or at the compliance with environmental regulations.

In their most common form, reverse logistics activities are processes by which a company collects used, damaged, unwanted, or outdated products, as well as packaging and shipping materials from the end-user.

Collection is the first and foremost stage in the recovery process, where product types are selected; products are located, collected, and, if required, transported to facilities for rework and remanufacturing.

Gatekeeping is the processes of deciding which products will be allowed into the reverse logistics system. It consists of screening for defective and unwarranted returned merchandise at the entry point and is critical for making the entire reverse flow manageable and profitable.

Inspection/sorting is deciding on what to do with each product and may be carried out either at the point and time of collection or afterwards. Collected items generally need sorting and this stage requires a skill in the sorting of used products.

Disposition is simply sending the products to their desired destination.

Pre-processing may be in the form of sorting, segregation, partial or complete disassembly or minor repair and refurbishing activities.

Packaging can be defined as the products made of any materials of any nature to be used for the containment, protection, handling, and delivery from the producer to the user or the consumer and presentation of goods, from raw materials to processed goods.

Reverse logistics activities for products and packaging can be summarized as below:

Retailers return products to the vendor because of defects, marketing returns, obsolescence or overstocks.

If the returned product is unused and unopened, the retailer may resell it as new.

If the retailer has too many stocks, returned product can be sold via an outlet or discount store.

When a firm is unable to sell a product and returning to vendors or selling via outlet stores are not viable options, products may be sold via the secondary market; which market consists of firms that specialize in buying close-outs, surplus and salvage items.

If the product is still serviceable, but perhaps with some slight cosmetic damage, retailers or vendors may decide to donate the product to charitable organizations.

Before deciding that the product or packaging is a complete loss and sending it to recycle, many firms try to repair, refurbish or remanufacture, which activities involve product reconditioning and upgrade.

Refurbishing and remanufacturing differ with respect to the degree of improvement and the amount of effort needed to upgrade the product; remanufacturing involves the greater effort of the two.

When the firm is not able to sell the product to the secondary market, and the other options are not feasible, and the recovery of packaging is impossible, the final option is disposal. Normally, the firm's objective is to receive the highest value for the item, or dispose of the item at the lowest cost.

Environmental excellence starts during the initial product and process design. Design for the environment component can be incorporated into new products and in the modification of existing products, where products are redesigned to eliminate waste, remove hazardous content, increase product durability and life span, minimize pollution during use, or to incorporate recycled materials.

In addition, to the extent environmental regulations become globally prevalent, that these can lead to modification of certain industrial structures and systems.

European Union regulations about recycling, reusing, using landfill sites, use of hazardous substances and responsibility for disposal are very good examples on this latter point.

In its simplest terms, remanufacturing is the process of returning a used, worn out product to as close to new as possible; it is a process of recapturing the value added to the material when a product was first manufactured. Remanufacture results in reduced energy and material use, and production cost reductions.

A product is considered remanufactured if its primary components come from a used product.

- The used product is dismantled to the extent necessary to determine the condition of its components.
- The used product's components are thoroughly cleaned and made free from rust and corrosion.
- All missing, defective, broken or substantially worn parts are either restored to reliable, functionally good condition, or they are replaced with new, remanufactured, or functionally good used parts.
- To put the product in good working condition, such machining, rewinding, refinishing or other operations are performed as necessary.
- The product is reassembled and a determination is made that it will operate like a similar new product.

There are five key steps of remanufacturing:

- complete disassembly of the product
- thorough cleaning of all parts
- inspection and sorting of all parts
- reconditioning of parts and/or replenishment by new parts
- product reassembly

It is worth noting, that, in Turkey, there are only a few enterprises active in the fields of remanufacturing. The above notwithstanding, the activities of TATKAP operating in the commerce of tires are particularly noteworthy. In our thesis, we have tried and analyzed, by a regression analysis based on data obtained from TATKAP (whose main activity is restoration of used tires to like-new conditions by retreading) and Turkish Statistical Institute, the effects of various factors (which we designated as dependant variables), such as, the aggregate number of tires retreaded by companies active on this domain, the amounts of brand-new tires sold in Turkey, the price of brand-new tires in Turkey and the aggregate number of trucks registered in Turkey, over the number of tires retreaded by TATKAP.

Numerical data on companies active in various industries throughout the world demonstrates the importance of remanufacturing activities for enterprises. This fact is further corroborated by the efforts deployed to develop and spread these activities on a global scale.

The data relating to automotive and engine remanufacturing is a clear indication of the importance (in size) and the annual growth propensity of this sector. With the ever increasing consumer awareness, the demand for remanufactured parts is on the rise, and returns for remanufacturing of end-of-life or damaged or reusable parts to producers are becoming more and more common. Furthermore, companies institute various systems and cooperate for return of relevant products, announcing these to the consumers. They sustain the growth of this sector by subscribing to, and fulfilling statutory remanufacturing standards, before the timelines prescribed by the regulatory requirements.

Technological advances realized by the manufacturers of copying and imaging products on re-evaluation of reusable and remanufacturable parts prevent the disposal – as waste- of tonnes of products. A number of return systems have been developed and implemented and partnerships through the supply chain have been instituted, to allow returns of reusable and remanufacturable parts by the consumers, to the producers. The

design for remanufacturing approach implemented by the companies further facilitates these activities.

Each year computer and mobile phone industry recovers tonnes of still usable products through various programmes and co-operations. As a result of these recovery efforts, many reusable parts and valuable materials are saved from being dumped into landfills.

Different data relating to these different sectors all point out to the same conclusion: remanufacturing activities do not begin at the time of return of a product, but rather, these activities begin at the design stage. In the event the remanufacturing of the components is taken into consideration while designing a product, remanufacturing activities can be performed on a more effective and cost efficient manner. In conjunction with the above, companies may further increase the efficiency of their remanufacturing activities by implementing co-operations processes.

ÖZET

Çevreye ilişkin problemler günümüzde giderek önem kazanmakta olup, bu durum, şirketlerin üretim fonksiyonlarının yanı sıra, tedarik zincirinin tüm işlevlerinde yeni yaklaşımları benimsemelerini gerekli kılmaktadır.

Günümüzde artık kimsenin kullanım ömrünün sonuna gelmiş veya hasarlı ürünleri çöpe göndermek gibi bir lüksü yoktur; hatta geri dönüşüm bile son çare olarak değerlendirilmelidir çünkü bir ürünün geri dönüştürülmesi, o ürünün ilk defa üretimi esnasında yaratılan katma değeri tamamiyle sıfırlamaktadır.

Tersine lojistik fonksiyonu, birçok farklı geri kazanım seçenekleriyle , çevrenin ve doğal kaynakların korunması için bir çözüm olabilir.

Lojistik, tedarik zincirinin bir parçası olup, kaynak noktasından tüketim noktasına kadar ürünlerin, servislerin ve bunlara ilişkin bilgilerin akışının ve depolanmasının kontrolünü sağlar. Aynı şekilde tedarik zinciri hammadde aşmasından nihai tüketiciye kadar oluşan bütün ürün ve bilgi dönüşümünü ve akışını kapsamaktadır. Buna karşın, tedarik zinciri yönetimi, tedarik zinciri boyunca en etkin ve en verimli yönteme ulaşabilmek adına üretim, depolama ve nakliye süreçlerinin koordinasyonu olarak tanımlanabilir.

Tersine lojistik tüketim noktasından kaynak noktasına doğru, hammadde, envanter, nihai ürün ve bunlara ilişkin bilgilerin akışının planlanması ve kontrolüdür. Tedarik zincirinin bir fonksiyonudur ve kullanım ömürlerinin sonuna geldikten sonra tüketici tarafından geri gönderilmiş ürünlerin geri kazanımı, geri dönüşümü ve yeniden kullanımı gibi aktiviteleri kapsar.

Kurumsal sosyal sorumluluk kavramının artan önemi ve müşteri sadakati üzerindeki olası etkisi, işletmeleri iade politikalarını gevşetme konusunda cesaretlendirmekte, aynı şekilde, günümüzde hissedilen rekabetçi ve yasal baskılar, firmaları, dağıtım kanallarını nihai ürünün değerlendirilmesini de kapsayacak şekilde genişletmeye zorlamaktadır; zira işletmeler, giderek, doğaya zarar vermeden değerlendirilebilecek kullanılmış ürünleri yeni ürün veya maddelere dönüştürmekle yükümlü hale gelmektedirler.

Ürünlerin iade nedenleri şu şekilde sıralanabilir: (i) tüketici iadeleri, (ii) pazarlama iadeleri, (iii) varlık iadeleri, (iv) ürün geri çağırmaları ve (v) çevresel iadeler.

Tüketici iadeleri altı nedenden biri altında sınıflandırılabilir: ürün tüketicinin ihtiyacını karşılamamaktadır, tüketici ürünün doğru şekilde nasıl kullanacağını anlayamamıştır (hasarlı olmayan hasarlılar), ürün çalışmamaktadır, ürün yeniden üretim vaya özel bir değerlendirme için iade edilmektedir veya tüketici şirketin serbest iade politikalarını kötüye kullanmaktadır.

Pazarlama iadelerinde ürün, tedarik zincirindeki bir üyeden, özellikle perakendeciden, sıklıkla, nakliye sırasındaki hasarlar, son tüketim tarihinin geçmiş olması, ürünün devamının olmaması, sezonluk ürün olması, perakendecinin stok fazlasının bulunması veya perakendecinin işini sonlandırması gibi nedenlerle geri gelir.

Varlık iadelerinde ise varlık yeniden konumlandırılır, bu tip ürünler tipik olarak üretici şirket yönetiminin geri dönmesini istediği ürünlerdir.

Ürün geri çağırmaları güvenlik veya kalite nedenleri ile isteğe bağlı olarak veya resmi bir merci talebi doğrultusunda ürünlerin geri toplanmasıdır.

Çevresel iadeler, zararlı maddelerin değerlendirilmesi amacıyla veyahut çevrenin korunması ile ilgili düzenlemelere uyum kaygıları nedeniyle gerçekleşir.

En yaygın şekliyle, tersine lojistik faaliyetleri, firmanın kullanılmış, hasarlı, istenmeyen ve zamanı geçmiş ürünler ile ambalaj ve nakliye malzemelerini nihai tüketiciden toplama süreçleridir.

Toplama geri kazanım sürecindeki ilk ve en önemli adımdır; bu adımda ürünler ayrılır, toplanır, depolanır ve ihtiyaç halinde yeniden işleme ve yeniden üretim için tesislere nakledilir.

Kapıda eleme (*gatekeeping*) tersine lojistik sistemine hangi ürünlerin gireceğine karar verme sürecidir. Daha giriş noktasında hasarlı ve garanti kapsamı dışındaki istenmeyen ürünlerin taranması ile tersine akışın daha yönetilebilir ve kârlı olmasını sağlar.

Muayene ve ayıklama, toplama esnasında veya sonrasında, herbir ürün ile ne yapılacağına karar verme sürecidir. Toplanan ürünlerin genellikle sınıflandırılarak ayrılması gerekir ve bu aşama sıklıkla kullanılmış ürünlerin sınıflandırılması konusunda uzmanlık gerektirir.

Değerlendirme *(disposition)* basit olarak ürünün arzu edilen hedefe gönderilmesidir.

Yeniden dağıtım (*pre-processing*) tasnif, ayırma, kısmen veya tamamen demontaj veya ufak tamirler ve ürünü yenileştirme faaliyetleri (*refurbishing*) şeklinde olabilir.

Ambalaj, ürünün hammadde aşamasından nihai ürün aşamasına kadar, üreticiden tüketiciye giderken, korunması, elleçlenmesi, teslimatı ve sunumu için kullanılan her türlü biçim ve malzemedeki ürün olarak tanımlanabilir.

Ürün ve ambalajlar için tersine lojistik faaliyetleri şu şekilde özetlenebilir:

Perakendeci, ürünleri hasar, pazarlama iadesi, metruk kalmalar veya stok fazlalığı olmaları sebeplerinden herhangi birine bağlı olarak, üreticisine iade eder.

Eğer geri dönen ürün açılmamış ve kullanılmamış ise perakendeci bunu yeni gibi yeniden satabilir.

Eğer perakendecinin çok fazla stoğu varsa iadeler indirim mağazaları yolu ile satılabilir.

Bir firma bir ürünü bu şekilde satamıyorsa, üreticisine göndermek veya indirim mağazaları yoluyla satmak da mümkün değilse, ürünler ikincil pazarlar aracılığı ile satılabilir.

Eğer ürün hala kullanılabilir durumdaysa, ancak, bazı yüzeysel kozmetik hasara uğramışsa, perakendeci vaya satıcı bu ürünü yardım kuruluşlarına bağışlayabilir.

Çoğu firma, bir ürünün vaya ambalajın tamamen kayıp olduğuna kanaat getirip geri dönüşüme göndermeden önce, bunları tamir etmeyi, ürünü yenileştirmeyi veya yeniden üretimi dener. Anılan bu faaliyetler, üründe değişiklikler ve güncellemeler yapılmasını gerektirir.

Ürün yenileştirme ve yeniden üretim, üründe yaratılan iyileştirmenin derecesi ve bunun için harcanan emek bazında farklılık gösterir; yeniden üretim, ürünü yenileştirmeye nazaran daha fazla çaba gerektirir.

Firma ürünü ikincil pazarlara satamıyorsa ve diğer seçenekler uygulanabilir değilse ve aynı zamanda ambalajın geri kazanımı da mümkün değilse, son seçenek elden çıkarmadır (*disposal*). Doğal olarak firmanın amacı, üründen en yüksek geliri elde etmek veya ürünü en az maliyetle elden çıkarmaktır.

Çevresel yaklaşım, ürünün ve süreçlerin tasarlanması aşamasında başlar. Çevre için tasarım, atıkların azaltılmasını, zararlı içeriklerin ortadan kaldırılmasını, ürünün dayanıklılığını ve ömrünü arttırmayı, ürünün kullanımı süresince yarattığı kirliliği azaltmayı ve geri dönüştürülmüş malzemeler kullanılmasını kapsar ve yeni ürünlere

uygulanabileceği gibi, hali hazırda var olan ürünlerin modifikasyonlarında da uygulanabilir.

Buna ek olarak, çevre ile ilgili yasal düzenlemelerin küresel olarak kabul görmesi, bazı endüstriyel yapı ve sistemlerde iyileştirmeler sağlayabilecektir.

Avrupa Birliği'nin, geri dönüşüm, yeniden kullanım, atık alanlarının kullanımı, zararlı maddelerin kullanımı ve elden çıkarılması sorumluluğu ile ilgili yasal düzenlemeleri buna iyi bir örnek teşkil etmektedir.

En basit şekliyle yeniden üretim, kullanılmış, yıpranmış bir ürünü olabildiğince yani hale getirme sürecidir, ürünün ilk üretimi sırasında yaratılan değerin yeniden kazanılmasını sağlar. Yeniden üretim ile enerji ve hammadde tüketimi azalırken, üretim maliyetlerinde düşüş sağlanır.

Bir ürünün yeniden üretilmiş olarak kabul edilebilmesi için, belli başlı parçaları kullanılmış ürünlerden sağlanmalıdır.

- Kullanılmış ürün, parçalarının durumunun anlaşılması için gerektiği kadar demonte edilmiş olmalıdır.
- Kullanılmış ürünün parçaları tamamen temizlenmiş, kir ve pastan arındırılmış olmalıdır.
- Eksik, hasarlı, kırılmış ve yıpranmış parçalar, ya iyi çalışacak ve kabul edilebilecek standardlara uygun olacak şekilde tamir edilmelidir ya da yeni veya yeniden üretilmiş veyahut iyi çalışır haldeki kullanılmış parçalar ile değiştirilmelidir.
- Ürünü iyi çalışır hale getirmek için gereken torna, rötuş gibi faaliyetler yapılmalıdır.
- Ürün yeniden monte edilmeli ve yeni bir ürüne benzer şekilde çalıştığı saptanmalıdır.

Yeniden üretimin beş anahtar aşaması bulunmaktadır:

- Ürünün tamamen demontajı;
- Bütün parçaların temizlenmesi;
- Bütün parçaların muayene ve ayıklanması;
- Parçaların yenilenmesi ve/veya yenisi ile değiştirilmesi; ve
- Ürünün tekrar monte edilmesi.

Ülkemizde yeniden üretim yapan çok sayıda işletme olmamakla birlikte, lastik sektöründe faaliyet gösteren TATKAP firmasının bu alandaki çalışmaları heyecan vericidir. Kullanılmış lastikleri kaplayarak tekrar yeni lastik kalitesine getiren TATKAP'tan elde edilen veriler ışığında yaptığımız regresyon analizinde, firmanın kaplama miktarındaki değişimde, bağımsız değişken olarak belirlediğimiz, bu alanda faaliyet gösteren firmaların toplam kaplama lastik miktarı, Türkiye'de satılan toplam yeni lastik miktarı, yeni lastik fiyatları, kaplama lastik fiyatları ve Türkiye'de kayıtlı kamyon miktarı gibi faktörlerin etkisini inceledik.

Dünyada yeniden üretim konusunda farklı sektörlerde faaliyet gösteren firmaların sayısal verileri göstermektedir ki, yeniden üretim şirketler için önemlidir ve bu durum özellikle bu faaliyetlerin dünya çapında yaygınlaştırılması için harcanan çabalarda da ifadesini bulmaktadır.

Otomotiv ve motor yeniden üretimine ilişkin veriler bu sektörün büyüklüğünü oldukça açık bir biçimde ifade etmektedir. Tüketcilerin bilinçlenmesi ve yeniden üretilmiş parçalara talebin artmasıyla, üreticilere yeniden üretim için iade edilen, kullanım ömrünün sonuna gelmiş, hasarlı veya tekrar kullanılabilecek parça içeren ürün sayısı artmaktadır. Firmalar bunun için çeşitli sistemler ve ortaklıklar kurmakta ve tesis edilen bu işbirliği imkânlarını tüketicilere duyurmaktadırlar. Şirketler, düzenlemelerin öngördükleri standardlara kendilerine tanınan zamandan önce ulaşmak suretiyle bu sektörün gelişimini ayrıca desteklemektedirler.

Aynı şekilde, kopyalama ve görüntüleme araçları üreticilerinin tekrar kullanılabilir ve yeniden üretilebilir parçalar üzerine geliştirdikleri teknolojik yenilikler ile tonlarca

ürün atık olmaktan kurtarılmaktadır. Tüketicilerin tekrar kullanılabilen ve yeniden üretilebilecek parçaları üreticilere ulaştırabilmeleri için, tedarik zinciri boyunca birçok sistem ve ortaklık kurulmuştur. Yeniden üretim için tasarım yaklaşımı bu faaliyetleri ayrıca kolaylaştırmaktadır.

Bilgisayar ve cep telefonu endüstrisi, her yıl çeşitli programlar ve ortaklıklarla, genellikle tüketici için ücretsiz olarak, tonlarca tekrar kullanılabilecek parçayı geri kazanmaktadır. Bu geri kazanım çabaları ile, birçok tekrar kullanılabilecek parça ve değerli madde çöplüğe gitmekten kurtarılmaktadır.

Farklı sektörlere ait farklı veriler hep aynı sonuca işaret etmektedir: yeniden üretim faaliyetleri ürün iade edildiğinde değil, ürünün tasarımı aşamasında başlamaktadır. Eğer ürün tasarlanırken, parçaların yeniden üretim için uygunluğu göz önünde bulundurulursa, yeniden üretim faaliyetleri daha etkin ve daha az maliyetli olarak gerçekleştirilebilir. Buna ek olarak, firmalar ortaklıklar kurarak yeniden üretim faaliyetlerinin daha verimli olmasını sağlayabilirler.

INTRODUCTION

Environmental issues become increasingly apparent and their importance in the contemporary economic circles continues to grow evermore. This shift on priorities calls for new approaches, which novelties are not limited with manufacturing functions, but also extend to the entirety of supply chain functions of today's companies.

Because of the rising concerns on the global warming issue, companies endeavor to reduce carbon dioxide emissions, not only in their plants, but in their offices as well, and the diminution of natural resources coupled with the environmental hazards created by filled-up landfill zones bring about the question of the disposal of the returned products.

One might argue that in today's world, no one has the luxury of dumping or disposing as waste material the end-of-life or defective products; even the recycling should be considered as the ultimate disposition option, since recycling a product completely annuls the added value created during its manufacture.

As opposed to recycling, remanufacturing of a product brings it to like new standards, allowing its reuse and prevents wasting of valuable natural resources and energy used in its original manufacture.

Given that we have very little time left to prevent our World from becoming irreparably damaged, we have no other option than to expand the implementation of remanufacturing activities.

My aim in writing this Thesis is not merely to examine the reverse logistics function in the supply chain; I will further try and demonstrate that the products returned

to the manufacturers from consumers, due to various reasons, should not be qualified as waste and that these returned products could be re-evaluated in a number of different ways, generating an economical added value.

I believe that reverse logistics function, coupled with its multitude of disposal options, can be the much needed solution, in an age where the concerns for the protection of environment and natural resources becomes more and more pressing.

The remanufacturing activities, which I looked into with a particular interest during my researches, offer a number of appealing and encouraging data for the companies. While labor-intensive, remanufacturing is an activity of undeniable value, with the savings it allows on natural resources and energy.

Having said the above, within the first part of my Thesis, I have tried, as an introductory step, to establish the place of reverse logistics functions within the supply chain (I.A). I have then analyzed various definitions proposed by the scholars and the scope of reverse logistics (I.B.1; I.B.2) and various reasons for returns (I.B.3); I described the disposal options for returned goods (I.C); and I briefly looked into the European legislation, which legislation is –arguably- the most advanced, as of today (I.D).

In the second part of my Thesis, following a description of remanufacturing activities (II.A.1) and their implementations (II.A.2), I tried to propose a regression analysis about remanufacturing activities of TATKAP and the factors which have an effect on the amount of pre-cured tire retreading of this company (II.B). Finally, I have tried to provide some notable examples of remanufacturing activities of the global firms, on a sectoral basis, based on the relevant data available on the companies having significant activity in this domain (II.C; II.D; II.E).

I sincerely hope that the present Thesis would bequeath its readers similar amount of knowledge and sensitivity which I had the opportunity to gain during my researches.

I. REVERSE LOGISTICS: FROM WASTE TO REMANUFACTURING

A. LOGISTICS AND SUPPLY CHAIN MANAGEMENT

Today's business world talks about supply chain management with an increasing interest. The activities related to the supply chain management solutions, like logistics and reverse logistics activities in particular, create substantial value for all trading partners, including suppliers, manufacturers and customers. The reverse logistics, which is the subject matter of the present thesis, is an integral part of the supply chain; and therefore, for a thorough understanding of reverse logistics, one must have basic knowledge on supply chain management. Supply chain decisions set forth the operating framework within which logistics is performed. Consequently, the concepts of logistics and supply chain management should be defined, before examining the reverse logistics.

A distinction is made by most scholars between the concepts of logistics and supply chain. First and foremost, the notion of supply chain has its origins rooted in the logistics literature and logistics have had a continuous and significant impact on the supply chain management concept.

Council of Logistics Management[1] has proposed the following definition in 1991; "*Logistics is that part of the supply chain process that plans, implements, and controls the efficient flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet customers' requirement*". Thus, the Council of Logistics Management distinguishes between logistics and supply chain

[1] Founded in 1963, The Council of Logistics Management (CLM) is a worldwide professional association dedicated to the advancement and dissemination of research and knowledge on supply chain management, with over 8,500 members from industry sectors, government, and academia from 67 countries. The organization is led by an elected group of global officers and its headquarters located in Lombard, Illinois, USA. In 2005, CLM get the name of CSCMP, short for the Council of Supply Chain Management Professionals. www.cscmp.org (2009)

management, acknowledging that logistics is one of the functions contained within supply chain management.

Bowersox *et al.* (2003) also make a distinction between these two concepts by giving their following definition: "*Supply chain management consists of firms collaborating to leverage strategic positioning and improve operating efficiency. In contrast, logistics is the work required to move and position inventory throughout a supply chain*"[2].

Hugos argues in a alternative definition that "*logistics typically refers to activities that occur within the boundaries of a single organization and supply chain refers to networks of companies that work together and coordinate their actions to deliver a product to the market. Also traditional logistics focuses its attention on activities such as procurement, distribution, maintenance, and inventory management. Supply chain management acknowledges all of traditional logistics and also includes activities such as marketing, new product development, finance, and customer service*"[3]. Logistics, however, is not simply about getting things to where they need to be. It requires coordination of many activities, network design, information, transportation, inventory and warehousing. Actually, logistics is a support function to operations, just like human resources, finance and other functions.

There are three distinct areas of logistics from the point of view of a firm, namely, "inbound logistics", which includes sourcing and materials management; "operations logistics", closely related to material management, emphasizing the way logistics affects operations and "outbound logistics", also known as physical distribution, which refers to the way the product is physically delivered to the customer[4].

---

[2] Donald J. Bowersox, David J. Closs, M. Bixby Cooper, **Supply Chain Logistics Management**, McGrawHill, New York, 2002, pg. 4

[3] Michael Hugos, **Essentials of Supply Chain Management**, John Wiley&Sons, Inc., New Jersey, 2003, pg. 4

[4] Douglas Long, **International Logistics: Global Supply Chain Management**, Kluwer Academic Publishers, USA, 2003, pg. 89

Reverse logistics may be considered as the fourth area of logistics, complementing the aforementioned, because of its growing importance, both for the companies active in recycling, reusing, remanufacturing activities, as well as such companies that have to pay for the disposal of their waste products. It should be noted that this forth function of logistics has yet to achieve a homogenous development throughout various industrial domains, since, while in some product groups recycling systems and activities have been systematised, like automobile, chemicals, computers, printers, batteries, white goods, and packaging; but for many other product categories, the development is only at its beginnings[5].

As we mentioned before, like logistics, supply chain also is an important aspect for the understanding of reverse logistics activities. According to Handfield and Nichols (1999), "*(…) the supply chain encompasses all activities associated with the flow and transformation of goods from the raw materials stage, through to the end user, as well as the associated information flows. Material and information flow both up and down the supply chain*"[6]. With this definition, Handfield and Nichols (1999) explain the importance of information flow as well as the material flow of supply chain. Indeed, the information flow helps the right function and efficiency of the chain. New telecommunications and computer technologies create new links between suppliers, manufacturers, distributors and customers, regardless of their physical locations; reducing paperwork and non-value-added activities of the supply chain and improve communication.

In an alternative definition; Chopra and Meindl (2007) focus on the members of the supply chain working together for the customer satisfaction: "*A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain includes not only the manufacturer and supplier, but also transporters, warehouses, retailers, and even customers themselves*"[7].

---

[5] Tage Skjoett-Larsen, "European logistics beyond 2000", *International Journal of Physical Distribution & Logistics Management*, Vol. 30, No.5, 2000, Emerald Library, pg. 385

[6] Robert B. Handfield, Ernest L. Nichols, Jr., **Introduction to Supply Chain Management**, Prentice Hall, New Jersey, 1999, pg. 2

[7] Sunil Chopra, Peter Meindl, **Supply Chain Management Strategy, Planning, and Operation**, Pearson & Prentice Hall, New Jersey, 2007, pg. 3

One of the advantages of this integrated co-operation between the members is the elimination of the distorted information in the chain, which can reduce the "bullwhip-effect", where even small changes on the demand (downstream) may result in large fluctuations upstream[8]. By virtue of this close co-operation among the members, it is possible to achieve efficiency in a chain.

According to Chopra and Meindl (2007), the objective of every supply chain should be to maximize the overall value generated. "*The value a supply chain generates is the difference between what the final product is worth to the customer and the costs the supply chain incurs in filling the customer's request*"[9].

In today's business practice, the structures of supply chain are quite complex and cannot accurately be described by figures. That said, the following figures may offer a clearer view on the matter:

Figure 1.1.1: Simple Supply Chain
(Source: Hugos, 2003, pg. 27)

"*A basic supply chain consists of a company, an immediate supplier, and an immediate customer directly linked by one or more of the upstream and downstream flows of products, services, finances, and information*"[10]. Presently, this form of supply chain is not very common but nevertheless, is helpful for understanding the core of the supply chain concept.

[8] Skjoett-Larsen, 2000, pg. 378
[9] Chopra, Meindl, 2007, pg. 5
[10] John T. Mentzer, editor, **Supply Chain Management**, Sage Publications, Inc., USA, 2001, pg. 6

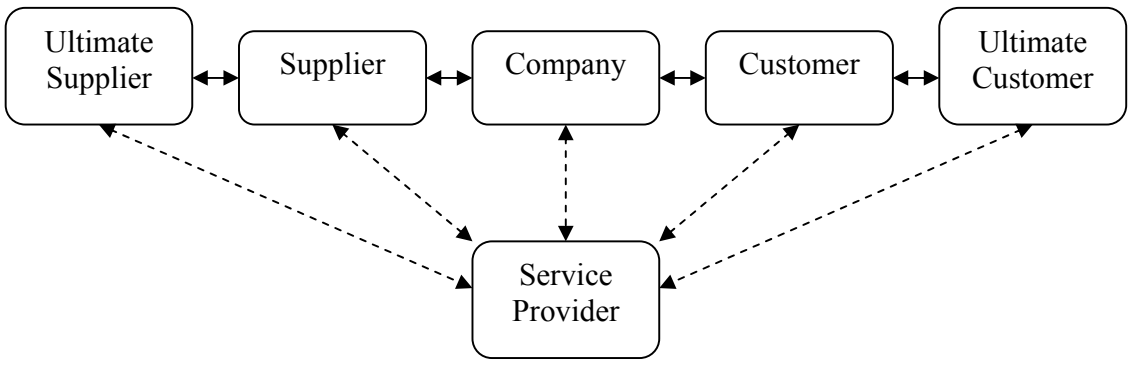


Figure 1.1.2: Extended Supply Chain
(Source: Hugos, 2003, pg. 27)

The extended form of the supply chain is the most common form of supply chain in today's business organizations. "*An extended supply chain includes suppliers of the immediate supplier and customers of the immediate customer, all linked by one or more of the upstream and downstream flows of products, services, finances, and information*"[11].

Despite the popularity of the term, there are differing views as to the meaning of supply chain management.

The Institute for Supply Management[12] describes supply chain management as *"the design and management of seamless, value-added processes across organizational boundaries to meet the real needs of the end customer. The development and integration of people and technological resources are critical to successful supply chain integration."*

[11] **İbid.**
[12] Founded in 1915 (United States), the Institute for Supply Management (ISM) is one of the largest supply management association in the world. ISM is a not-for-profit association that provides opportunities for the promotion of the profession and the expansion of professional skills and knowledge, through promotional activities and education. www.ism.sw (2009)

The Supply-Chain Council's[13] definition of supply chain management is "*managing supply and demand, sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, and delivery to the customer*".

The Council of Logistics Management defines supply chain management as "*…the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole*". Members of the supply chain must be working together with an aim of improving performance of not only their respective individual businesses but also, for improving the performance of the chain. This latter objective can be difficult to achieve and for this reason, the flow of information in the supply chain is very important for the efficiency of the chain.

Hugos argues that "*supply chain management is the coordination of production, inventory, location, and transportation among the participants in a supply chain to achieve the best mix of responsiveness and efficiency for the market being served*"[14]. His definition gives a special attention to the responsiveness and efficiency, asserting that if one cannot meet the customers' request at the right time and at the right place with a good quality product, or is inefficient; one cannot maximize the value of the chain, and can not talk about an effective supply chain management system.

In view of Lambert *et al.* "*Supply chain management is the integration of key business processes from end user through original supplier that provides products, services, and information that add value for customers and other stakeholders*"[15].

---

[13] The Supply-Chain Council (SCC) is a global non-profit organization established in 1996. It has international chapters in North America, Europe, Greater China, Japan, Australia/New Zealand, South East Asia, Brazil and Southern Africa and its membership consists primarily of practitioners representing a broad cross section of industries, including manufacturers, services, distributors, and retailers. www.supply-chain.org (2009)

[14] Hugos, 2003, pg. 4

[15] Douglas M. Lambert, Martha C. Cooper, Janus D. Pagh, "Supply Chain Management: Implementation Issues and Research Opportunities", *The International Journal of Logistics Management,* Vol. 12, No. 2, 2001, Emerald Library, pg. 13

These differing views on the definition set aside, eight key business processes need to be implemented within and across firms in a supply chain structure[16]. These are:

- Customer Relationship Management
- Customer Service Management
- Demand Management
- Order Fulfillment
- Manufacturing Flow Management
- Supplier Relationship Management
- Product Development and Commercialization
- Returns Management

A combination of all of these processes creates an efficient supply chain management system, which adds not only to the physical value of a product; also ensures a better reputation for the members of the supply chain. These key business processes, however, have an unequal importance in view of the companies and the returns management is, arguably, the most neglected aspect of the supply chain practices. Such neglectful approach is problematic because returns management is one of the few areas left for companies to improve supply chain efficiencies and well-managed reverse logistics systems can reduce costs and improve customer satisfaction[17].

On the basis of our above summary explanations regarding the concepts of logistics, supply chain and supply chain management, we will be touching upon the concept of reverse logistics in the next section.

---

[16] Dale S. Rogers, Douglas M. Lambert, Kelly L. Croxton, Sebastián J. García-Dastugue, "The Returns Management Process", *The International Journal of Logistics Management,* Vol. 13, No. 2, 2002, Emerald Library, pg. 2

[17] R. Glenn Richey, Stefan E. Genchev, Patricia J. Daugherty, "The role of resource commitment and innovation in reverse logistics performance", *International Journal of Physical Distribution & Logistics Management*, Vol. 35, No. 4, 2005, Emerald Library, pg. 234

B. SCOPE AND SIZE OF REVERSE LOGISTICS

Reverse logistics is a new trend in supply chain management, with the activities of the recovery, recycling, or reuse of returned products from the end user after they have reached the end of their useful life. Competitive and regulatory pressures force the organizations to extend their distribution channels beyond the end customer with an aim to include the final products for reuse in the making of new products.

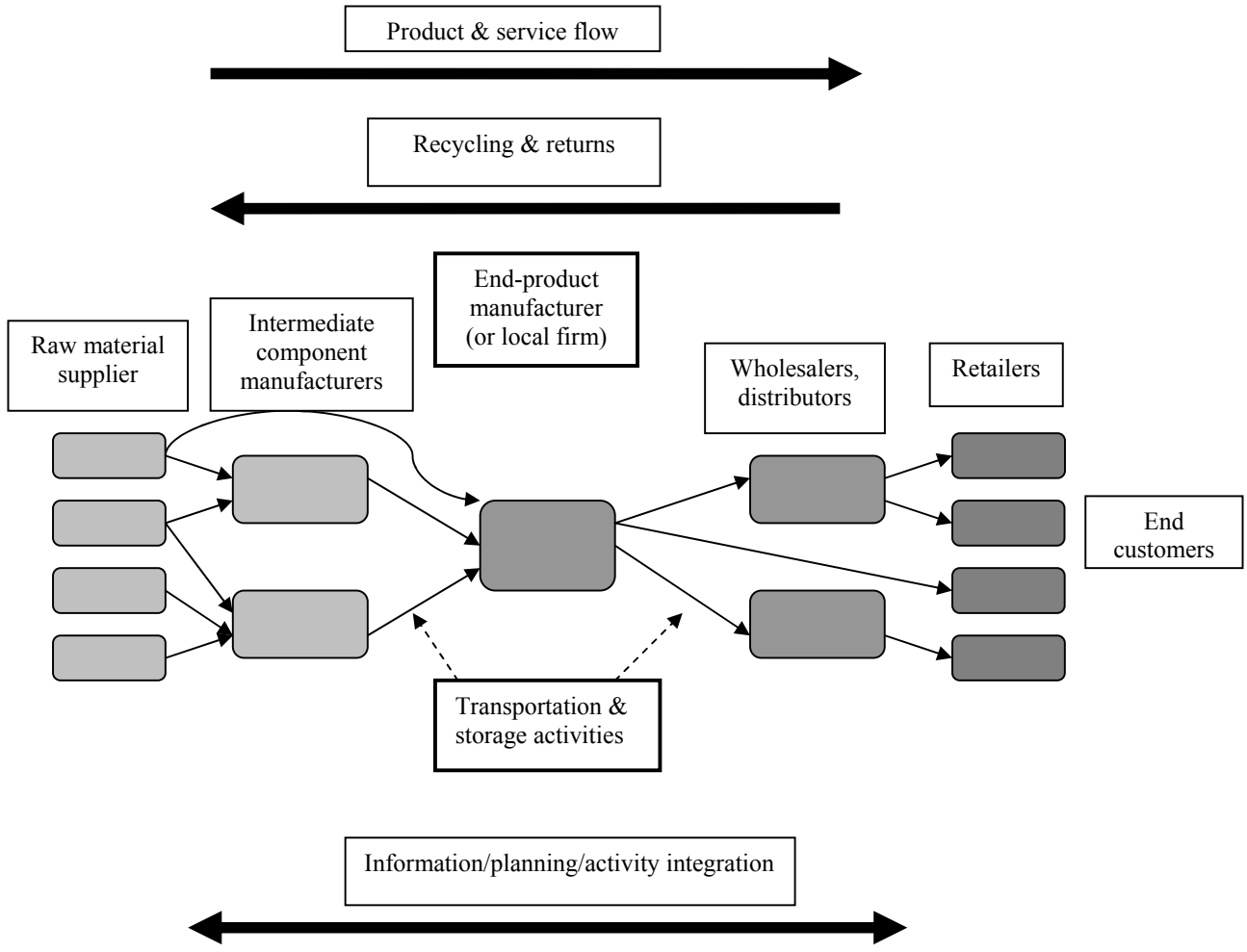


Figure 1.2.1: A generic supply chain
(Source: Wisher *et al.*, 2005, pg. 6)

Figure 1.2.1, above, shows this new trend with a supply chain including reverse flow in it.

The increasing importance of corporate social responsibility and its potential impact on customer loyalty encourage the organizations for relaxing returns policies[18] and because of the increasing importance of returns disposition, organizations are actively working to create and improve reverse logistics systems, to manage the reverse flow of products and services through the supply chain. Through closed-loop chains, organizations eventually transform used products into new products or materials that can be disposed of without harming the environment[19].

When a customer takes a product home and finds it to be defective, it is the starting point of the upstream flow of the defective product in the supply chain, the reverse logistics. Customer returns it to the retailer, retailer sends it to a central return center, and all along this process the product is defined by the information systems, and ultimately product is shipped back to the manufacturer. Product is scanned into the database and the manufacturer decides on how to dispose of it, whether to resale, refurbish, remanufacture or recycle. Depending on its choice, the manufacturer can retrieve some value from this defective asset[20]. On the other hand, too often reverse logistics is viewed as an expensive headache and the potential value of effective reverse logistics is overlooked. The reality is that a good reverse logistics system can be a differentiator and provide an opportunity to gain a competitive advantage[21].

The following section is aiming to provide a general presentation of the concept of reverse logistics, followed by a summary analysis of reverse logistics activities, and a step by step analysis of the main stages of a reverse logistics process.

---

[18] Monique L. French, Richard Discenza, "Returns in process industries: a managerial perspective", *Management Research News,* Vol 29, No.12, 2006, Emerald Library, pg. 769
[19] Handfield, Nichols,1999, pg. 4
[20] Ronald H. Ballou, **Business Logistics/Supply Chain Management, Planning, Organizing, and Controlling the Supply Chain**, Pearson Education, New Jersey, 2004, pg. 8
[21] Richey, Genchev, Daugherty, 2005, pg. 234

1. Reverse Logistics

Logistics is defined by Rogers and Tibben-Lembke (1999) as *"the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of origin to the point of consumption for the purpose of conforming to costumer requirements."* On the other hand, reverse logistics is *"the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal."*[22].

Based on the above definition, a great number of activities can be deemed to be covered by the term of reverse logistics but, as a general principle, if there are no goods or materials being sent backwards in the supply chain, the activity concerned would not be deemed as a reverse logistics activity.

Council of Logistics Management, opting for the term of reverse distribution, defines these activities as "*the process by which a company collects its used, damaged, or outdated products and/or packaging from end- users.*"

According to the Reverse Logistics Association[23]; reverse logistics is "*all activity associated with a product/service after the point of sale, the ultimate goal to optimize or make more efficient aftermarket activity, thus saving money and environmental resources.*"

An important point to note is that reverse logistics is not a symmetric picture of forward distribution. A closer examination of the main differences between the forward and reverse flow would, in our opinion, offer a more clear view on the specificities of

[22] Dale S. Rogers, Ronald S. Tibben-Lembke, **Going Backwards: Reverse Logistics Trends and Practices**, University of Nevada, Center for Logistics Management, 1999, pg. 2-3

[23] The Reverse Logistics Association, established in 2002, is a trade association focused on third party service providers to whom OEMs (Original Equipment Manufacturers), ODMs (Original Design Manufacturers), branded and retail companies outsource. www.reverselogisticsassociation.org (2009)

and on some of the main issues underlying the reverse logistics processes. Accordingly, main differences between reverse logistics and the forward flow can be summarized as follows:

Table 1.2.1: Differences between forward logistics and reverse logistics

Forward Logistics	Reverse Logistics
Forecasting relatively straightforward	Forecasting more difficult
Distribution is one to many	Distribution is many to one
Product quality uniform	Product quality not uniform
Destination/ routing clear	Destination/ routing not clear
Pricing relatively uniform	Pricing dependent on many factors
Disposition options clear	Disposition options not clear
Importance of speed recognized	Speed often not a priority
Forward distribution costs visible	Reverse costs less visible
Inventory management consistent	Inventory management not consistent
Product lifecycle manageable	Product lifecycle issues more complex
Straightforward negotiation between parties	Negotiations complicated by several factors
Marketing methods well known	Marketing complicated by several factors
Visibility of process more transparent	Visibility of process less transparent

(Source: Tibben-Lembke, Rogers, 2002, pg. 276)

First and foremost, planning for reverse logistics is more difficult than planning for forward distribution because of the greater uncertainty involved in reverse logistics. Especially in remanufacturing, forecasts are needed not only of customer demand, but also of the availability of product to be remanufactured.

Another important difference would be the number of origin and destination points. Whereas forward logistics is generally the movement of product from one origin to many destinations, in the reverse flow, product has many potential destinations,

depending on the condition of the item and its current location; the supplier is not necessarily the most immediate recipient. The flow in reverse may take place at time and locations difficult to synchronize into a steady flow coordinated by standardization[24].

Furthermore, in reverse logistics product flow lacks the orderly process characteristic of outbound movement. Aside from damage in transit, new or first-quality products delivered by the vendor comes in complete packaging which protects it during the transport; whereas most products in the reverse channel may not have complete packaging. Reverse movement typically consists of non-uniform individual packages and cartons as contrasted to outbound movement of cases and pallet loads. Packages are often broken, and product is not packaged correctly, the condition or quality of products is not the same. If the returns have been opened or the container is damaged, they could be contaminated, often the storage conditions or the conditions during shipment are unknown and the product could be damaged as a result. Return products typically require significant manual sorting and inspection to determine appropriate disposal[25, 26].

Based on the foregoing, an author argues that it can cost four times as much to take something back as to send it out. For retailers and manufacturers, poorly packed, broken and misshapen packages make up an increasingly large chunk of their reverse flowing shipments and consequently, those who can master the complex process of reverse logistics stand to make big savings in efficiency as well as keep their customers happy[27].

Routing of the products through the reverse logistics channels is another matter of divergence between the forward and reverse flow. Indeed, once a product reaches a centralized return centre from a store, its further destination is unclear and unlike a forward distribution centre, a reverse logistics facility may need to spend a significant amount of time determining where a particular item will be shipped. Similarly, disposition options are attached closely to destination, before a disposition decision can

---

[24] Arni Halldorsson, **Reverse Logistics,** *Supply Management,* Jan 31, 2008; Vol. 13, No. 3, ABI/INFORM Global, pg. 26
[25] Bowersox, Closs, Cooper, 2002, pg. 387
[26] French, Discenza, 2006, pg. 777
[27] Sarah Murray, **Hidden beauty of the 'uglies'**, *Financial Times,* London (UK), May 17, 2007, Business Source Complete, pg. 16

be adopted; the centralized return centres must first identify the possible destination for the product.

A new product of uniform quality would be sold at different prices for different customers. The range of price differences, however, would not be as broad as the price differences for an item sold in reverse flow. This is because; all products in the reverse flow would not be of prime and uniform quality.

In the forward channel, it is important to fulfil customer orders quickly, to keep customers satisfied. By contrast, in reverse logistics, if the returns processing were to be carried out slowly, the customers of the returned product would not complain. This however, does not mean that timing is not an important issue for reverse logistics activities; since, the longer a product waits for disposal at a centralized return centre, potential for damages and the likelihood of losses of value would increase. This latter point is especially important for technology products, because of the short lifecycle of which, reselling quickly is very important in recovering as much value as possible.

As to the nature and visibility of costs, there is an important difference between the forward flow, where standardized products are concerned, and the reverse logistics. Due to irregular and uneven quality of the products concerned, transportation costs, handling costs and inventory holding costs greatly depend on the condition of items.

Another difference is the inventory modelling. More concretely, the assumptions for traditional inventory models applicable in the case of a forward flow cannot be applied for the reverse situation. Unlike traditional assumptions, the arrival of product through the reverse channel tends to be random and simultaneous and the management of reverse logistics inventory tends to be more sensitive to seasonal accounting deadlines than new product shipments.

The product lifecycle plays a very different role in reverse logistics than forward logistics because the changing stages of the product lifecycle offer some particular challenges in the reverse logistics activities.

In reverse logistics, negotiation is often about the sale of a product, waiting for disposal at a centralized return centre, rather than the shipment of a product some time in the future, which is the standard case in forward logistics. Furthermore, negotiating is more complicated than bargaining for a new product because of the non-uniform quality of the products concerned.

Marketing of returned products can be much more complicated than marketing of new product. There are restrictions motivated by anxiety of vendors about market cannibalization as a result of which, identification and communication with customers interested in purchasing remanufactured products becomes much more difficult.

Finally, unlike forward logistics, reverse logistics has, in general, a lower priority degree for firms, because of which, the information resources needed to increase its efficiency are commonly not available[28].

Because of the aforementioned differences, reverse logistics operations require special handling and additional resource allocation when compared with standard, outbound operations.

Because of the potential pay-offs, a firm must deploy three types of resources to develop capabilities and increase the performance of their reverse logistics processes, and these are: financial resources, technological resources and managerial resources. Concretely, firms must allocate adequate resources to hire reverse logistics personnel and necessary managerial resources should be focused on developing innovative ways to handle returns[29].

A number of scholars propose a more restrictive definition of reverse logistics activities, limiting those to activities relating only to waste materials. One such definition argues that reverse logistics is a broad term referring to the logistics

[28] Ronald S. Tibben-Lembke, Dale S. Rogers, "Differences between forward and reverse logistics in a retail environment", *Supply Chain Management: An International Journal*, Vol. 7, No. 5, 2002, Emerald Library, pg. 276-280

[29] Richey, Genchev, Daugherty, 2005, pg. 234, 251

management skills and activities involved in reducing, managing, and disposing of hazardous or non-hazardous waste from packaging or products. It includes reverse distribution, which causes goods and information to flow in the opposite direction of normal logistics activities[30].

As was mentioned previously, reverse logistics deals with the handling, storage and movement of material that flows from the end costumer back to the seller or supplier, including returns, defectives, containers or boxes and packaging material. Reverse logistics is also known as "environmentally responsible logistics", since it helps to recycle unwanted material (boxes, bottles etc) and allows the recirculation of returns or defectives through alternative channels (thrift stores, flea markets etc)[31].

Environmental concerns are not a novelty in the domain of logistics. That said, it may be argued that the concerns to conduct business in an environmentally sensitive way is on the rise and logistics activities will further be affected by this developing trend. New forms of packaging will have to be developed that offer acceptable levels of protection while either being recyclable or biodegradable; transportation will have to be accomplished in ways that reduce energy consumption and minimize pollution; reverse logistics channels will have to be established to return greater numbers of defective and worn-out products to a designated point for recycling[32].

Companies producing durable products like computers, telephone equipment and copy machines, whose customers may return the products for trade-in, repairs, or salvage and disposal, and companies dealing in returnable containers, are affected by an ever increasing concern with regard to environmental issues. These companies must, therefore, develop reverse logistics systems to dispose of packaging materials or used products[33].

---

[30] James C. Johnson, Donald F. Wood, Daniel L. Wardlow, Paul R. Murphy, Jr., **Contemporary Logistics,** Prentice Hall, New Jersey, 1999, pg. 74
[31] Raja G. Kasilingam, **Logistics and Transportation Design and Planning**, Kluwer Academic Publishers, Netherlands, 1998, pg. 245
[32] Kent N. Gourdin, **Global Logistics Management A Competitive Advantage for the New Millenium,** Blackwell Business, USA, 2001, pg. 224
[33]John J. Coyle, Edward J. Bardi, C. John Langley Jr., **The Management of Business Logistics**

2. Evaluation of Reverse Logistics with Numbers

Reverse Logistics Executive Council[34], estimates that reverse logistics costs account nearly 1 % of the total gross domestic product of the United States of America. The impact of reverse logistics is most critical in industries with high return rates, warranty operations and short lifecycle products.

On the other hand, Forbes Magazines estimates that American firms spend 100 billion US Dollars annually on returns, which returns represent up to 7 % of company gross sales[35].

Table 1.2.2, below, shows the return percentages for a number of categories of products.

Especially for some industries, returns management is a serious and inevitable activity with the possibility of creating a value for the returns. For example in the apparel industry, product return rates as a percentage of catalogue sales are reported to range from 10 to 20 percent for casual apparel and as high as 35-40 percent for high fashion[36]. For the short lifecycle products like software, retail, computers, appliances, cell phones etc. return rates are also very high, as 300 million cell phones and Personal Digital Assistants (PDAs) go obsolete each year[37]. Accordingly, effective management is important because mishandled returns can erode profitability of a firm and can

---

West Publishing Company, USA, 1996, pg. 48

[34] The Reverse Logistics Executive Council is a not-for-profit professional organization whose purpose is to develop best practice industry standards that take costs out of the system for consumers, retailers and manufacturers, provide on-going benchmark studies, and return causal information in order to improve the entire reverse logistics process. www.rlec.org (2009)

[35] Ron Cain, **How to Turn Returns Into Revenue**, *Transport Topics,* Jan 21, 2008, 3776, ABI/INFORM Trade & Industry, pg. 9

[36] Julie Ann Stuart, Winston Bonawi-tan, Sarah Loehr, "reducing costs through improved returns processing", *International Journal of Physical Distribution & Logistics Management*, Vol. 35, No. 7, 2005, Emerald Library, pg. 469

[37] Rob Martinez, **Returns to Sender**, *Multichannel Merchant,* June 2008, ABI/INFORM Global, pg. 52-53

adversely affect relationships with customers and end-users, as well as have a negative impact on a firm's reputation with its' stakeholders[38].

Table 1.2.2: Return percentages

Industry	Percent
Magazine publishing	50%
Book publishers	20-30%
Book distributors	10-20%
Greeting cards	20-30%
Catalog retailers	18-35%
Electronic distributors	10-12%
Computer manufacturers	10-20%
CD-ROMs	18-25%
Printers	4-8%
Mail order computer manufacturers	2-5%
Mass merchandisers	4-15%
Auto industry (Parts)	4-6%
Consumer electronics	4-5%
Household chemicals	2-3%

(Source: Bayles, 2001, pg. 261)

Based on the above figures, one may argue that the management of the returns is a very important aspect for many firms' activities.

In the United States, retail customer returns for general merchandise are estimated to be approximately six percent of revenue[39]. At this rate, returns for the top 30

[38] Diane Mollenkopf, Ivan Russo, Robert Frankel, "The returns management process in supply chain strategy", *International Journal of Physical Distribution & Logistics Management,* Vol. 37, No. 7, 2007, Emerald Library, pg. 569

[39] Rogers, Tibben-Lembke, 1999, pg. 6

American non-grocery retailers for 2001 amounted approximately to 44 billion US Dollars. Return rates can be even higher for speciality retailers.

The average logistics costs associated with managing returns have been estimated at four percent of a firm's total logistics costs. In 2001, this would represent about 40 billion US Dollars for the American economy[40]. The magnitude and impact of reverse logistics varies by industry and channel position but it is clear that the amount of reverse logistics activities in the economy is large and still growing. The importance of these numbers indicates to a need for a closer examination of the reasons of product returns, which will be the subject matter of the following section.

3. Reasons For Returns

In the late 1980s, most retailers and manufacturers have liberalized their return policies for using returns as a competitive weapon in the battle to win market share. Customers began to use the liberalization of return policies for their benefits because of the firm's belief that the satisfaction of the customers is their most important asset. There is a fine line between a fraudulent return and the return of a defective product and customers, who believe that an item does not meet their needs, can return it easily, regardless of whether it functions properly or not.

At this point, a distinction can be made between internal and external returns. Obsolete products from inventory, rework from production, partial containers from batch shortages or overruns, or equipment cleaning water are the examples of internal returns. External returns can be from end consumers, distributors, or shipping companies and might be returned for a variety reasons including not meeting specifications, contamination, past shelf-life, or damage during shipment[41]. In the present thesis, emphasis will be made on external returns which will be examined in detail.

[40] Rogers, Lambert, Croxton, García-Dastugue, 2002, pg. 1
[41] French, Discenza, 2006, pg. 770

Bayles gives the following examples with an aim of explaining the amount of reverse flow: at the department store holding company Macy's (formerly, the Federated Departement Stores), 25 million units amounting to 820 million US Dollars in merchandise goes back to the vendors; at cosmetic products company Estée Lauder, which does 4 billion US Dollars in sales worldwide, returns, excess, obsolescence, and destruction amounts to 190 million US Dollars on annual basis and finally in the consumer electronics industry, product returns cost more than 15 billion US Dollars a year[42].

Returns are a fact of life, at rates commonly ranging from 5 % for hard goods and gifts to more than 25 % for shoes and apparel[43]; accordingly companies must become adept at reverse logistics to get and keep more customers, to maximize and extend the value of goods sold and to minimize the impacts of returns on profits.

A number of research results on consumers' preferences clearly indicate that keeping a customer satisfied is the most important strategy, for American firms, to maintain a competitive advantage.

More concretely, according to Harris Interactive's research, 95 % of customers say they are likely to shop with an online or catalogue company if the returns process is convenient, and 85 % say they will stop buying from a retailer if the returns process is a hassle. On another survey, 75 % of consumers questioned by KPMG say a simple return policy is a deciding factor in their shopping behaviour. 89 % of online buyers of BizRate.com say returns policies influence their decision to shop, and according to Jupiter Research 40 % of shoppers don't buy online due to returns difficulty. McKinsey's research says that customers who have their complaints resolved quickly have a repurchase intention rate of 82 %[44].

---

[42] Deborah L. Bayles, **E-Commerce Logistics and Fulfillment Delivering the Goods**, Prentice Hall, New Jersey, 2001, pg. 258-261
[43] Martinez, 2008, pg. 52
[44] **Ibid.**

Depending on the reason of product returns, companies use reverse logistics systems for a number of different purposes, as shown in below Table 1.2.3:

Table 1.2.3: The reasons of returns

Primary reason for installing a reverse logistics system	Common examples of when reverse logistics systems are used
Return of goods for credit or refund	VCR not meeting customer expectations is returned for a refund
Short-term rental returns or long-term lease returns	Return of yard equipment rented for the day
Returns sent to the manufacturer for repair, remanufacture, or return of core portion of product	Return of a used automobile alternator to the manufacturer to be remanufactured and resold
Warranty returns	TV is returned- malfunction while under warranty
Reusable containers	Return of soda bottle to be cleaned and reused
Consignment agreement returns	Stereo placed in a salesperson's care is not sold and later returned to the owner
Trade-ins when a new unit is sold to the customer	Dealership receives a used car when a new car is purchased. The used car is prepared for resale
Units sent to the organization for a product upgrade	Your old computer is sent to the manufacturer for installation of a CD-ROM drive
Take-backs	Unnecessary product packaging or pallets taken back when not needed
Universal product recalls	Return of an automobile to the dealership because of a faulty seatbelt
Units sent to the manufacturer for inspection or calibration	Medical or SCUBA equipment returned to have gauges inspected and recalibrated
Products not meeting the manufacturer's guarantee to the customer	Return of a TV when it does not perform as promised

(Source: Bloomberg *et al.*, 2002, pg. 200)

In very broad terms, the reasons of returns can be summarized as: the product recalls for quality or safety reasons, the return of unwanted goods by customers or distributors and the return of used packaging for recycling or disposal.

In addition to the above, there are businesses where reverse logistics is a part of the organizational structure. For example, the mail order/catalogue companies can experience return rates up to 50 %, especially where fashion items are concerned[45]. Return rates are high for catalogue shoppers since they cannot see, feel or try the products. Industry experts argue that the top reasons for apparel returns are size, colour and fabric. For an apparel company that uses catalogues or the internet for sales, a significant level of product returns is inherent to the business[46].

In the following sections, the reasons for returns will be examined in greater detail, under five headings: consumer returns, marketing returns, asset returns, product recalls and environmental returns[47].

a. Consumer Returns

Consumer returns resulting from to customers' remorse or product defects make up for the largest category of returns. Because of the prevailing managerial belief that revenues will increase by a more consumer-friendly approach, many companies have liberal return policies and allow an easy return of products by their customers.

The consumer returns can be categorized under one of the following six reasons: (i) product doesn't meet the costumer needs; (ii) costumer doesn't understand correctly how the product must be used (non-defective defectives); (iii) product doesn't work; (iv) product is returned to be manufactured or (v) for proper disposal and (vi) customers' misuse of liberal return policies[48, 49].

Skinner *et al.* underline that, with an increased access to product and retailer information, return opportunism is on the rise; customers tend to abuse return policies by

---

[45] Alan Rushton, John Oxley, Phil Croucher, **The Handbook of Logistics and Distribution Management**, Kagan Page, Glasgow, 2000, pg. 543
[46] Stuart, Bonawi-tan, Loehr, 2005, pg. 469
[47] Rogers, Lambert, Croxton, García-Dastugue, 2002, pg. 3
[48] Alexandre K. Samii, **Strategic Logistique Supply Chain Management**, DUNOD, Paris, 2004, pg. 365
[49] Ronald S. Tibben-Lembke, "Life after death: reverse logistics and the product life cycle", *International Journal of Physical Distribution & Logistics Management*, Vol. 32, No. 3, 2002, Emerald Library, pg. 225

new and creative ways to take advantage of retailers regarding returns, warranties, and service policies. Customers can return a big screen TV after a super bowl party or a prom dress after the prom[50].

Consumer returns may relate to new, used or reused products.

In the case of customer returns of new products, reverse logistics systems allow customers to return unwanted or defective products.

As to customer returns of used products, occasionally customers are encouraged to return used products to their retail outlet for a financial credit. By way of example, in the automotive industry customers are given a financial credit if they return the "core" of a used product. Automotive alternators, starters, and water pumps can all be remanufactured from used parts.

Finally, as to the case of customer returns of reused products, while many returned products must undergo some sort of remanufacturing or alteration process, some products can be reused with minimal effort. For instance, with sterilization and cleaning, some glass bottles can be reused several times[51].

PricewaterhouseCoopers made a research to explain the reasons of costumers for returns[52]:

[50] Lauren R. Skinner, Paul T. Bryant, R. Glenn Richey, "Examining the impact of reverse logistics disposition strategies", *International Journal of Physical Distribution & Logistics Management*, Vol. 38, No. 7, 2008, Emerald Library, pg. 522
[51] Bloomberg, Lemay, Hanna, 2002, pg. 203-204
[52] Martinez, 2008, pg. 53

Table 1.2.4: The reasons of customers for returns

Product was not what I expected	40%
Product was damaged	31%
Quality not as expected	31%
Right product wrong characteristics (color, size, etc.)	27%
Wrong product	26%
Decided I didn't want it	19%
Product delivery was too late	17%
Partial order received only	7%

(Source: Martinez, 2008, pg. 53)

O'Connell provides the example of Estée Lauder which could save millions of dollars after having modified its reverse logistics systems. In the first year after investing 1.3 million US Dollars to build a system of scanners and other technologies, Estée Lauder was able to sharply reduce the percentage of products that it dumped into landfills and also to save half a million dollars in labour costs. It has built 250 million US Dollars worth product line from returned cosmetics, selling them to second hand stores or to retailers in developing countries[53].

b. Marketing Returns

Marketing returns consist of products returned from a position forward in the supply chain, especially from retailers, often due to damage in transit, expired date code, product discontinued or replaced, product being seasonal, retailer inventories being too high, and retailer going out of business. Despite a product's positive sales performance in some markets, the same product may fail to achieve significant sales in others. As the result of an uneven sales performance the retailer may decide not to carry the product, and may send unsold product to their centralized return centers (CRCs). Manufacturer

[53] Andrew O'Connell, **Improve Your Return On Returns**, *Harward Business Review*, Nov 2007, ABI/INFORM Global, pg. 30

may, concurrently, accept the product back and send it to its distribution centers (DCs) or centralized return centers where the unsold product can often be resold to another retailer to sell as new, or it may be disposed of in some other way[54].

Under marketing returns distinction can be made between the close-out returns, which are first quality products that the retailer or distributor has decided to no longer carry; buy-outs, where one manufacturer purchases a retailer's supply of a competitor's product to get access to shelf space; job-outs, where seasonal merchandise is returned after the season's end; and, surplus and overruns. In many cases, marketing returns can represent a significant percentage of sales[55, 56].

In a number of trading operations, goods are sent to distributors with an understanding that unsold ones may be returned, subject to certain conditions set by the manufacturer or the distributor. In essence, this is an incentive for later members of the supply chain to hold more inventory because the risk of unsold inventory are born by their suppliers[57].

In addition to returns driven by market issues, some marketing returns are driven by management practices. For example, end-of-quarter loads to the channel in order to achieve positive short-term financial results are artificial loads that can produce high return rates.[58]

c. Asset Returns

Asset returns consist of recapturing and repositioning of an asset. Products subject to this kind of returns are typically characterized as items that management wants to see returned.

---

[54] Tibben-Lembke, 2002, pg. 225
[55] Rogers, Lambert, Croxton, García-Dastugue, 2002, pg. 3
[56] Samii, 2004, pg. 370
[57] Johnson, Wood, Wardlow, Murphy, 1999, pg. 75
[58] Rogers, Lambert, Croxton, García-Dastugue, 2002, pg. 3

The main purpose of asset returns is repositioning of an asset, such as oil drilling equipment, and reusable containers[59]. Reusable or returnable containers are a type of returnable packaging and they can be used more than once in the same form for packaging products during transport from a sender to a recipient, either in retail or in industry[60].

Reusable totes are stackable, protect the product better than corrugated cardboard and are less expensive on a per movement basis. The use of reusable pallets, racks or totes should be coordinated with customer relationship management and/or supplier relationship management teams[61].

In 1994, the European Union made a directive on Packaging and Packaging Waste, which was subsequently implemented in national law in EU countries. This directive forced many companies to consider their type of packaging and form of transport in order to minimize their packaging expenditures[62]. For example, in 1991 the Dutch government and industry signed the so-called "Packaging Covenant", forcing the industry to think new ways to deal with packaging material. Similarly, the German Packaging Order requires manufacturers to take responsibility for their packaging waste. In order to comply with this regulatory requirement, German manufacturers and retailers created a non-profit organization, Duales System Deutschland, to collect packaging material for recycling. Participating companies pay a per-item fee based on the amount of packaging used and receive in return a green dot symbol that appears on their one-way packaging material[63].

As an example for reusable items, Cain gives the example of Kodak. This well known camera company offers nine different models of disposable or single-use cameras, including special models for weddings and underwater use. When these cameras are used, they are taken to a photo finishing shop and are finally returned to

---

[59] **Ibid.**
[60] Leon Kroon, Gaby Vrijens, "Returnable containers: an exemple of reverse logistics", *International Journal of Physical Distribution & Logistics Management*, Vol. 25, No. 2, 1995, Emerald Library, pg. 57
[61] Rogers, Lambert, Croxton, García-Dastugue, 2002, pg. 4
[62] Skjoett-Larsen, 2000, pg. 385
[63] Kroon, Vrijens, 1995, pg. 57-58

Kodak by the photo processor. These represent a very important stream of returns to Kodak, of which 80 % of the weight will be used or recycled[64].

d. Product Recalls

Products may also be returned to the retailer or the manufacturer, because of a recall by the manufacturer.

Product recalls are a form of return usually initiated because of a safety or quality issue. Recalls can be voluntary or mandated by a government agency. They require more direct planning than most of other return types, and this planning is crucial for an effective management of a product recall. Information technologies and effective communications also play pivotal roles in product recall processes.

In some cases, the manufacturer may authorize the retailers to fix the product at the retail location or may send repair kits to consumers. If the product's defect cannot be remedied, the manufacturer may instruct the retailer to collect and destroy the product and provide a new product to the consumer. For industries that are susceptible to recalls, like the automotive or food industries, part of designing an effective returns management process requires developing procedures for informing customer of a recall and efficiently handling the return[65, 66].

It is possible to return many defective products to a supplier and forcing it to deal with disposal, but it would be unrealistic to expect that millions of defective items would simply be returned to China.

Reports of defective or potentially harmful products shipped from China affect many well-known brands and include a wide spectrum of goods, such as toothpaste tainted with antifreeze, imported seafood contaminated with undesirable chemicals, pet food containing melamine, children's toys recalled because of lead paint and choking

[64] Cain, 2008, pg. 9
[65] Tibben-Lembke, 2002, pg. 225.
[66] Rogers, Lambert, Croxton, García-Dastugue, 2002, pg. 4.

hazards, and assorted problems with automobile tires, cell phone batteries, pharmaceuticals, vitamins, food additives and a multitude of electronic items[67].

For example, Mattel, the toymaker, recalled 19 millions Chinese-made toys for safety reasons. Mattel recommended to consumers not to return products to retailers because the company is in better position to help them. Mattel provided pre-paid mailing labels that should help predict the timing and volume of toys receiving from consumers. After the return of the products, another problem had surfaced: what was to happen to the goods coming back, could they be refurbished? In the case of Mattel, this was impossible because of the lead paint used on toys. The company was compelled to prepare a program to handle toys returned under the recall in an environmentally appropriate way[68, 69].

When the computers company Dell recalled 4 millions defective computer batteries in 2006, thanks to company's business model, it could handle well the returns process.

After Dell learned that the batteries manufactured by the electronics company Sony, could overheat and leading to fires, it made the recall process visible to customers and cooperated with the U.S. Consumer Product Safety Commission, the governmental agency charged with protecting the public from risks of consumer products under its jurisdiction, to assure regulatory compliance and public awareness. The single-channel, online and build-to-order sales structure simplified identification and contacting affected customers. Dell established separate phone lines and a Web site for the recall and make it easy for the customer.

---

[67] Laurie Turnbull, **the real reason for reverse logistics**, *Canadian Transportation Logistics*, Oct 2007, Vol. 110, No. 10, ABI/INFORM Trade&Industry, pg. 38

[68] Bill Dibenedetto, **Reverse Logistics: Be prepared**, *The Journal of Commerce*; New York, Sep 3, 2007, Business Source Complete, pg. 16, 17

[69] Corinne Kator, **The logistics of a recall**, *Modern Materials Handling*, Sept 2007, Business Source Complete, pg. 10

Product recalls on a grand scale on the basis of safety or health issues like the ones experienced by Mattel or Dell, if not handled well, can quickly degenerate into an embarrassing and costly public relations and product-handling nightmare.

It can be argued that for a successful recall, a company must offer three things: customer contact, returns processing and outbound replacement shipping, as successfully demonstrated by Dell, with the achievements of its reverse logistics system[70].

e. Environmental Returns

Environmental returns either aim at the disposal of hazardous materials or at the compliance with environmental regulations. Environmental returns are different from other types of returns because they might include regulatory compliance that limits the available set of optional courses of action. Additionally, there are often stringent documentation and audit requirements[71]. Environmental regulations force the companies not only to collect hazardous materials but also to recycle their products with an aim of source reduction and protecting the environment.

In some cases where reuse of product is not possible, there may be a potential value, intrinsic to the valuable components and materials of a product. For example in the case of mobile phones, batteries or semiconductor boards contain reusable raw materials, including copper, nickel and titanium.

On the other hand, some of the components of a product may require a particular treatment, if the material concerned is construed to be hazardous in accordance with the European Directive on the Restriction of Hazardous Substances (RoHS), detailed information on this matter will be provided in the section I.D.3[72].

---

[70] William Hoffman, **Dell in reverse**, *Journal of Commerce*, New York, Sep 4, 2006, Business Source Complete, pg. 1
[71] Rogers, Lambert, Croxton, García-Dastugue, 2002, pg. 4
[72] Halldorsson, 2008, pg. 27

C. DISPOSITION AND REVERSE LOGISTICS ACTIVITIES

In their most common form, reverse logistics activities are processes by which a company collects used, damaged, unwanted, or outdated products, as well as packaging and shipping materials from the end-user. These processes generally include authorization of returns, transportation, auditing, product disposition, and generation of information about the product types being returned and their point of origin[73, 74]. Figure 1.3.1, below, demonstrates various options for product disposition, which will be touched upon within the present section.

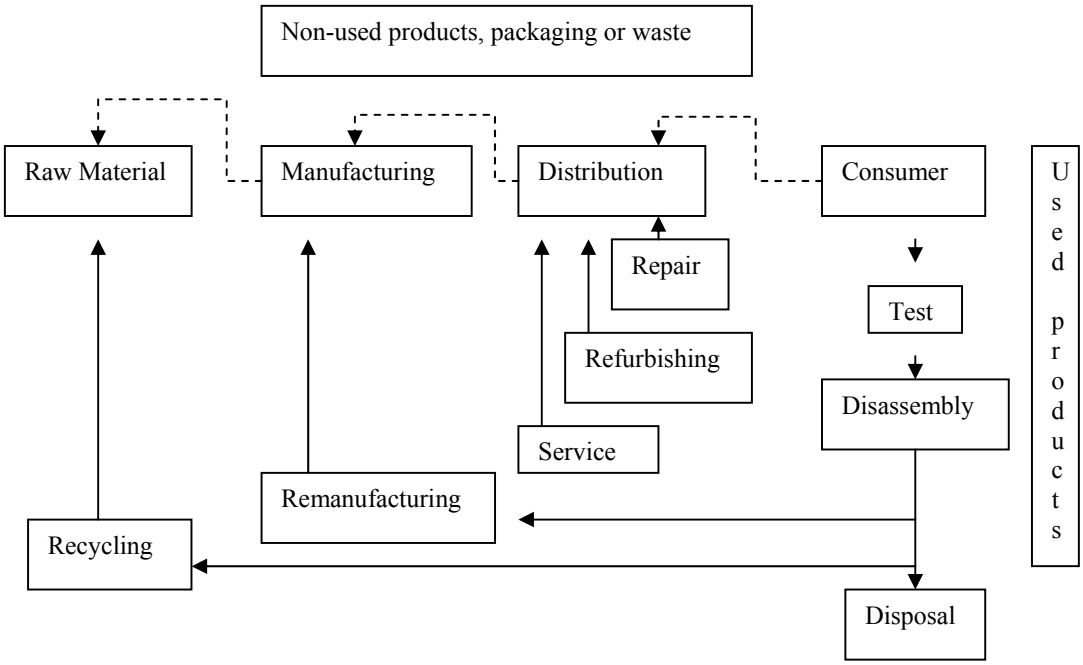


Figure 1.3.1: Flow diagram of reverse logistics activities
(Source: S. K. Srivastava, R. K. Srivastava, 2006, pg. 257)

[73] Skinner, Bryant, Richey, 2008, pg. 519
[74] Rogers, Tibben-Lembke, 1999, pg. 9

1. Type and Source of Returned Products

The reasons for returns have been discussed in detail in the previous section. A summary reminder, however, may be useful to recall the returned products[75].

1. Close-outs: These items are first-quality products that the retailer has decided to stop carrying.
2. Buy-outs: One manufacturer can buys out a retailer's entire supply of a competitor's product to gain space in the shelf to put its product.
3. Job-outs: They are first-quality seasonal products; the firms can sell them at a discount, or attempt to recover some of its value through its reverse logistics system.
4. Surplus: These are first-quality overstock, overrun, marketing returns, slow-moving merchandise, etc. by the reason of an overestimated demand or an inaccurate forecast.
5. Defectives: Defective items have been discovered by the retailer or by the customer to be truly defective.
6. Non-defective defectives: Sometimes customers don't understand correctly how the product must be used and claim that the product is defective.
7. Salvage: These items have been used or damaged, and cannot be sold as new.
8. Returns: Returns are products that have been opened and used by the customer.

Reverse logistics include a wide variety of disposal options which can differ in accordance with the type of returned products. Returned product may be a product coming from the end user or from another member of the distribution channel. These factors help to determine a basic framework for classifying reverse logistics activities.

The origin of the returned products also has an impact on the disposition decision. As noted above, products may come either from the end consumer or from a supply chain partner. If a product enters the reverse logistics flow by way of a customer return, it may be a defective product or a product that the customer believes to be defective,

[75] **Ibid.**, pg. 76-78

whereas the product is not defective (non-defective defectives). If the product has not yet reached the end of its useful life, it may be returned for service or because of a recall. If the product has reached the end of its useful life, the customer may return the product to its manufacturer for a proper disposal.

If a supply chain partner returns a product, this may be the result of a product surplus because of an incorrect forecast, or because the product failed to sell. Other reasons include the expiry of the useful life of a product; ending of a regular selling season (for seasonal products) or the product may have been damaged in transit[76].

Regardless of their source or final destination however, all products in the reverse flow must be collected and sorted before being sent on to their next destination and these stages of product disposal will be discussed in greater detail in the following sub-sections.

2. Collection and Auditing of Returned Products

Distinction can be made between various stages of collection and auditing activities, namely, collection, gatekeeping, inspection/sorting, pre-processing.

Collection is the first and foremost stage in the recovery process, where product types are selected and products are located, collected, and, if required, transported to facilities for rework and remanufacturing. Used products originate from multiple sources and are brought to a product recovery facility, mostly a centralized return centre, resulting in a converging process.

Gatekeeping is the processes of deciding which products will be allowed into the reverse logistics system. It consists of screening for defective and unwarranted returned merchandise at the entry point and critical in making the entire reverse flow manageable and profitable.

---

[76] **Ibid.**, pg. 12-13

Inspection/sorting is deciding what to do with each product and may be carried out either at the point and time of collection or afterwards. Collected items generally need sorting and this stage requires a skill in the sorting of used products[77]. Normally, the reverse flow has no sufficient quantity or regularity to justify unitized movement, so the only convenient method for inspection and sorting of reverse flows is manual handling. Materials handling design should consider the cost and service impact of reverse logistics, because reverse flows often involve pallets, cartons, and packaging materials in addition to damaged, dated, or excess merchandise. Nowadays, many firms are choosing to work with a third-party service provider to separate forward and reverse flows to reduce the risks for error or contamination and due to environmental concerns[78].

Logistics outsourcing, also known as the use of third-party service providers, consists of using independent third party organizations as a means for accomplishing some, or all, of the logistics related functions within the firm. A company can retain the reverse logistics responsibility within its organizational structure or assign the same to it's third-party trading partners but in today's business practice, reverse logistics is frequently considered a prime candidate for outsourcing.

Handling reverse logistics internally allows the firm to keep control over the process, but this approach requires commitment of considerable resources and assumption of internal capabilities and expertise which may or may not be present. Alternatively, trading partner may be better suited to handling returns, as nowadays, third-party service providers customize their offers to fit the individual needs of their corporate clients. They have started building relationships or strategic alliances with other logistics providers to offer more attractive and all-inclusive packages to their potential customers[79, 80].

---

[77] **Ibid.**, pg. 38, 87
[78] Bowersox, Closs, Cooper, 2002, pg. 435-436
[79] Bloomberg, Lemay, Hanna, 2002, pg. 204-205
[80] Chad W. Autry, Patricia J. Daugherty, R. Glenn Richey, "The challenge of reverse logistics in catalog retailing", *International Journal of Physical Distribution & Logistics Management*, Vol.31, No.1, 2001, Emerald Library, pg. 28-29

Pre-processing may be in the form of sorting, segregation, partial or complete disassembly or minor repair and refurbishing activities. It may be carried out either at collection centres or at rework facilities depending on technological and economical factors[81]. For example, for the waste electrical and electronic equipment, because of the advanced age and low value, reuse of products or parts collected from private household can be inapplicable, therefore disassembly activities would focus on removing harmful substances and extracting valuable materials[82].

Disposition is simply sending the products to their desired destination and it will be described in greater detail in the following sub-section.

An important point to note is that in many industries, such as computers and peripherals, short product life cycles mean that returned items must be treated as perishable. Every delay in transporting, sorting, grading etc. reduces the value remaining in the product and accordingly, all of the stages preceding the disposition phase must be operated effectively and without any undue delays[83].

3. Product Disposition

Once a product has been returned to a company, and arrives at the centralized return centre, a decision must be made about where the product would be sent. At the centralized return centre, employees consider the condition of each incoming item, and determine the best place for, and modality of, disposal.

Depending on the specificities of the returned product, companies have several disposal options[84].

---

[81] Samir K. Srivastava, Rajiv K. Srivastava, "Managing product returns for reverse logistics", *International Journal of Physical Distribution & Logistics Management*, Vol. 36, No. 7, 2006, Emerald Library, pg. 527-528

[82] Grit Walther, Thomas Spengler, "Impact of WEEE-directive on reverse logistics in Germany", *International Journal of Physical Distribution & Logistics Management*, Vol. 35, No. 5, 2005, Emerald Library, pg. 339

[83] O'Connell, 2007, pg. 30

[84] Tibben-Lembke, Rogers, 2002, pg. 273

Table 1.3.1, below, summarizes common reverse logistics activities, which we will discuss shortly, in the light of the explanations of Rogers and Tibben-Lembke.

Table 1.3.1: Common reverse logistics activities

Product	Packaging
Return to vendor	Reuse
Sell as new	Refurbish
Sell via outlet or discount	Reclaim materials
Sell to secondary market	Recycle
Donate to charity	Salvage
Remanufacture	
Refurbish	
Materials Reclamation	
Recycle	
Landfill	

(Source: Rogers, Tibben-Lembke, 1999, pg. 10)

a. Return to vendor

Retailers return products to the vendor because of defects, marketing returns, obsolescence or overstocks. Marketing returns occur when the vendor has created an encouragement for the retailer to order a larger quantity than usual with the promise to accept the returns of additional units. Vendors also allow returns when they have a motivation to help the retailer avoid inventory obsolescence. Returns to vendors can also result from selling product on consignment or through a similar arrangement.

If a customer returns a product as defective, the manufacturer may ask to retailer to return the product by providing some reasoning or rationalization. This is because the manufacturers often want to identify the exact nature of the defect to determine the cause of returns so to eliminate the alleged defects in the future. The manufacturers may

also wish to evaluate the number of non-defective defectives; depending on the product, the vendor may be able to re-shelf and resell these products as new. Another reason would be to prevent the item from entering the market through another disposition channel and cannibalize the demand. Further, to protect the brand's image, the manufacturer may want the product not to be seen in certain retail outlets. The vendor may also want to prevent re-returns. Re-returns are products sold at a discounted price at an outlet store and then returned for full price through the regular returns channel.

b. Sell as new

If the returned product is unused and unopened, the retailer may resell it as new. The product may need to be repackaged before the sale, but in some industries, there are legal restrictions due to which products cannot be resold as new once a customer has returned them.

c. Sell via outlet or discount

If the product has been returned, or if the retailer has too many stocks, returned product can be sold via an outlet or discount store. This option offers a number of advantages over other disposition options. Using their own outlet store system, firms can maintain some form of control over their products and for many firms, if not all, protecting their reputation and market positioning is an important issue.

d. Sell to secondary market

When a firm is unable to sell a product and returning to vendors or selling via outlet stores are not viable options, products may be sold via the secondary market; which market consists of firms that specialize in buying close-outs, surplus and salvage items.

A company's last option is to sell the returned product to a broker. Brokers operate in the secondary market, buying and selling products that, for one reason or another,

cannot be sold in the primary retail channel. Brokers can buy almost any product in any condition and will pay typically very low prices[85].

However, more and more companies have to deal with reverse logistics. For example, in the early to mid-1990s, the representatives of Hallmark Cards, an American company manufacturing greeting cards, would collect and destroy out-of-season merchandise and no value was reclaimed. Today, Hallmark uses a third-party firm to collect excess seasonal inventory and repackage it for sale in secondary markets. Firms are finding it useful or even necessary to deal with returns in a more effective and efficient manner[86].

e. Donate to charity

If the product is still serviceable, but perhaps with some slight cosmetic damage, retailers or vendors may decide to donate the product to charitable organizations. In this case, the retailer usually does not receive any money for the product. It may, however, be able to gain a tax advantage for the donation, and thus receive some value, while being a good corporate citizen.

f. Remanufacture/ Refurbish

Before deciding that the product is a complete loss and sending it to recycle, many firms try to repair, refurbish or remanufacture, which activities involve product recondition and upgrade.

Disposition options are often industry or product-specific and depend upon characteristics of the product such as price/value, cost to transport, shelf life of the product, and market demand patterns and they are differ with the respect to the degree of improvement.

---

[85] **Ibid.**, pg. 273
[86] Autry, Daugherty, Richey, 2001, pg. 35

Many consumer products cannot be remanufactured but when products have a sufficiently high value and can be remanufactured for re-sale, efficient reverse logistics can be profitable.

Companies such as Canon, the renowned Japanese multi national corporation specializing in the manufacture of imaging and optical products, and Xerox, the global document management company, manufacturer of printers and copiers, routinely remanufacture their products.

The automobile parts market provides another example of an industry that recovers product for remanufacture[87, 88].

Some items, such as electronics products, can also be refurbished. For example, if a customer returns a fax machine to the retailer because it does not work, the retailer can send the machine back to the manufacturer or a third party that specializes in refurbishing. Refurbishing and remanufacturing differ with respect to the degree of improvement and the amount of effort needed to upgrade the product; remanufacturing involves the greater effort of the two.

In case the resale value of a returned asset would be very low, rather than to sell the product in its current condition, the manufacturer would diagnose the problem and repair the product. At this point, the manufacturer may send the product to a secondary market firm and sell the product as “reconditioned” or “remanufactured”; or the machine may be sold via an outlet store[89, 90].

Furthermore, for some consumers, remanufactured or refurbished product may have an additional appeal due to environmental concerns. Remanufacturing may be the accepted industry or trading norm for some products, such as the automobile parts

[87] Rogers, Tibben-Lembke, 1999, pg. 84-85
[88] Skinner, Bryant, Richey, 2008, pg. 523-524
[89] Rogers, Tibben-Lembke, 1999, pg. 84-85
[90] Skinner, Bryant, Richey, 2008, pg. 523-524

market. For items like starters and alternators, a very high percentage of aftermarket sales consist of remanufactured items[91].

The essential difficulty in this option is sorting the goods, deciding which to refurbish, remanufacture and reuse and which to dismantle and recycle. By way of example, companies such as Cisco (trading in networking and communication services and products), Hewlett-Packard and IBM (both of whom are active in computer technologies market) have regional processing centres, to which products can be sent for evaluation[92].

A distinction can be made between two types of rework sites, namely, repair and refurbishing centers and remanufacturing centers. Repair and refurbishing centers require lower capital investment, are more skill-based and generally repair/refurbish goods in order to make them almost as good as new. Remanufacturing centers require very high capital investment, are more technology-based and produce upgraded remanufactured goods[93].

g. Materials Reclamation/ Recycling/ Landfill

When the firm is not able to sell the product to the secondary market, and the other options are not feasible, the final option is disposal. Normally, the firm's objective is to receive the highest value for the item, or dispose of the item at the lowest cost[94]. If managers do not have adequate resource support for reverse logistics, and if the primary motivation is the profit augmentation, they should choose to destroy the product, since in these conditions destroying or recycling represent potentially viable disposition strategies. Products should be destroyed when it's too costly to return the product, when the product value is very low, when the product is perishable, or when there is no alternative market/buyer available. On the other hand, whether or not to recycle involves

[91] Tibben-Lembke, Rogers, 2002, pg. 281
[92] Murray, 2007, pg. 16
[93] S. K. Srivastava, R. K. Srivastava, 2006, pg. 529, 530
[94] Rogers, Tibben-Lembke, 1999, pg. 85

an easier decision making procedure because the products are either appropriate for recycling or not[95].

It is important to note that reverse logistics emphasizes source reduction and substitution over reuse and recycling. Source reduction refers to doing the same things with less resources and the practice reduces total waste released in the environmental system. Substitution means using more environmentally friendly materials instead of regular ones such as pollutants. Reuse is employing the same item multiple times in its original form and recycling gives discarded materials a new life after some chemical or physical processes[96].

There are opportunities to reuse products or to recover their reusable materials. By way of example, in the electronics sector, copper, tin and gold extracted from computers and other high-tech devices can be sold or used in new machines. Moreover, working equipment that has been replaced by newer models can be refurbished and resold. This can be a profitable course of action, since a four-year-old laptop has a relatively good market value. However, the real value of the returns lies in its influence on the design of new products; a product can be re-designed and improved in the light of information gained from previous returns[97].

Recycling of a product or a material commences once a product is finally used for its primary purposes, at its end-of-life. The product is transferred to an intermediary as a first step of separation of products and materials. During the course of subsequent transfers the part-products or materials are separated for further reuse or recovery in different stages[98]. The major cost in this process is the collection, sorting and transportation of returned products.

---

[95] Kasilingam, 1998, pg. 246
[96] Haw-Jan Wu, Steven C. Dunn, "Environmentally responsible logistics systems", *International Journal of Physical Distribution & Logistics Management*, Vol.25, No.2, 1995, Emerald Library, pg. 38
[97] Murray, 2007, pg.16
[98] Hélen Anderson, Maria Huge Brodin, "The consumer's changing role: the case of recycling", *Management of Environmental Quality: An International Journal*, Vol. 16, No. 1, 2005, pg. 77

Reverse flow for recycling involves two main activities, namely, collection and reprocessing. Collection is the process of making returned products available for reprocessing, and reprocessing is the process by which materials are made into substitutes for primary materials[99].

Products are destroyed and sent to landfill when they cannot be sold or used at the current location but the rising prices of recycled materials make it increasingly desirable for a firm to manage its flow of recyclables rather than destroy its' returned products. To this end, companies often have to redesign their systems to pay more attention to recycling and utilize more reusable parts in the production. Recycling or taking back the product for re-work or disposal is also often mandated by regulation [100, 101].

Without sacrificing quality and performance, recycled, refurbished and remanufactured parts and supplies should be selected by the logistics managers because their environmental impact is usually less than that of new items. However, a balance must be found between the performance of used parts and the cost of handling them, particularly if it affects customer perception. For example, as the luxury and performance cars manufacturer BMW has tried to move to using more recycled parts in its automobiles, buyers have become concerned that they are not getting the best buy for the money. Further, the company has discovered that some of the recycled plastic parts do not look as good as brand-new plastic parts[102].

Many manufacturers are designing their products with recycling in mind. Scania AB, Swedish manufacturer of heavy trucks, buses and diesel engines, produces heavy trucks that are completely constructed of materials that may be recycled. Carpet makers Interface and Shaw Industries collect used-up materials to feed back into production. Patagonia uses in production the fibers recaptured from old fleeces and T-shirts, even

[99] Bente M. Flygansvaer, Lars-Erik Gadde, Sven A. Haugland, "Coordinated action in reverse distribution systems", *International Journal of Physical Distribution & Logistics Management*, Vol. 38, No. 1, 2008, Emerald Library, pg. 6, 9
[100] Johnson, Wood, Wardlow, Murphy, 1999, pg. 76
[101] Skinner, Bryant, Richey, 2008, pg. 523-524
[102] Wu, Dunn, 1995, pg. 35

those sold by its commercial rivals. This process costs more than virgin polyester but more protective for the environment.

In light of the foregoing it may be argued that the future challenge for all manufacturers will be to retrieve and recycle their own products[103, 104].

h. Packaging

The European Community regulations defines packaging as *"…all products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer. Disposables used for the same purpose are to be considered as packaging, too"*[105]. Packaging is essential in outbound logistics activity, it can be trolleys, pallets, roll cages, tote boxes etc. for business to business trading and wheeled bins, shopping, and baggage trolleys in business to customer environments[106].

Currently, most products in the market come in a form of packaging protecting the product from damage, making the product easy to handle as noted in the definition of the European Community Directive. The use of packaging, whether it is made of glass, metal, paper or plastic, contributes heavily to the solid waste stream. In order to address these environmental impacts of packaging, many countries now have programs and legislation that aims to minimize the amount of packaging that enters the waste stream, such as the Packaging Directive in the European Union. Recycling and re-use are key strategies in packaging waste reduction programs. For example, the home care, cosmetics, health and beauty products company Amway delivers its detergent and other house cleaning products to customers in plastic containers. After their use, these plastic containers are collected by the Amway sales force, brought back to the company and are

---

[103] Rushton, Oxley, Croucher, 2000, pg. 537

[104] Brian Hindo, **Cleaning Up With Reverse Logistics**, *Business Week*, April 8, 2008, Issue 4094, Business Source Complete, pg. 46

[105] Gerard P. Prendergast, "The EC directive on packaging and packaging waste: current status and logistical implications", *Logistics Information Management*, Vol. 8, No. 3, 1995, Emerald Library, pg. 12

[106] Liz Breen, "Give me back my empties or else! A preliminary analysis of customer compliance in reverse logistics practices (UK)", *Management Research News*, Vol. 29, No. 9, 2006, Emerald Library, pg. 533

recycled. The empty paper cartons in which the suppliers deliver the raw materials to the company are given back to the suppliers for re-use[107].

Similarly to the case of returned products which was examined in previous sections, there exist several options in the reverse flow of the packaging.

One option is to avoid individual packing products and to transport products in bulk. Another possibility is to use returnable containers. Other options to process packaging material are: returns to the vendor; sending to refurbishing centers for reuse; recycling or destruction. The companies may use a combination of the above[108]. For example, the automobile industry uses packaging materials designed specifically for their parts. This material may be very expensive, thus needs to be reused. In fact, there are prices in the tariff books of carriers just for these packaging materials[109].

European countries have specific regulations for the packaging and packaging waste. For example, Germany passed the Packing Ordinance in 1991, which mandates that companies have the legal duty to take back used packaging from customers and arrange for recycling or reuse. In theory, the law refers only to products produced in Germany. However, there have been reports of packaging not being accepted at German ports and borders because of failure to adhere to German packaging standards[110].

Furthermore, in many European countries, vendors are required by law to take back transport packaging such as corrugated paper boxes, pallets and shrink-wrap. In the United States, however, this is not the case and, instead of sending such materials back to the vendor, most companies dispose of excess materials by using them to send product to their own customers, or by selling them to third party vendors or recyclers. In many European countries, vendors are also responsible for ensuring that the primary

---

[107] Purba Rao, Diane Holt, "Do green supply chains lead to competitiveness and economic performance?", *International Journal of Operations & Production Management*, Vol. 25, No. 9, 2005, Emerald Library, pg. 904
[108] Kasilingam, 1998, pg. 246
[109] Long, 2003, pg. 90
[110] Binshan Lin, Charlotte A. Jones, Chang-tseh Hsieh, "Environmental practices and assesment: a process perspective", *Industrial Management & Data Systems*, Vol. 101, No. 2, 2001, pg. 77

product packaging is recycled, as in the case of Germany, deposits paid on purchased packages are used to fund a national collection and recycling program. In the United States, most of the consumers' packaging is handled by residential recycling organizations; therefore, most packaging materials flows to a recycling company, and does not move backwards from one stage of the supply chain to the previous stage[111].

[111] Tibben-Lembke, 2002, pg. 224

D. IMPACT OF REVERSE LOGISTIC ON ENVIRONMENT AND REGULATIONS

Environmental concerns became major issues for the business world with the increasing importance of the impact of consumer behavior on the environment. Firms are creating "green alliances" to improve their environmental performance and public reputation. In green alliances, businesses and environmental groups work jointly to integrate corporate environmental responsibilities with market goals. Some firms elected to enter into alliances to improve their environmental practices, while others focused on implementing internal environmental programs[112].

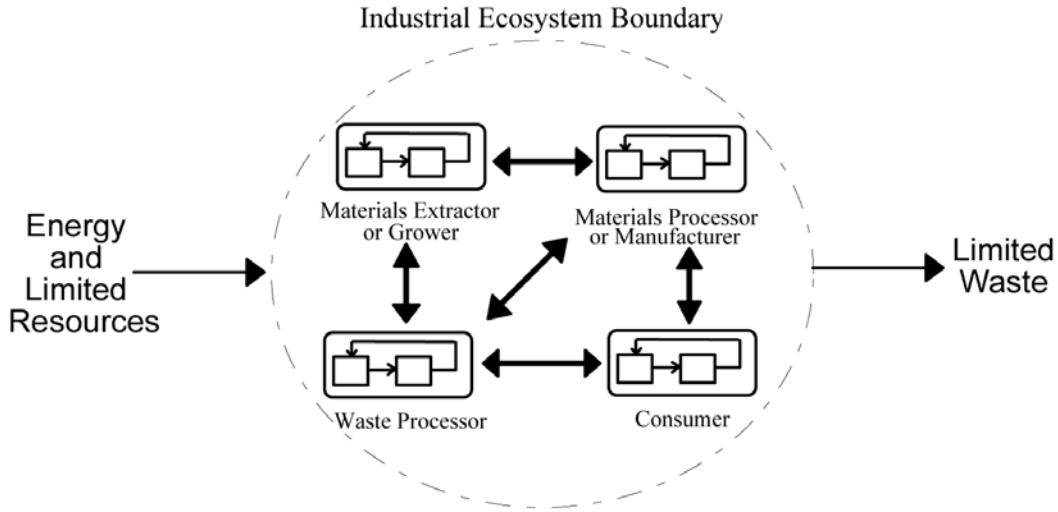


Figure 1.4.1: A generic industrial ecosystem framework
(Source: Sarkis, 2001, pg. 670)

Environmental excellence starts during the initial product and process design. Design for the environment component can be incorporated into new products and in the modification of existing products, where products are redesigned to eliminate waste, remove hazardous content, increase product durability and life span, minimize pollution during use, and incorporate recycled materials.

[112] Bloomberg, Lemay, Hanna, 2002, pg. 205-207

Design for the environment has a number of functional elements that should be included in a successful environmental strategy. The functional elements include design for recyclability, remanufacturability, reuse, disassembly, and disposal.

Design for remanufacturing refers to the design of a product with respect to repair, rework, or refurbishment of components and equipment.

Design for reusability and recyclability focuses on the overall product design. Reusability involves the use, with or without treatment, of a waste product. If design for recyclability is a goal, the organization must consider the capabilities of the materials that can be recycled, or at least capabilities of the materials and sub-components of the product.

Design for disassembly focuses on designing a product that may be dismantled for recycling, remanufacturing or reuse.

Design for disposal includes consideration of materials and transportation requirements of materials that will be used in a product. The issue of a product's biodegradability and toxicity will play a large role in this design process[113].

Design for the environment and functional elements are a part of environmentally conscious manufacturing that involves developing and implementing manufacturing processes that minimize or eliminate waste, reduce energy consumption, improve materials utilization efficiency, and improve operational safety.

Nowadays, many companies are realizing that a reverse logistics system combined with environmentally conscious manufacturing processes can not only achieve cost savings and regulatory compliance, also they can enable the companies to be perceived as good corporate citizens, committed to protect the environment[114, 115].

---

[113] Lin, Jones, Hsieh, 2001, pg. 73
[114] **Ibid.**, pg. 71
[115] Bayles, 2001, pg. 267

Due to severe environmental (e.g. landfill zones rapidly filling up) and financial costs and because of efficiency concerns, waste products and packaging should be minimized and firms can expect increased pressure from consumers, consumer groups, and socially responsible investors to increase their recycling efforts.

Many companies have discovered that good recycling practices lead to improved profitability. Product and packaging design activities can help by enabling the usage of less new materials or of more recycled or recyclable material. An integrated reverse logistics system is, therefore, indispensable to comply with the design for the environment philosophy.

Firms and consumers can also assist the recycling effort by opting for buying either recycled products or products that contain a certain amount of recycled materials[116, 117].

On the other hand, environmental regulations are becoming globally prevalent, even to the extent that these can lead to modification of certain industrial structures and systems.

These new regulations create several new roles for customers, as recipients of goods, processors of waste material, and suppliers to the recycling chain: consumers will have to actively participate in effective implementation of reverse logistics, by returning the waste as well as by reusing refurbished products.

Concurrently with the above, these new prevalent environmental regulations underline the importance of reverse logistics. Producers are required to seek to have the cooperation of other producers to deal with the economic and transportation complexities associated with reverse logistics. These will require new structures and rules of competition because of the need for collaboration between competitors[118, 119].

---

[116] Johnson, Wood, Wardlow, Murphy, 1999, pg. 77
[117] Long, 2003, pg. 90
[118] Anjula Gurtoo, S.J. Antony, "Environmental regulations", *Management of Environmental Quality: An International Journal*, Vol. 18, No. 6, 2007, Emerald Library, pg. 637

European Union regulations about recycling, reusing, using landfill sites, use of hazardous substances –hazardous substances can be classified as explosives, radioactive materials, gases, liquid and solid flammables, oxidizing materials, organic peroxides, corrosive materials, poisons and other products under the miscellaneous category- and responsibility for disposal are very good examples[120, 121].

1. Waste Electrical and Electronic Equipment (WEEE)

European Union legislation of restricting the use of hazardous substances in electrical and electric equipment and promoting the collection and recycling of the same has been in force since February 2003. The legislation provides for the creation of collection schemes where consumers return their used e-waste free of charge. The objective of these schemes is to increase the recycling or re-use of such products. The Regulation further requires heavy metals such as lead, mercury, cadmium, and chromium and flame retardants such as polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE) to be substituted by safer alternatives[122].

2. End of Life Vehicles (ELV)

Every year, end of life vehicles generate between 8 and 9 million tonnes of waste in the European Union which calls for further measures so as to be managed correctly. In 1997, the European Commission adopted a Proposal for a Directive which aims at making vehicle dismantling and recycling more environmentally friendly, setting clear quantified targets for reuse, recycling and recovery of vehicles and their components and pushing producers to manufacture new vehicles also with a view to their recyclability. This legislation was officially adopted in September 2000[123].

---

[119] **Ibid.**, pg. 635
[120] Halldorsson, 2008, pg. 26
[121] Bloomberg, Lemay, Hanna, 2002, pg. 214
[122] http://ec.europa.eu/environment/waste/weee/index_en.htm (2009)
[123] http://ec.europa.eu/environment/waste/elv_index.htm (2009)

3. Restriction of Hazardous Substances (RoHS)

The Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment, commonly referred to as the RoHS Directive was adopted in February 2003 by the European Union. The RoHS Directive took effect on 1 July 2006, and is required to be enforced and become law in each member state. This directive restricts the use of six hazardous materials (lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyl (PBB) and polybrominated diphenyl ether (PBDE) flame retardants) in the manufacture of various types of electronic and electrical equipment. It is closely linked with the Waste Electrical and Electronic Equipment Directive[124], mentioned in (1) above.

4. Waste Legislation on Batteries and Accumulators

The European Directive on Batteries and Accumulators and Waste Batteries and Accumulators aims at minimising the negative impacts of batteries and accumulators on the environment and also harmonising requirements for the smooth functioning of the internal market. To achieve these objectives, this directive introduces measures to prohibit the marketing of some batteries containing hazardous substances. It contains measures for establishing schemes aiming at high level of collection and recycling of batteries with quantified collection and recycling targets. The Directive sets out minimum rules for producer responsibility and provisions with regard to labelling of batteries and their removability from equipment[125].

5. Packaging and Packaging Waste

The Community first introduced measures on the management of packaging waste in the early 1980's and this initial directive covered the packaging of liquid beverage containers intended for human consumption only, but it was too vague to bring about an

[124] www.en.wikipedia.org/wiki/Restriction_of_Hazardous_Substances_Directive (2009)
[125] http://ec.europa.eu/environment/waste/batteries/index.htm (2009)

effective harmonisation of national policies. As a consequence, diverging national legislation appeared in several member states.

For this reason, economic operators and member states approached the European Commission to introduce comprehensive legislation on packaging. In 1992, Directive on Packaging and Packaging Waste was adopted.

This second directive –still in effect as of today- aimed to harmonise national measures in order to prevent or reduce the impact of packaging and packaging waste on the environment and to ensure the functioning of the Internal Market. It contains provisions on the prevention of packaging waste, on the re-use of packaging and on the recovery and recycling of packaging waste[126].

As an example of the recycling efforts in member states of the European Union, Sweden, where recycling rates of many materials and products are high, only 10 per cent of what is collected for recycling is transferred to deposit stations or to energy recovery; with the rest being recovered through different stages of industrial processes. The recycling rates depend on the material concerned; however, for products like paper and scrap metal, recycling has been going on for decades[127].

[126] http://ec.europa.eu/environment/waste/packaging_index.htm (2009)
[127] Anderson, Brodin, 2005, pg. 78

II. SPECIAL FOCUS ON REMANUFATURING AND ITS INDUSTRIAL APPLICATIONS

A. FUNDAMENTALS OF REMANUFACTURING

In its simplest terms, remanufacturing is the process of returning a used, worn out product to as close to new as possible; it is a process of recapturing the value added to the material when a product was first manufactured.

Remanufacture results in reduced energy and material use, and production cost reductions. At the same time, remanufacturing is a key enabler of industrial sustainability, it is a sophisticated process where component parts are reengineered to equal or exceed their original quality and functionality. Often, remanufactured parts are combined with new technology to perform beyond their original specifications. Moreover, remanufacturing provides meaningful environmental benefits. It eliminates the need to mine raw materials a second time and saves the energy required to manufacture a new part from scratch[128].

Since remanufacturing is a concept of strategic importance, it is no longer acceptable to continually dispose of strategically important materials in landfill sites or waste the energy associated with their processing. The process has already expanded so much in volume that global turnover of remanufacturing has crossed USD 100 billions and production facilities are established in Europe, Latin America, Asia and Africa, in addition to the biggest market, namely, the United States[129, 130].

---

[128] Practising Law Institute, www.pli.edu
[129] Anil Kumar Kanungo, **Remanufacturing: India needs to be alert**, 2008, www.rediff.com
[130] Integrated Products Manufacturing Knowledge Transfer Network, www.integratedproductsktn.org.uk

1. What Is and Is Not Remanufacturing

Remanufacturing has many industry specific synonyms, such as, rebuilding, recharging, overhauling etc. which are also frequently used. However, remanufacturing is becoming the standard term for the process of restoring used durable products to a like new condition.

Rebuilding is a term that is sometimes used in lieu of remanufacturing; it is a process that is generally thought of as being not as thorough as remanufacturing. Rebuilding is synonymous with remanufacturing when used in connection with motor vehicle parts and systems but not the entire vehicle.

Recharged is used in connection with the remanufacture of imaging products, for example laser toner cartridges.

Overhaul is synonymous with remanufacturing, particularly in the aerospace industry[131, 132, 133].

Also there are many terms which may be confused with remanufacturing, some of which are as follows:

Reconditioning is restoration of a product functionally to as-new or almost as-new condition but may be without the warranty that matches a new product. Reconditioning may aim at returning a product to like-new quality but in the course of the process, not all of the product's components may be disassembled or cleaned; which means that reconditioning is not remanufacturing.

Restored is a generic term generally applied to antique or classic goods.

---

[131] Casper Gray, Martin Charter, "Remanufacturing and Product Design", The Center for Sustainable Design, UK, 2007, pg. 5

[132] Rolf Steinhilper, "Remanufacturing The ultimate form of Recycling", Fraunhofer IRB Verlag, Stuttgart, Germany, 2006, pg. 3

[133] Production Engine Remanufacturers Association, www.pera.org

Re-used or *used* refers to a product that is not new and has received little or no repair to correct existing problems or testing to insure that no problems exist. Therefore, its useful life is unknown.

Repair makes a broken product operational again. An analysis of the root cause of the problem is generally not performed in the repair process which means the product may not perform like a new product. Typically, a warranty on a repair will only apply to the specific repair and not the whole item.

Recycling returns a product to raw material form, which can be used as raw material for a future manufacturing process. The term recycling is generally applied to consumable goods; for example newspapers, glass bottles, and aluminium cans but can also be applied to durable goods such as an engine. Recycling in this sense destroys the value added to the raw material by forming it in the original manufacturing process.

In the automotive sector, this term usually refers to the reuse of a product that has been removed from a scrap or salvage vehicle and resold with little or no work performed on it[134, 135].

Below Figure 2.1.1 describes the flow of materials through the cycle of manufacture, repair, reuse, remanufacture, and recycling of durable materials, and is helpful to determine the boundaries of remanufacturing.

[134] Gray, Charter, 2007, pg. 9-10
[135] Production Engine Remanufacturers Association, www.pera.org

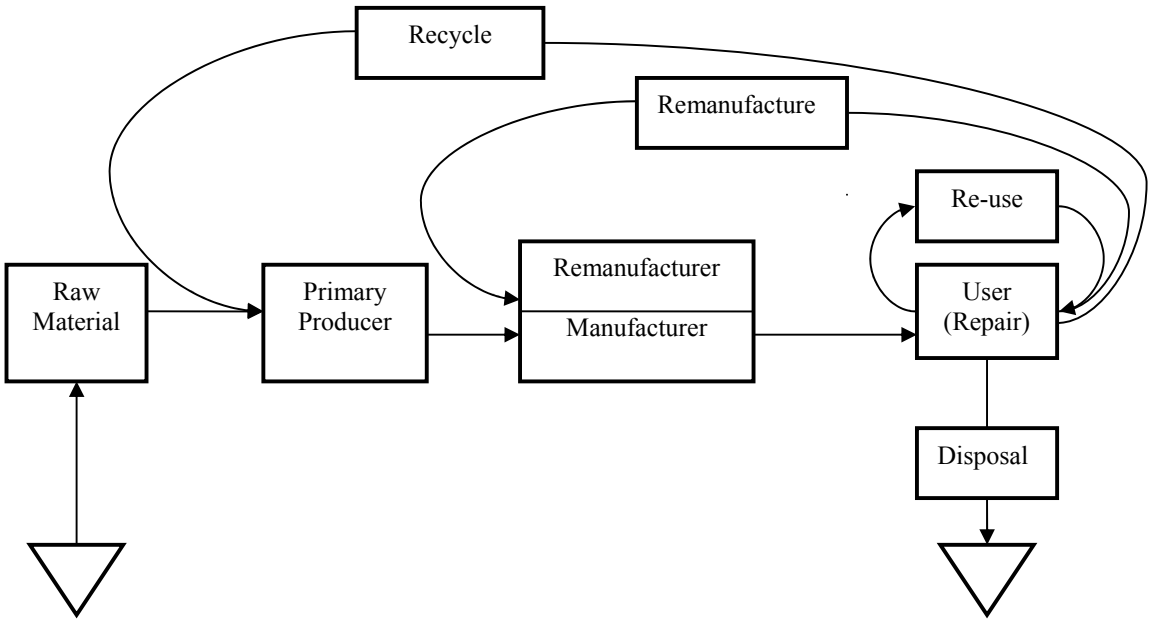


Figure 2.1.1: Materials Flow
(Source: Hauser, Lund, 2003)

A product is considered to be remanufactured if:

- Its primary components come from a used product.
- The used product is dismantled to the extent necessary to determine the condition of its components.
- The used product's components are thoroughly cleaned and made free from rust and corrosion.
- All missing, defective, broken or substantially worn parts are either restored to reliable, functionally good condition, or they are replaced with new, remanufactured, or functionally good used parts.
- To put the product in good working condition, such machining, rewinding, refinishing or other operations are performed as necessary.
- The product is reassembled and a determination is made that it will operate like a similar new product.

Any product that can be manufactured can also be remanufactured. However, some products are remanufactured more often than others. For example aerospace machinery, bakery equipment, compressors, data communication equipment, gaming machines, high end electronics and electrical machinery, industrial machinery, laser toner cartridges, motor vehicle parts, musical instruments, office furniture, photocopiers, refrigeration, robots and vending machines are amongst those products which are most often subject to remanufacturing[136, 137].

Table 2.1.1: Remanufactured Product Areas

Sector	Product Areas
Automotive & Other Transport	12
Compressors	2
Electrical Apparatus	14
Machinery	42
Office Furniture/Equipment	1
Tires	1
Toner Cartridges	2
Valves	1
Other	8
Total	83

(Source: Hauser, Lund, 2003)

2. Five Key Steps of Remanufacturing

There are five key steps of remanufacturing[138]:

- complete disassembly of the product
- thorough cleaning of all parts
- inspection and sorting of all parts
- reconditioning of parts and/or replenishment by new parts
- product reassembly.

[136] The Remanufacturing Institute, www.reman.org
[137] Gray, Charter, 2007, pg. 18
[138] Steinhilper, 2006, pg. 40

a. Disassembly

As a prerequisite of all further steps to remanufacture a unit to its like new condition, in this first step the product is completely disassembled to the single part level. This applies only to such an extent where joinings can be loosened without damaging or destroying a part. Innovative remanufacturers are developing their own new technological solutions for disassembly[139].

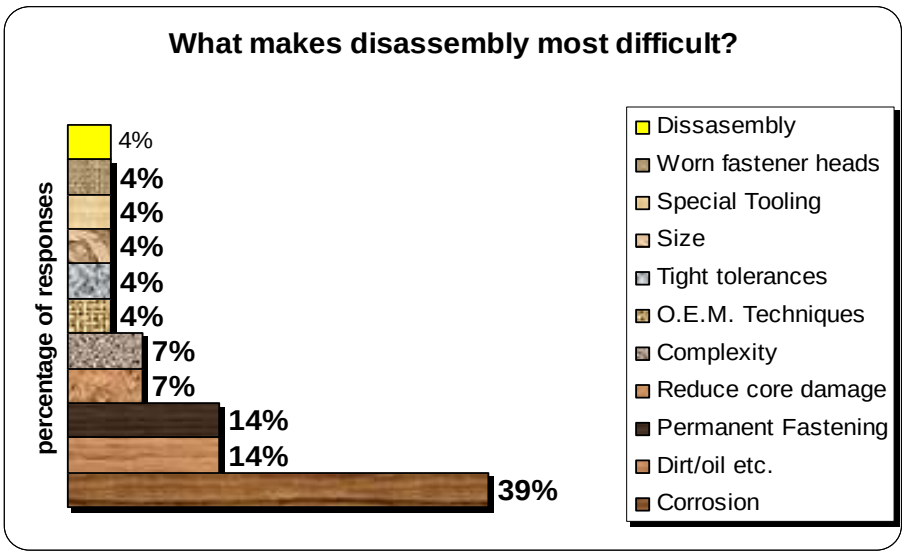


Figure 2.1.2: Difficulties Relating to Disassembly
(Source: Gray, Charter, 2007, pg. 30)

In a survey concerning of electrical rebuilders section of the automotive industry, as stated above corrosion is identified as the biggest problem for disassembly. This problem could be solved by a different design perspective, for example better isolation of parts, the specification of non-corrosive materials or the use of different fastening mechanism can be helpful for this problem[140].

[139] **Ibid.**, 2006, pg. 42
[140] Gray, Charter, 2007, pg. 30

b. Cleaning

The second step in the remanufacturing process is the cleaning of all parts coming from the disassembly process to their reconditionable or reusable condition. Cleaning is much more than washing away dirt and dust from the parts. It is also de-greasing, de-oiling, de-rusting and freeing the parts from old paint. Remanufacturers' cleaning processes must be environmentally friendly at the same time[141]. The survey of electrical rebuilders indicates on this matter the same problem; the issue of compliance with the Environmental Protection Agency (EPA) rules is the most important difficulty during the cleaning phase[142].

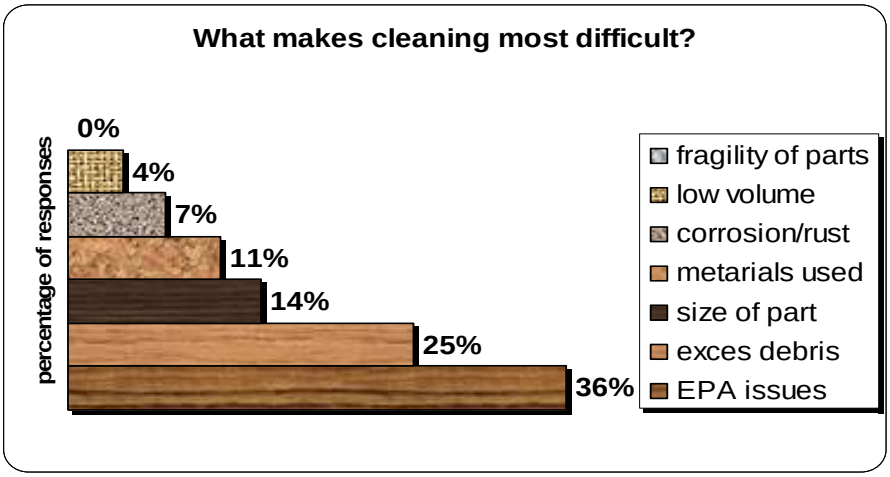


Figure 2.1.3: Difficulties Relating to Cleaning
(Source: Gray, Charter, 2007, pg. 32)

c. Inspection and Sorting

Another step of great importance in remanufacturing is to assess the condition of the disassembled and cleaned parts as to their reusability or reconditionability. This has two aspects; first the definition of objective criteria and condition characteristics to determine the condition of the components, second, the development and application of suitable and affordable testing equipment.

---

[141] Steinhilper, 2006, pg. 45
[142] Gray, Charter, 2007, pg. 32

Depending on the various inspection results, parts are being sorted into three classes: reusable without reconditioning, reconditionable and not reusable or reconditionable[143].

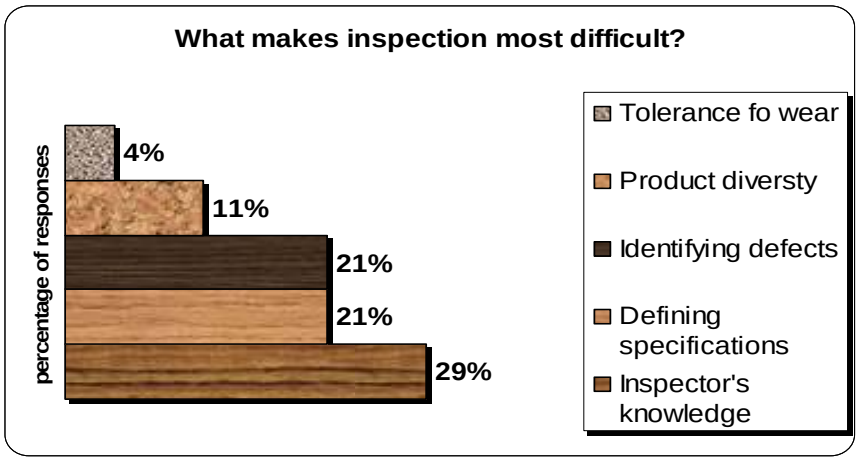


Figure 2.1.4: Difficulties Relating to Inspection
(Source: Gray, Charter, 2007, pg. 35)

The survey of electrical rebuilders describes that inspector's knowledge of the inspected parts and required quality is a big issue, but the question of definition of quality specifications could be resolved by legislation, or by detailed design activities[144].

d. Reconditioning

Reconditioning is the remanufacturing step ensuring a like new condition on the part level again. It is the most important step in many applications. After professional reconditioning, it is very hard to tell whether it's new or remanufactured part. The survey of electrical rebuilders indicates that the skill of employee is the most important difficulty for reconditioning[145, 146].

[143] Steinhilper, 2006, pg. 48
[144] Gray, Charter, 2007, pg. 35
[145] **Ibid.**, 2007, pg. 33
[146] Steinhilper, 2006, pg. 52

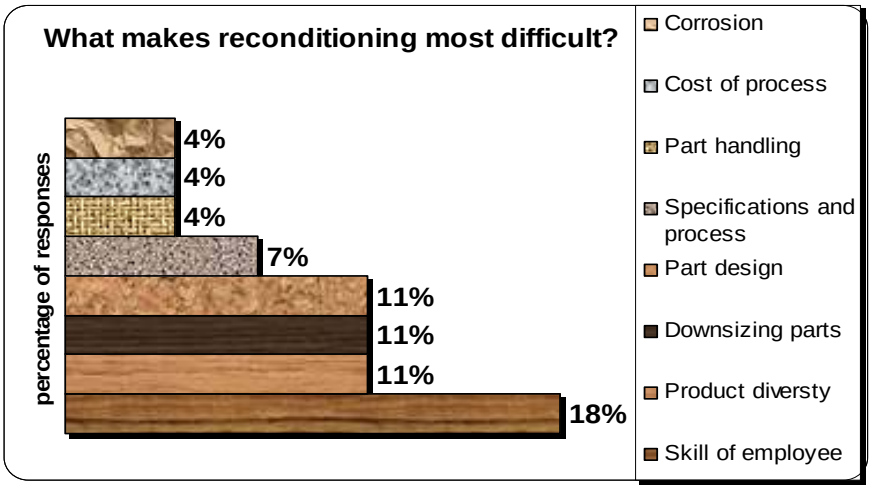


Figure 2.1.5: Difficulties Relating to Reconditioning
(Source: Gray, Charter, 2007, pg. 33)

e. Reassembly

The reassembly of the parts to remanufactured products takes place on small batch assembly lines, using the same power tools and assembly equipment that used in new product assembly operations[147].

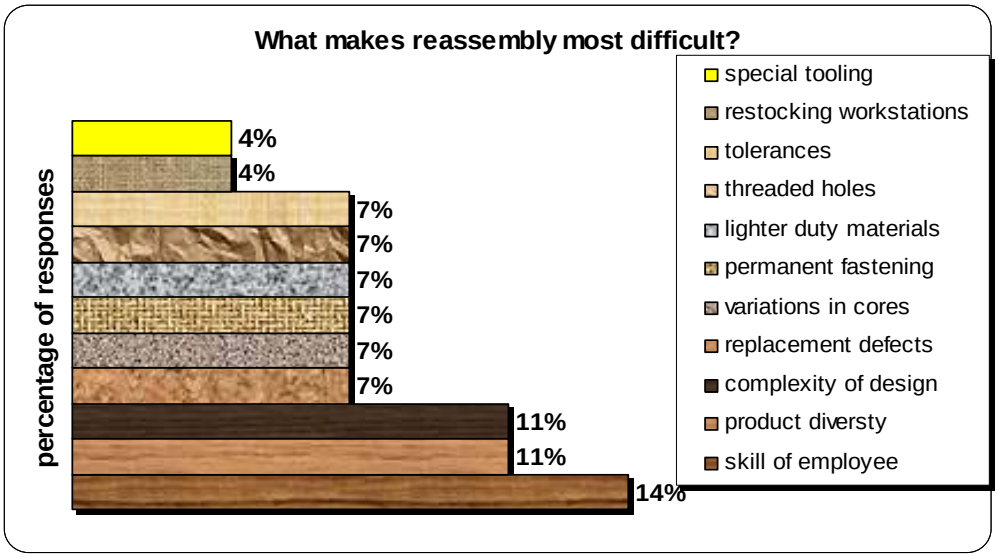


Figure 2.1.6: Difficulties Relating to Reassembly
(Source: Gray, Charter, 2007, pg. 30)

[147] **Ibid.**, 2006, pg. 57

The lack of skills is the biggest problem for reassembly according to the survey of electrical rebuilders; which arguably suggests that employees need greater training, and that a simpler product designs may be helpful for reassembly procedures[148].

The assembly procedure is followed by a functional inspection or test run of each remanufactured product.

3. The Scope and Size of Remanufacturing

Robert T. Lund, from Boston University, performed a survey back in 1996 about the size of remanufacturing activities in United States. His research was the very first step for academic studies in this area and several associations still use his data presently for describing the importance of remanufacturing.

Table 2.1.2: Size and Scope of Remanufacturing Activity in the U.S.

Total number of firms	70,000
Total industry sales	USD 53 billions
Total direct employment	480,000
Average annual company sales	USD 2,9 millions
Average company employment	24
Number of product areas	Over 46 major categories

(Source: Robert T. Lund, 1996)

The industry is made up thousands of companies, most of which are small, 20 employees or fewer firms. Even the very largest remanufacturers would be classified as medium-sized firms. Direct employment by these firms is impressive, if we add the non-direct employment of remanufacturers, such as employment of suppliers, distributors, retailers, etc., the total number would be counted in the millions.

[148] Gray, Charter, 2007, pg. 30

The total estimated annual sales volume of these companies is very large and remanufacturing may be to be considered as a major industry in the United States.

Table 2.1.3: Relative Size of Remanufacturing Activity in the U.S.

Industry Sector	Employment	Shipment Value
Remanufacturing	480,000	USD 53 billions
Household consumer durables	495,000	USD 51 billions
Steel mill products	241,000	USD 56 billions
Computer & peripherals	200,000	USD 56 billions
Pharmaceuticals	194,000	USD 68 billions

(Source: Robert T. Lund, 1996)

Table 2.1.3 compares the size of the remanufacturing industry with some of United States' major industries.

Remanufacturing typically uses 85 % less energy than manufacturing. Studies performed at the Fraunhofer Institute in Stuttgart, Germany, estimate the energy saving by remanufacturing worldwide equals the electricity generated by 5 nuclear power plants. This corresponds to 10,744,000 barrels of crude oil or a fleet of 233 oil tankers a year. The Fraunhofer Institute determine that raw materials saved by remanufacturing worldwide in a year would fill 155,000 railroad cars forming a train 1,100 miles long[149].

According to OEM Product Service Institute, the United States spends an estimated USD 47 billions a year on remanufacturing. It represents only 0.4 % of GDP, compared to 10 % for new product manufacturing[150].

Automotive Parts Remanufacturers Association (APRA) provides the below figures about the remanufacturing process of automotive parts.

[149] **Ibid.**, 2007, pg. 15
[150] Material Handling Management, www.mhmonline.com

- About 50 % of the original starter is recovered in the remanufacturing process. This can result in annual savings in the United States of 8.2 million gallons of crude oil from steel manufacturing, 51,500 tons of iron ore, and 6,000 tons of copper and other metals.
- Rebuilt engines require 50 % of the energy and 67 % of the labor required to produce new engines[151].

According the information provided by the National Center for Remanufacturing and Resource Recovery:

- In Europe, under stiff recycling requirements, by the year 2002, no more than 15% of a scrap vehicle can go to a landfill. That percentage would drop to 5% in 2015.
- Just by remanufacturing office furniture rather than buying it new, American businesses could avoid USD 93 millions in disposal costs and small companies could save 30-50% in purchasing costs.
- A survey of remanufacturing companies found that over 80 percent had training programs and that average annual expenditures on these programs was over $30,000 per company.
- Purchasing a remanufactured product can cost consumers 50 to 75 % less than a new product[152].

The Center for Sustainable Design, in United Kingdom, mentioned that remanufacturing in the UK was worth approximately £5 billions per year and employed up to 50,000 people. However, the UK manufacturing industry in 2003 was worth £447 billions an employed approximately 3,500,000 people[153].

[151] Automotive Parts Remanufacturers Association, www.apra.org
[152] National Center for Remanufacturing and Resource Recovery, www.reman.rit.edu
[153] Gray, Charter, 2007, pg. 18

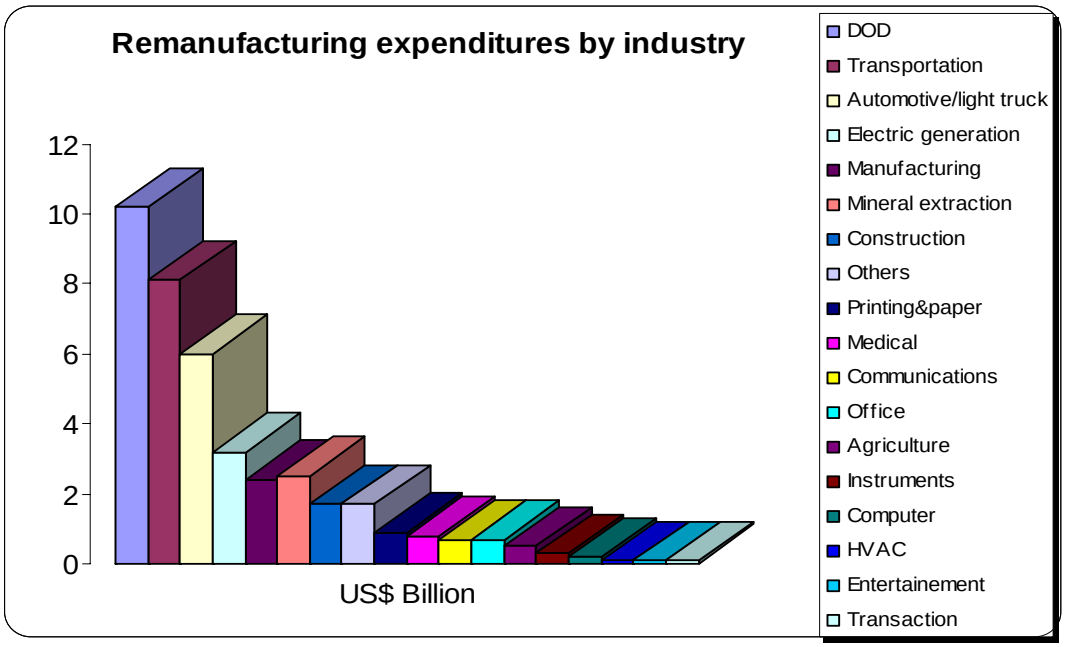


Figure 2.1.7: Remanufacturing Expenditures by Industry in the United States
(Source: OEM Product Service Institute Survey, 2001)

Figure 2.1.7 shows that Department of Defence (DOD), Transportation Industry and Automotive/light truck Industry are the foremost industries for the remanufacturing activities.

Following our above explanations on what is remanufacturing, its various stages and its importance for the global economy, we will, in the following section, try and determine the factors affecting the production of TATKAP, one of the few Turkish companies operating in this field, through a multiple regression analysis.

B. CASE STUDY: A MULTIPLE REGRESSION ANALYSIS ABOUT REMANUFACTURING ACTIVITIES OF TATKAP

Having discussed on the definition and the stages of remanufacturing activities, we will in the present section take a closer look on TATKAP, a Turkish company active in the field of remanufacturing. Following a summary presentation of the company and its business, we will try and determine factors affecting its activities by a regression analysis.

1. TATKAP

Tatko group of companies, active in the commerce of tires, owns several undertakings, one of which is TATKAP Lastik Kaplama İmalat Sanayi ve Ticaret A.Ş. (referred hereinafter as "**TATKAP**").

TATKAP operates a factory located in Gebze and owns two warehouses located respectively in İkitelli and Ümraniye Dudullu. Providing fleet management services to its clients such as Omsan Lojistik, Reysaş Logistics, Mars Logistics, Yurtiçi Kargo, Barsan Global Lojistik, Ünkar, Ulustrans, Karınca, Ran Logistics, Alışan Group, the company is also a dealer of Goodyear, Dunlop, Fulda and Michelin brands of tires. Notwithstanding the foregoing, for the purposes of our study, we will be focusing on retreading (remanufacturing by way of remoulding of previously worn-out tires) activities of TATKAP.

Tires used on truck-type vehicles have an average useful life of 1 million kilometers. That said, after 300,000 kilometers of usage, the tires must either be replaced or retreaded, mainly due to safety reasons. From a theoretical standpoint all tires can be retreaded; in practice, however, retreading may be not possible because of the damages sustained by the tire casing or because of late replacement of a worn-out tire due to customers' ignorance.

The statistical rate of retreading activities has increased since 1991, from 3% to 15% in 1996. Currently, for 1.3 million of new tires sold per year, 25 % (i.e. approximately 300,000 worn-out tires) are retreaded and used as like-new. There are approximately 200 enterprises active in this domain, of which close to 40 retreads more than 500 tires per year.

Retreading is a remanufacturing activity applied to worn-out tires. As a first step, the worn-out layer of rubber tread is peeled-off, with the help of special machinery. A coating of solvent is applied, following repairs –if any is needed- on the used tire casing shaved bare, and a new compound like rubber (patterned and formed in cold) is adhered to the tire casing. The newly coated tires are then placed within special protective containers and cooked in owens, which have an average processing capacity of 22 tires, under 80 bars of pressure, on 105 degrees Celsius, during 4 to 5 hours, before final examinations. TATKAP has a capacity to process 80 to 90 tires per day.

Retreaded tires offer performance levels equal to new tires, can sustain same weights as new tires and can easily be used on the same speeds, for same capacities and on same axle shafts as new tires. New tires produced with current technological means are designed in a fashion to allow several retreading operations, if used properly.

Presently, retreaded tires are widely used on commercial and military planes. The process is considered to be quite safe, provided that it is performed in compliance with the latest technological requirements, using good quality materials and is implemented by experts.

1. Retreading allows worn-out tires to be kept functional for another usage cycle, delays formation of deposits of junk tires and contributes to the protection of the environment.
2. Retreading greatly alleviates operating expenses of vehicles, by reducing costs incurred per kilometer. A retreaded tire costs approximately 40 % of a new tire while offering same levels of performance. Retreading, therefore, entails substantial financial gains for businesses.

3. Retreading requires considerably lesser amounts of natural resources than the production of brand new tires (whereas 160 liters of petroleum are required for manufacturing a new tire, 40 liters of petroleum would suffice for retreading). Accordingly, retreading greatly benefits both national and global economy[154].

For the purposes of our study we shall try and determine the factors having a bearing on the amount of tires retreaded by TATKAP, through a regression analysis, which analysis shall be based on the statistical data obtained from TATKAP and Turkish Statistics Institute. Before proceeding with the actual analysis however, a summary definition of regression analysis shall be provided.

2. Multiple Regression Analysis Study In TATKAP Remanufacturing

Regression analysis is a statistical tool for the investigation of relationships between variables. Usually, the researcher seeks to ascertain the causal effect of one variable upon another.

More concretely regression analysis is concerned with the study of dependence of one variable, *i.e.* the *dependent variable*, on one or more other variables, *i.e.* the *explanatory variables*, with a view to estimating and/or predicting the (population) mean or average value of the former in terms of the known or fixed (in repeated sampling) values of latter.

If one is looking into the dependence of a variable on a single explanatory variable, such study would be called as a simple or two-variable regression analysis. If, on the other hand, the dependence of one variable on more than one explanatory variable is studied, the analysis would then be a multiple regression analysis[155].

---

[154] www.tatkap.com.tr
[155] Damodar N. Gujarati, **Basic Econometrics**, McGraw-Hill, New York, 2003, pg. 18, 25

In our case, the study will be a multiple regression analysis. The dependent variables will be denoted by the letter Y and the explanatory variables will be denoted by X's ($X_1, X_{2,...,}X_k$).

For the purposes of our analysis, the monthly amounts of tires retreaded by TATKAP will be the dependent variable; whereas the explanatory variables shall comprise the monthly amounts of tires retreaded by other companies active within this field, the monthly amounts of brand new tire sales in Turkey, the prices of brand new tires, the prices of retreaded tires and the monthly statistics of trucks registered in Turkey.

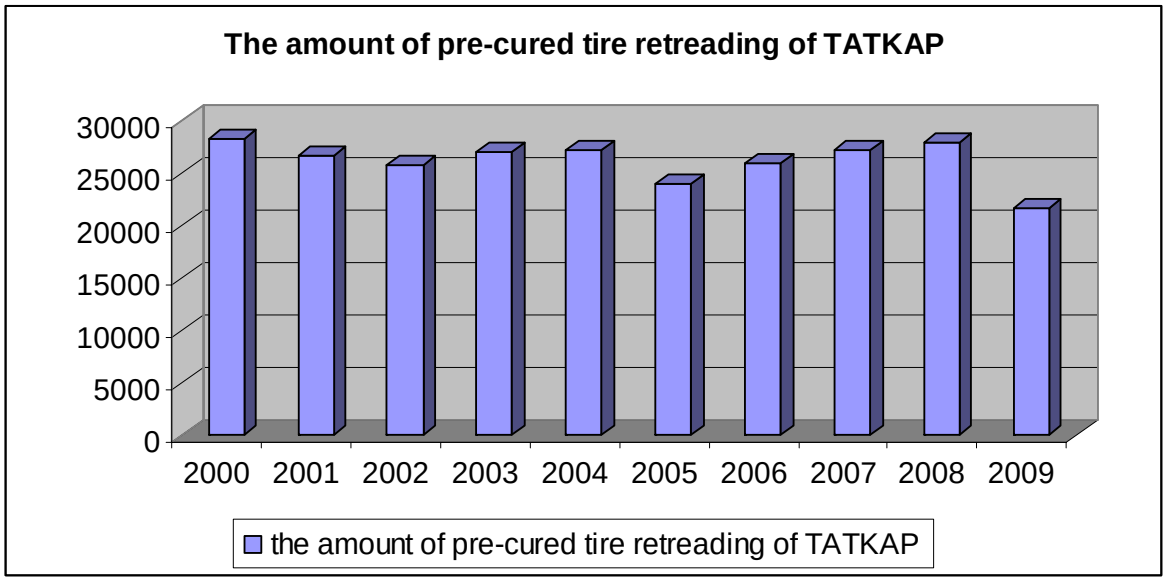


Figure 2.2.1: The Change in Amount of Pre-cured Tire Retreading of TATKAP
(Source: TATKAP Lastik Kaplama İmalat Sanayi ve Ticaret A.Ş.)

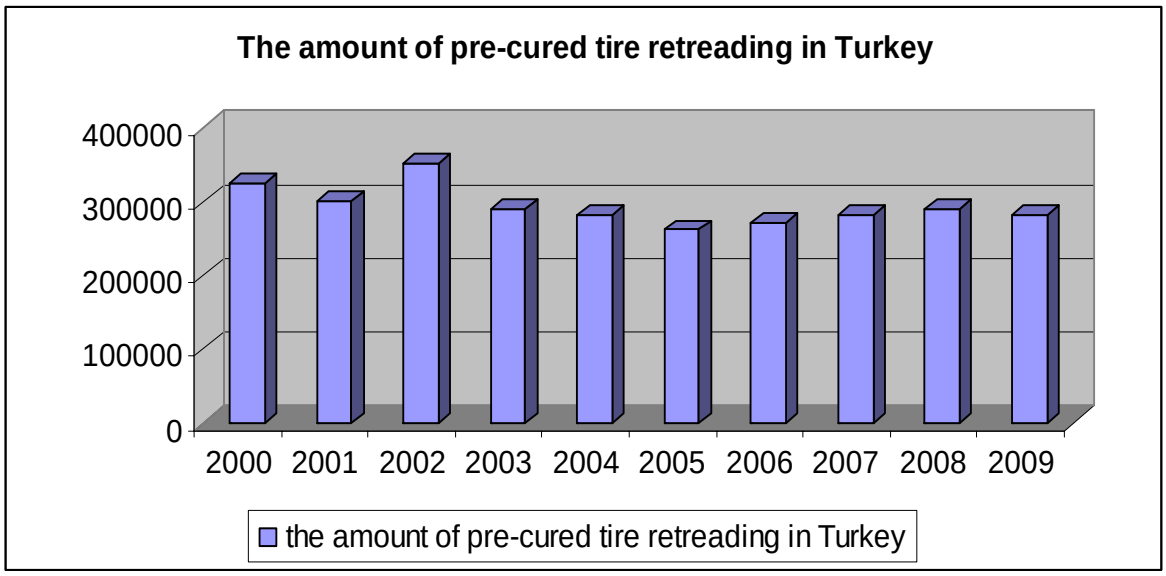


Figure 2.2.2: The Change in Amount of Pre-cured Tire Retreading in Turkey
(Source: TATKAP Lastik Kaplama İmalat Sanayi ve Ticaret A.Ş.)

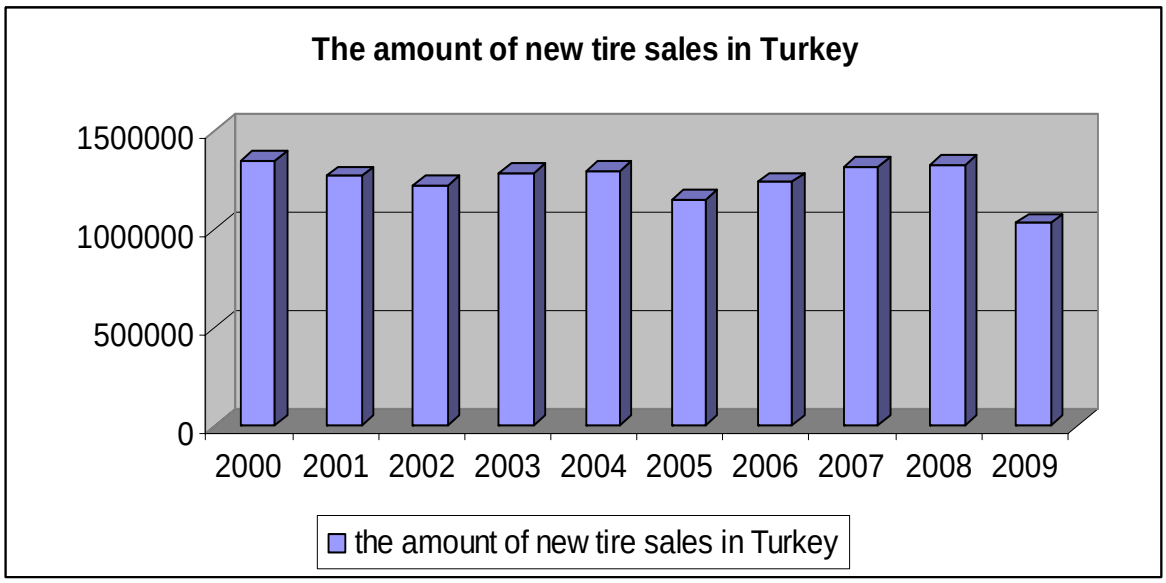


Figure 2.2.3: The Change in Amount of New Tire Sales
(Source: TATKAP Lastik Kaplama İmalat Sanayi ve Ticaret A.Ş.)

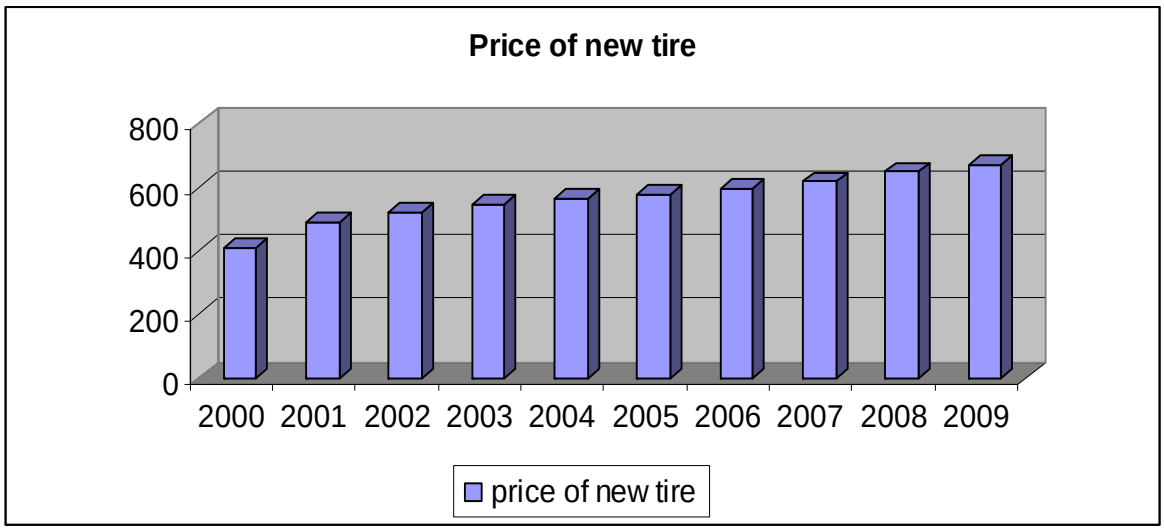


Figure 2.2.4: The Change in Price of New Tire
(Source: TATKAP Lastik Kaplama İmalat Sanayi ve Ticaret A.Ş.)

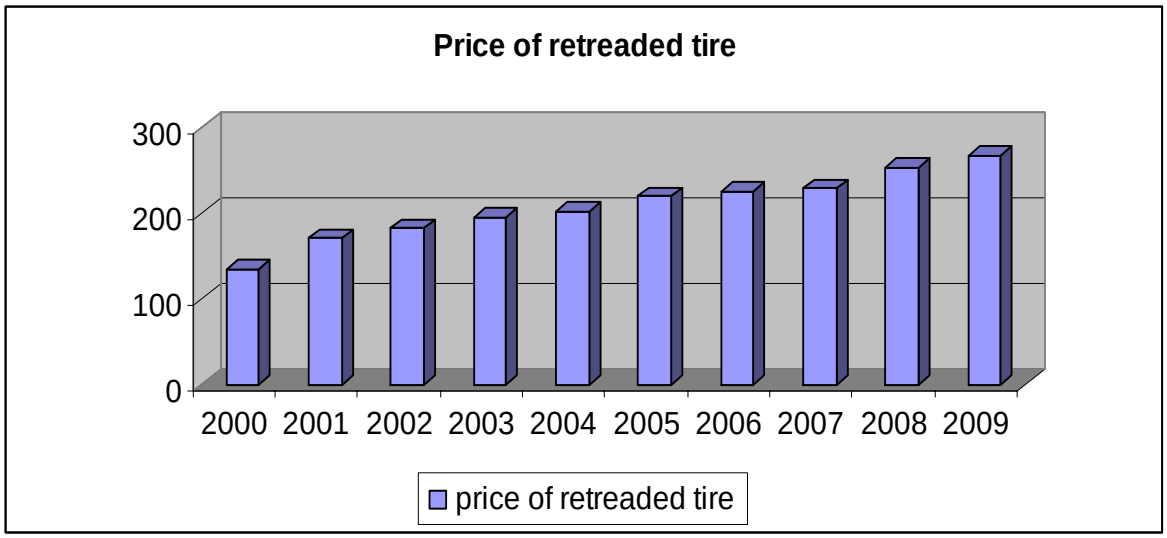


Figure 2.2.5: The Change in Price of Retreaded Tire
(Source: TATKAP Lastik Kaplama İmalat Sanayi ve Ticaret A.Ş.)

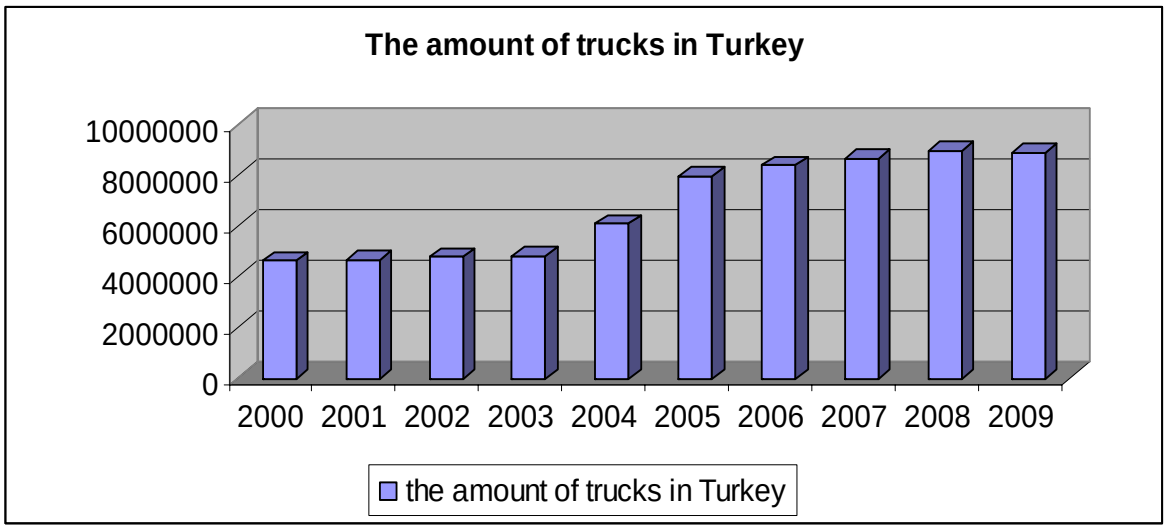


Figure 2.2.6: The Change in Amount of Trucks
(Source: Turkish Statistics Institute[156])

a. First model of regression analysis

When applying multiple regression, we construct a model to explain variability in the dependent variable.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon$$

Y: the amount of pre-cured tire retreading of TATKAP
$\mathbf{X_1}$: the amount of pre-cured tire retreading in Turkey
$\mathbf{X_2}$: the amount of new tire sales in Turkey
$\mathbf{X_3}$: price of new tire
$\mathbf{X_4}$: price of retreaded tire
$\mathbf{X_5}$: the number of trucks registered in Turkey
ε : error term

In our analysis, the number of observation shall be 118 (monthly data between January 2000 and October 2009 shall be observed, n=118) and we will construct 95 % confidence intervals (α=0,05).

[156] www.tuik.gov.tr/ulastirmadagitimimapp/ulastirma.241

According to the results of data analysis program of Microsoft Excel, we can construct the model below:

$$Y' = -155{,}0382 + 0{,}02255\ X_1 + 0{,}01552\ X_2 + 1{,}11942\ X_3 - 2{,}99724\ X_4 + 0{,}00028\ X_5$$
$$(176{,}6803)\quad (0{,}00371)\quad (0{,}0009)\quad (1{,}10929)\quad (2{,}38557)\quad (0{,}00012)$$

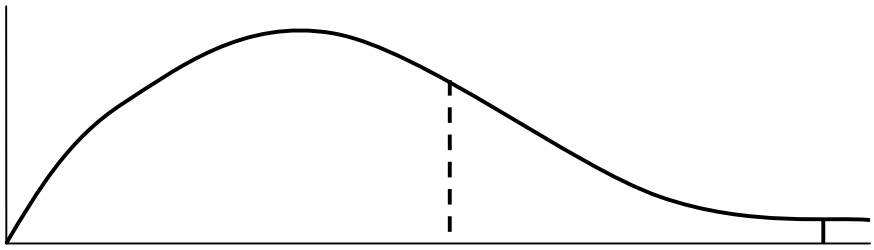
1) Analyze of variance

$H_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$

H_1 = At least one is different

Critical $F_{0{,}05\ ;\ 5,\ 112} = 2{,}29$

Test Statistic F = 724,404



2,29 724,404

H_0 is rejected, so at least one parameter is different.

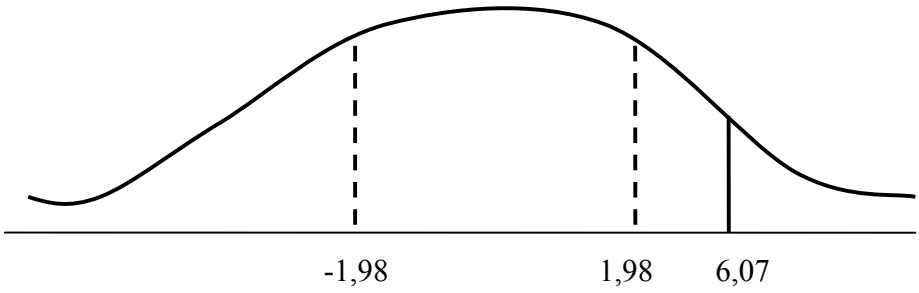
2) Individual tests

- $H_0 = \beta_1 = 0$

  $H_1 = \beta_1 \neq 0$

  Critical $t_{0{,}025\ ;\ 112} = 1{,}980$

  Test Statistic $t_{stat} = 6{,}07679$



If p-value of $X_1 < \alpha$, we reject H_0

p-value of X_1 is 1,72949E-08 < 0,05

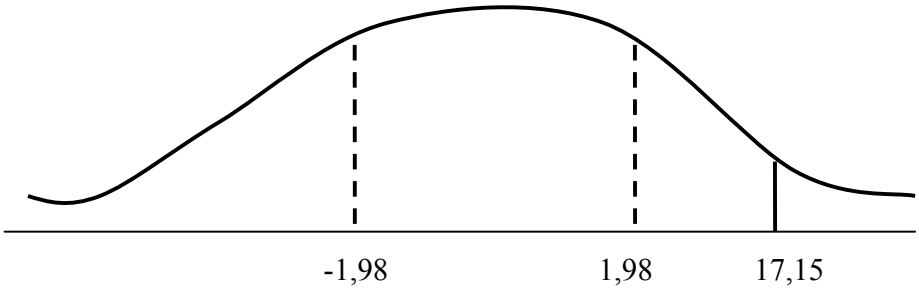
According to the Student's t statistic and p-value for a two tailed test of X_1, H_0 is rejected, X_1 is significant.

- $H_0 = \beta_2 = 0$

  $H_1 = \beta_2 \neq 0$

  Critical $t_{0,025\ ;\ 112} = 1,980$

  Test Statistic $t_{stat} = 17,15121$



If p-value of $X_2 < \alpha$, we reject H_0

p-value of X_2 is 4,11051E-33 < 0,05

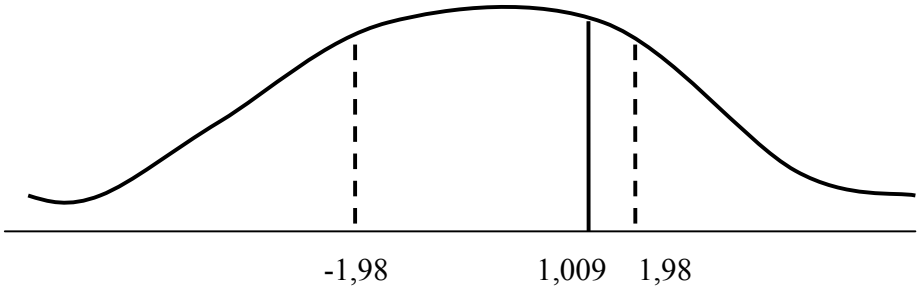
According to the Student's t statistic and p-value for a two tailed test of X_2, H_0 is rejected, X_2 is significant.

- $H_0 = \beta_3 = 0$

  $H_1 = \beta_3 \neq 0$

  Critical $t_{0,025\ ;\ 112} = 1,980$

  Test Statistic $t_{stat} = 1,00913$



If p-value of $X_3 < \alpha$, we reject H_0

p-value of X_3 is 0,315085639 > 0,05

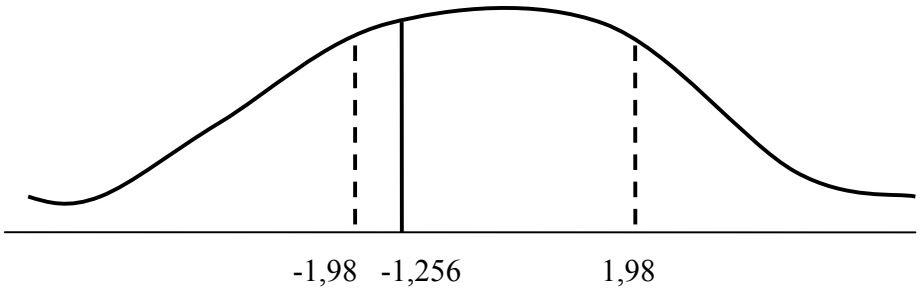
According to the Student's t statistic and p-value for a two tailed test of X_3, H_0 is accepted, X_3 is not significant.

- $H_0 = \beta_4 = 0$

  $H_1 = \beta_4 \neq 0$

  Critical $t_{0,025\ ;\ 112} = 1,980$

  Test Statistic $t_{stat} = -1,256$

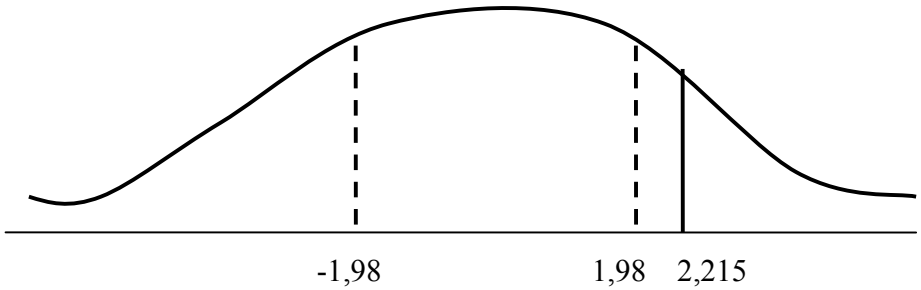


If p-value of $X_4 < \alpha$, we reject H_0

p-value of X_4 is 0,211584642 > 0,05

According to the Student's t statistic and p-value for a two tailed test of X_4, H_0 is accepted, X_4 is not significant.

- $H_0 = \beta_5 = 0$
  $H_1 = \beta_5 \neq 0$
  Critical $t_{0,025\ ;\ 112} = 1,980$
  Test Statistic $t_{stat} = 2,21595$



If p-value of $X_5 < \alpha$, we reject H_0
p-value of X_5 is 0,028716786 < 0,05
According to the Student's t statistic and p-value for a two tailed test of X_5, H_0 is rejected, X_5 is significant.

In our model, the explanatory variables X_3 and X_4 are not statistically significant predictor variables. In order to understand the reason underlying this outcome, we will detect the linear relationship of variables, multicollinearity.

3) Test of multicollinearity

The term multicollinearity denotes the existence of a "perfect", or exact, linear relationship among some or all explanatory variables of a regression model. In the case of perfect multicollinearity the regression coefficients remain indeterminate and their standard errors are infinite. If we use the test of Klein to analyze the multicollinearity[157]:

[157] Gujarati, 2003, pg. 342

i. The results of the estimation

$$Y' = -155{,}0382 + 0{,}02255\ X_1 + 0{,}01552\ X_2 + 1{,}11942\ X_3 - 2{,}99724\ X_4$$
$$(176{,}6803)\quad (0{,}00371)\quad (0{,}0009)\quad (1{,}10929)\quad (2{,}38557)$$
$$+ 0{,}00028\ X_5$$
$$(0{,}00012)$$

$n = 118$

$R^2 = 0{,}97$

ii. Calculation of correlation coefficients between the explanatory variables

$r^2x_1x_2 = 0{,}8147$

$r^2x_1x_3 = 0{,}05714$

$r^2x_1x_4 = 0{,}0617$

$r^2x_1x_5 = 0{,}0307$

$r^2x_2x_3 = 0{,}0225$

$r^2x_2x_4 = 0{,}02824$

$r^2x_2x_5 = 0{,}0012$

$r^2x_3x_4 = 0{,}9858$

$r^2x_3x_5 = 0{,}7180$

$r^2x_4x_5 = 0{,}7545$

$r^2x_3x_4 = 0{,}9858 > R^2 = 0{,}97$

The correlation coefficient between explanatory variables X_3 and X_4 is bigger than R square. Based on the results above, there is a risk of multicollinearity. Besides, X_5 is significant according to the results of the Student's t statistic and p-value for a two tailed test, test statistic of this variable is very close to the Critical t value. In a model X_1, X_2, X_5 are accepted as explanatory variables, X_5 becomes insignificant. As a consequence, a new model must be constructed without the explanatory variables X_3, X_4, X_5.

b. Last model of regression analysis

Y: the amount of pre-cured tire retreading of TATKAP

$\mathbf{X_1}$: the amount of pre-cured tire retreading in Turkey

$\mathbf{X_2}$: the amount of new tire sales in Turkey

$$Y' = 0{,}8365 + 0{,}0188\ X_1 + 0{,}0165\ X_2$$
$$(37{,}89245) \quad (0{,}00339) \quad (0{,}000807)$$

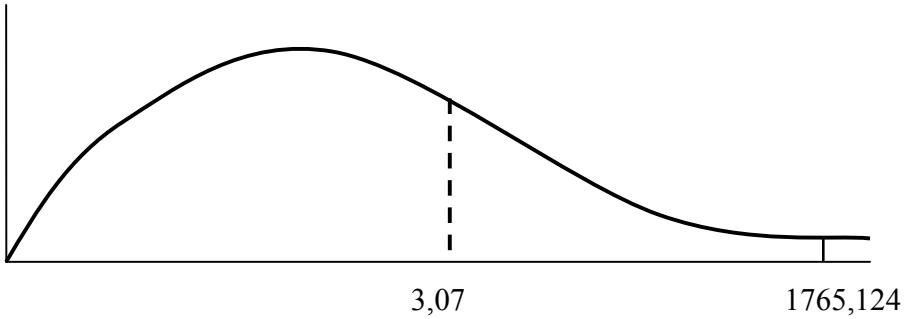
1) Analyze of variance

$H_0 = \beta_1 = \beta_2 = 0$

H_1 = At least one is different

Critical $F_{0{,}05\ ;\ 2,\ 115} = 3{,}07$

Test Statistic F = 1765,124



H_0 is rejected, at least one parameter is different

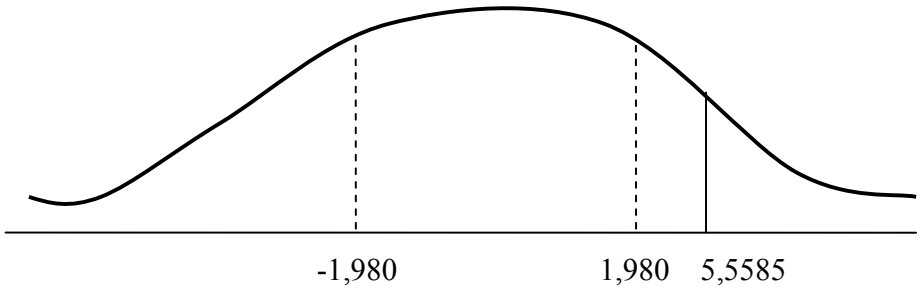
2) Individual tests

- $H_0 = \beta_1 = 0$

  $H_1 = \beta_1 \neq 0$

  Critical $t_{0{,}025\ ;\ 115} = 1{,}980$

  Test Statistic $t_{stat} = 5{,}5585$



If p-value of $X_1 < \alpha$, we reject H_0

p-value of X_1 is 1,78703E-07 < 0,05

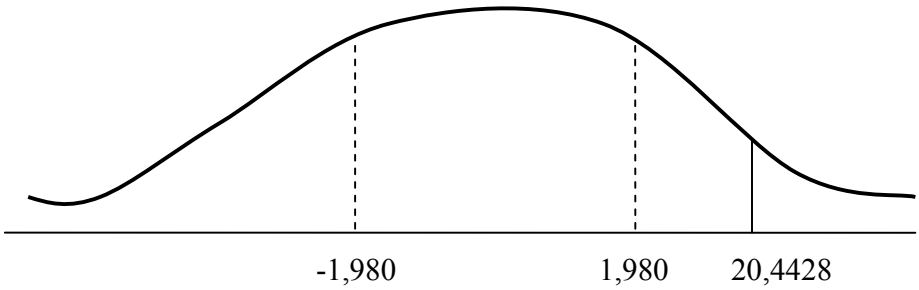
According to the Student's t statistic and p-value for a two tailed test of X_1, H_0 is rejected, X_1 is significant.

- $H_0 = \beta_2 = 0$

  $H_1 = \beta_2 \neq 0$

  Critical $t_{0,025\ ;\ 115} = 1,980$

  Test Statistic $t_{stat} = 20,4428$



If p-value of $X_2 < \alpha$, we reject H_0

p-value of X_2 is 4,26571E-40 < 0,05

According to the Student's t statistic and p-value for a two tailed test of X_2, H_0 is rejected, X_2 is significant.

c. Results of Analysis

$$Y' = 0{,}83652 + 0{,}01886\ X_1 + 0{,}01650\ X_2$$
$$(37{,}89245) \quad (0{,}00339) \qquad (0{,}000807)$$

1) If X_2 (the amount of new tire sales in Turkey) is held constant, an increase of 1 unit in X_1 (the amount of pre-cured tire retreading in Turkey) cause, in average, 0,01886 unit of increase in Y (the amount of pre-cured tire retreading of TATKAP).

If X_1 (the amount of pre-cured tire retreading in Turkey) is held constant, an increase of 1 unit n X_2 (the amount of new tire sales in Turkey) cause, in average, 0,01650 unit of increase in Y (the amount of pre-cured tire retreading of TATKAP).

2) The coefficient of determination, R^2, of the fitted regression is defined as the proportion of the total sample variability explained by the regression[158].

$0 \leq R^2 \leq 1$

$R^2 = 0{,}968$

96,8 % of variability of Y (the amount of pre-cured tire retreading of TATKAP) can be explained by linear relationship of X_1 (the amount of pre-cured tire retreading in Turkey) and X_2 (the amount of new tire sales in Turkey).

3) Confidence intervals for regression coefficients

$$P\left[b_j - (t_{n-K-1\ ,\ \alpha/2})\ (s_{bj}) < \beta_j < b_j + (t_{n-K-1\ ,\ \alpha/2})\ (s_{bj}) \right]$$ [159]

where (n-K-1) degrees of freedom is 115 and α=0,05.

[158] Paul Newbold, William L. Carlson, Betty Thorne, **Statistics for Business and Economics**, Pearson Education, New Jersey, 2007, pg. 472

[159] Ibid, pg. 480

i. For parameter β_1:

Coefficient estimator $b_1 = 0{,}018863$

Standard deviation $s_{b1} = 0{,}00339$

$t_{115\ ;\ 0{,}025} = 1{,}980$

$P\ [\ 0{,}018863 - (1{,}980)\ (0{,}00339) < \beta_1 < 0{,}018863 + (1{,}980)\ (0{,}00339)] = 0{,}95$

$P\ [\ 0{,}01214 < \beta_1 < 0{,}25584] = 0{,}95$

Thus, the 95% confidence interval for the expected increase in the amount of pre-cured tire retreading of TATKAP resulting from 1 unit increase in amount of pre-cured tire retreading in Turkey, given a fixed amount of new tire sales in Turkey, runs from 0,01214 to 0,25584.

ii. For parameter β_2:

Coefficient estimator $b_2 = 0{,}01650$

Standard deviation $s_{b2} = 0{,}000807$

$t_{115\ ;\ 0{,}025} = 1{,}980$

$P\ [\ 0{,}01650 - (1{,}980)\ (0{,}000807) < \beta_2 < 0{,}01650 + (1{,}980)\ (0{,}000807)] = 0{,}95$

$P\ [\ 0{,}014903 < \beta_2 < 0{,}01810] = 0{,}95$

Therefore, we can see that the 95% confidence interval for the expected increase in amount of pre-cured tire retreading of TATKAP resulting from a 1 unit increase in amount of new tire sales in Turkey, for a fixed amount of pre-cured tire retreading in Turkey, runs from 0,014903 to 0,01810.

4) Prediction from the multiple regression model

Given that the population regression model

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_K X_{Ki} + \varepsilon_i \quad (i\text{: } 1,2,\ldots,n)$$

The best linear unbiased forecast of $\hat{y}_{n+1}$ is

$$\hat{y}_{n+1} = b_0 + b_1 x_{1,\,n+1} + b_2 x_{2,\,n+1}$$

If the amount of pre-cured tire retreading in Turkey is 25000 and the amount of new tire sales in Turkey 105000,

$x_{1,\, n+1} = 25000$

$x_{2,\, n+1} = 105000$

$b_0 = 0{,}83652$

$b_1 = 0{,}01886$

$b_2 = 0{,}01650$

Using these values, we find that our point predictor of the amount of pre-cured tire retreading of TATKAP is

$\hat{y}_{n+1} = 0{,}83652 + (0{,}01886)(25000) + (0{,}01650)(105000)$

$\hat{y}_{n+1} = 2204{,}836$

$P\,(\hat{y}_{n+1} - (t_{\,n-K-1\,,\,\alpha/2})s_y < Y < \hat{y}_{n+1} + (t_{\,n-K-1\,,\,\alpha/2})s_y) = 0{,}95$

where s_y is estimated standard error.

$\hat{y}_{n+1} = 2204{,}836$

$t_{\,115\,;\,0{,}025} = 1{,}980$

$s_y = 96{,}332$

$P\,[(2204{,}836 - (1{,}980)\,(96{,}332) < Y < 2204{,}836 + (1{,}980)\,(96{,}332)] = 0{,}95$

$P\,(2014{,}098 < Y < 2395{,}573) = 0{,}95$

Thus, the 95% confidence interval of the amount of the pre-cured tire retreading of TATKAP, given the 25000 units of pre-cured tire retreading in Turkey and 105000 units of new tire sales in Turkey, is between 2014,098 and 2395,573.

C. ENGINE AND AUTOMOTIVE INDUSTRY

Remanufacturing activities as depicted and analysed in the previous section are, in fact, only one of the many applications existing in engine and automotive industry. This is because; remanufacturing has its strongest tradition and its strongest current representation in this sector. More concretely, remanufacturing of automotive products accounts for two thirds of all the remanufacturing activities. While in the European countries the remanufacturing business is growing fast, in the United States it has already reached approximately 50 % market share for the replacement parts in the automotive aftermarket.

As an example, one out of ten cars and trucks on the road, on an average, needs a replacement engine, after ten years of utilization. The automotive aftermarket industry reworks worn out or defective engines back to original equipment standards. Other automotive remanufacturing activities include, among others, starters, alternators, clutches, electronic control units[160].

Within this section, information relating to remanufacturing activities four of the main companies of this industry; namely Caterpillar, Honda, Mazda and Toyota will be analyzed in detail.

1. Caterpillar

Caterpillar Inc. is a United States-based corporation headquartered in Peoria, Illinois. Caterpillar (commonly referred to simply as CAT) was founded in 1925 and it is one the largest maker of construction and mining equipment, diesel and natural gas engines and industrial gas turbines in the world. Caterpillar's portfolio of products, services and technologies fall into three principal lines of business: machinery, engines and financial products.

[160] Steinhilper, 2006, pg. 65-70

Today, Caterpillar is one of the world's largest remanufacturers, offering a full line of Cat Reman parts for Cat machines and engines and providing remanufacturing services to original equipment manufacturers (OEMs) and others in the industrial, defense and automotive products industries.

Caterpillar's 14 remanufacturing facilities take back end-of-life components, so-called "cores", from around the world. Cores are inspected and subsequently are completely disassembled, regardless of the parts' original identities and functions. Every part from each core is remanufactured to print specifications incorporating all the applicable engineering updates. The remanufactured parts, supplemented by new parts where required, are assembled into finished remanufactured products, tested, packaged for sale and warranted same as new products.

Caterpillar, through its remanufacturing process, recovered more than 2.2 millions end-of-life units in 2005. Of the approximately 135 millions of pounds (61 millions of kg) of material recovered, close to 70% was remanufactured and reused to produce Cat Reman products[161].

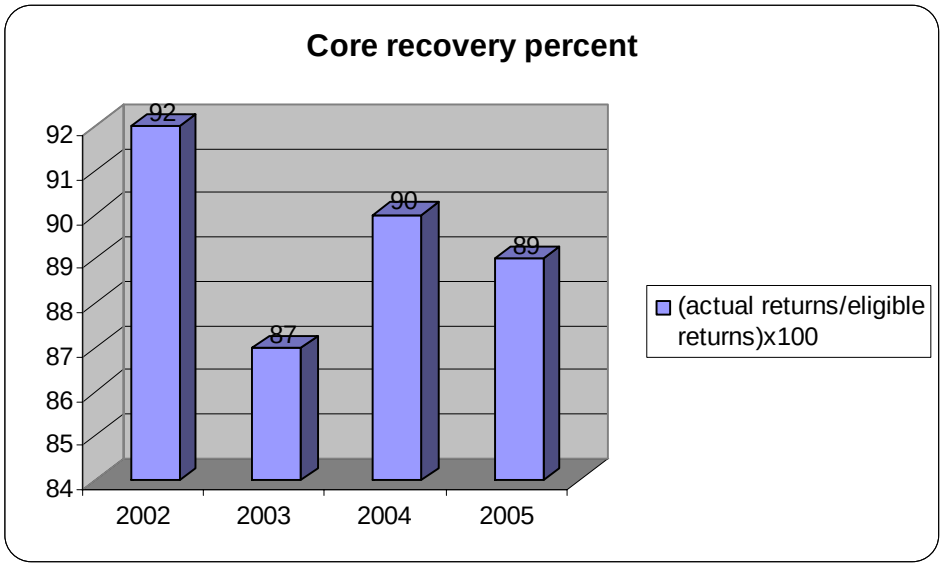


Figure 2.3.1: Caterpillar-Core Recovery Percent (2005)
(Source: Caterpillar 2005 Sustainability Report)

[161] Caterpillar 2005 Sustainability Report, www.cat.com

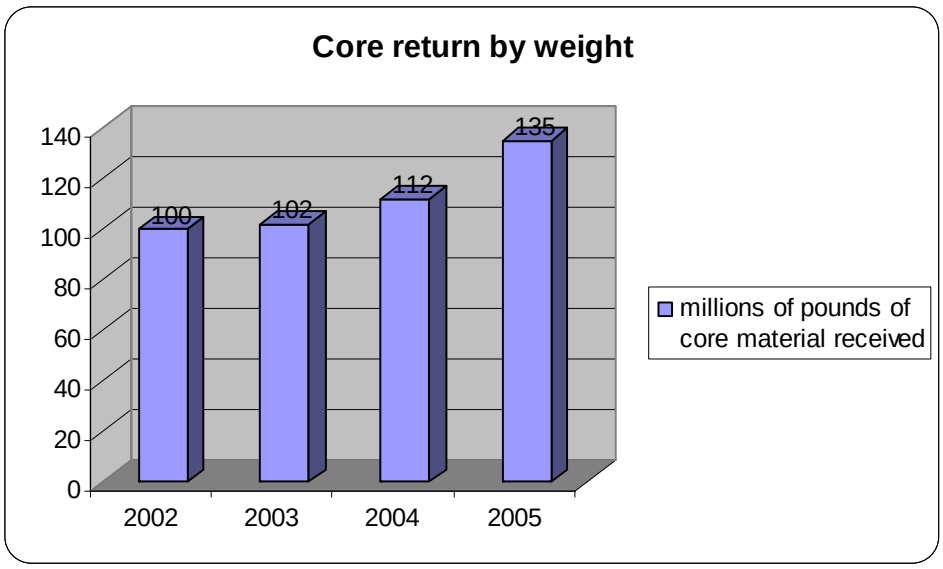


Figure 2.3.2: Caterpillar-Core Return by Weight (2005)
(Source: Caterpillar 2005 Sustainability Report)

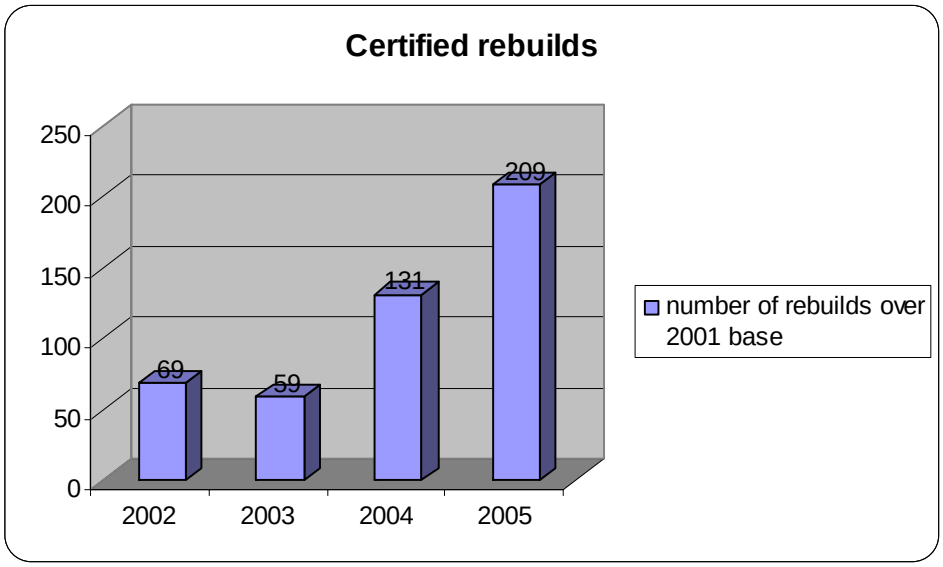


Figure 2.3.3: Caterpillar-Certified Rebuilds (2005)
(Source: Caterpillar 2005 Sustainability Report)

Caterpillar products are built to be rebuilt, and the Cat Certified Rebuild program helps ensure Cat machines and engines can be transformed back to their original like-new condition at the end of their first useful life.

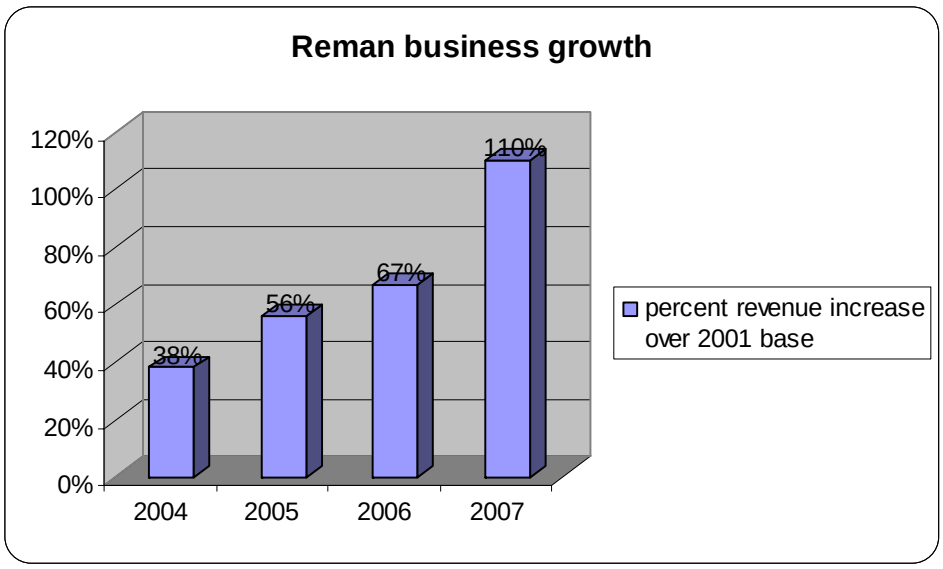


Figure 2.3.4: Caterpillar-Remanufacturing Business Growth (2007)
(Source: Caterpillar 2007 Sustainability Report)

Remanufacturing business of Caterpillar grew 110 % between 2001 and 2007. In 2007, 93 % of returns were remanufactured, making for 141 millions of pound end-of-life returns.

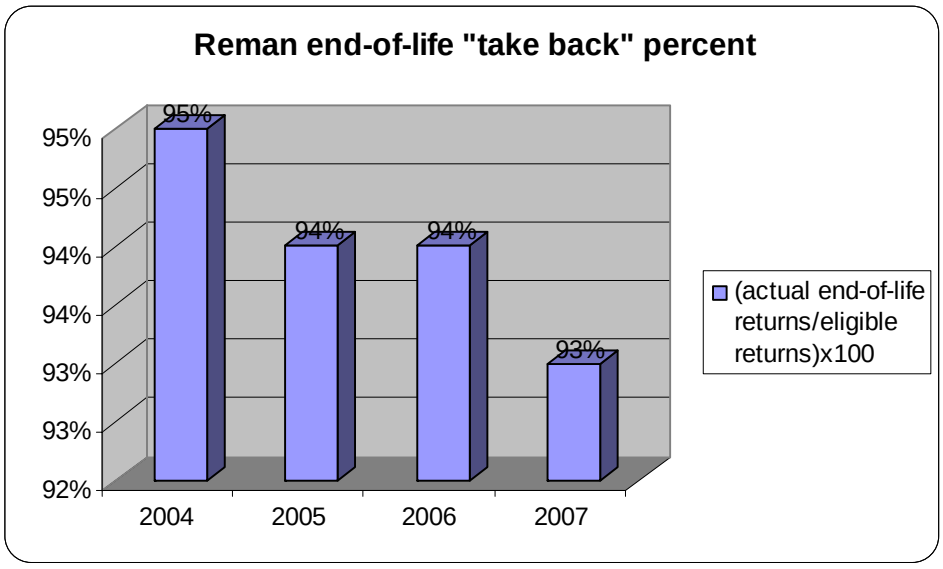


Figure 2.3.5: Caterpillar-Reman End-of-Life "Take Back" Percent (2007)
(Source: Caterpillar 2007 Sustainability Report)

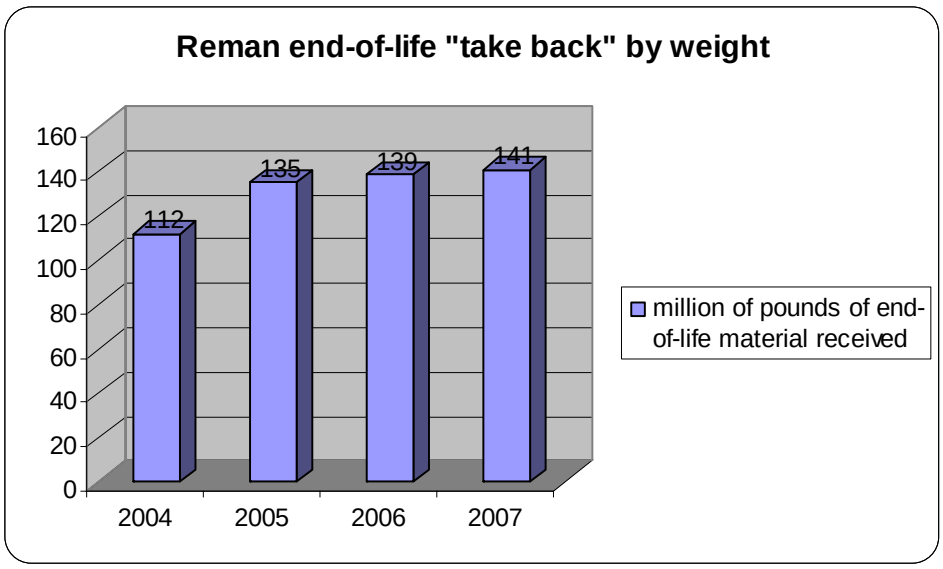


Figure 2.3.6: Caterpillar-Reman End-of-Life "Take Back" by Weight (2007)
(Source: Caterpillar 2007 Sustainability Report)

At the same time, number of certified rebuilds increased to 447 over 2001 base.

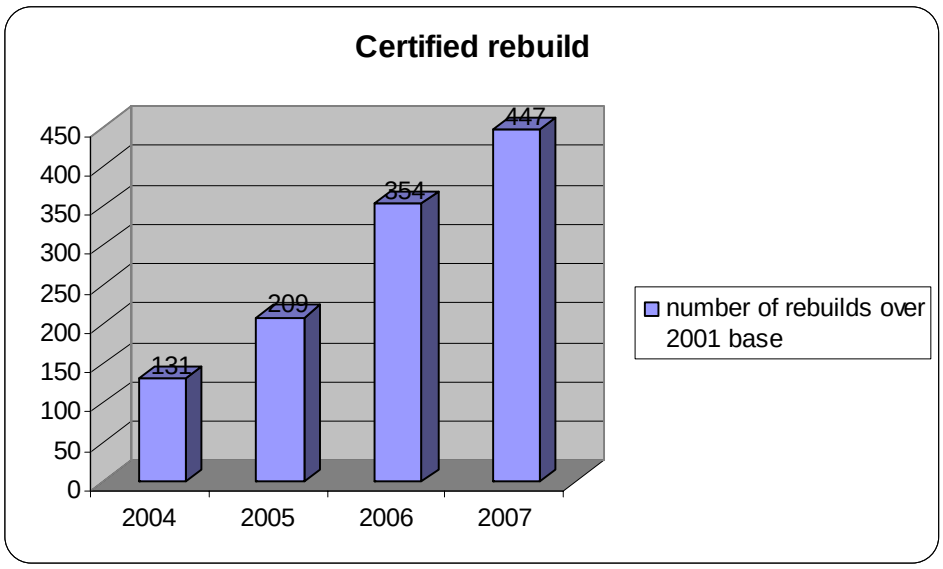


Figure 2.3.7: Caterpillar-Certified Rebuild (2007)
(Source: Caterpillar 2007 Sustainability Report)

2. Honda

Honda Motor Company, Ltd. is a Japanese multinational corporation known as a manufacturer of automobiles and motorcycles. It was founded in 1948 and headquartered in Minato, Tokyo. Honda is the world's largest manufacturer of motorcycles and internal combustion engines measured by volume.

Since the introduction of Japan's End-of-Life Vehicle Recycling Law in 2005, automakers have been obliged to recycle and properly dispose of shredder residue, airbags and CFCs (chlorofluorocarbon) and HFCs (hydrofluorocarbon). Honda has long been proactive in implementing product recycling. In 1991, Honda began recovering and recycling replacement bumpers and in 1998, it launched the sale of remanufactured parts. In 2004, they began recovering and recycling automobile oil filters and in 2007 Honda succeeded in recovery about 27% of all filters sold in Japan [162].

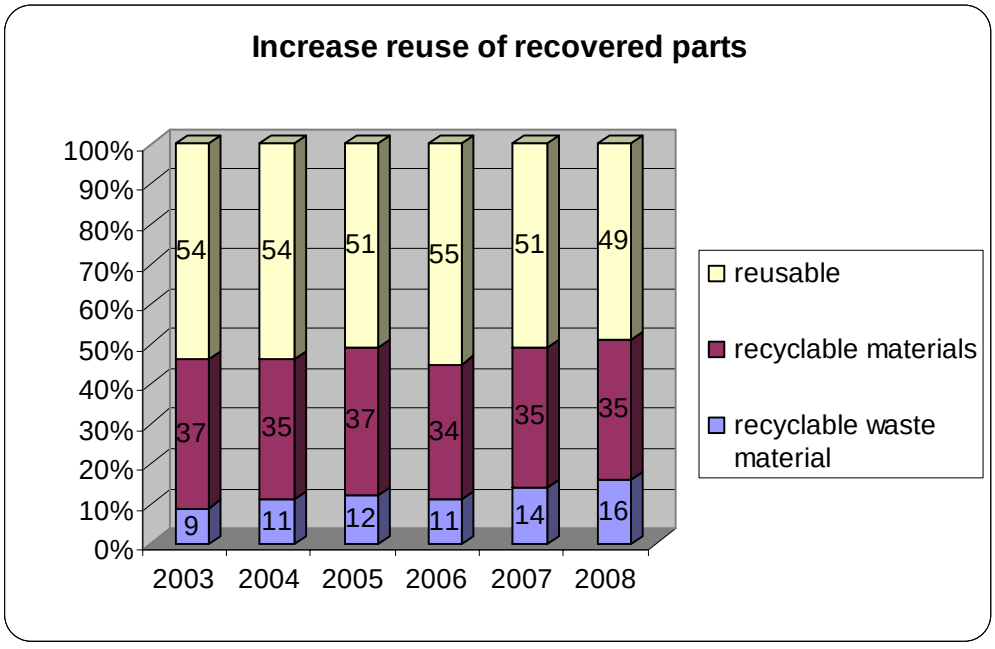


Figure 2.3.8: Honda-Increase Reuse of Recovered Parts (2008)
(Source: Honda Environmental Annual Report 2008)

[162] Honda Environmental Annual Report 2008, www.honda.com

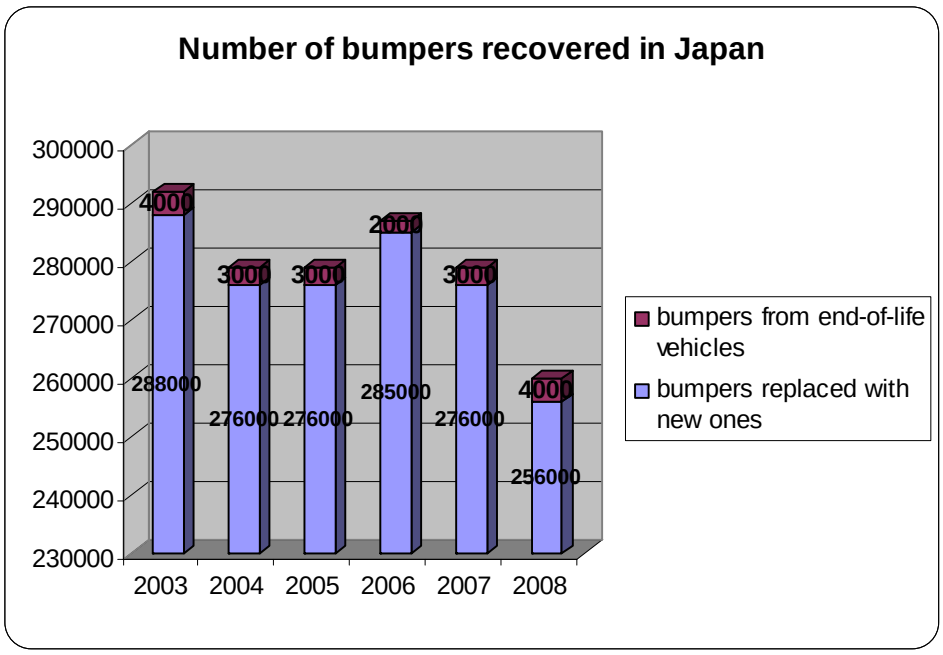


Figure 2.3.9: Honda-Number of Bumpers Recovered in Japan (2008)
(Source: Honda Environmental Annual Report 2008)

Since 1998 Honda has collected used batteries from customers through 72 sales locations in Japan and is expanding voluntary collection through cooperation with recovery agencies.

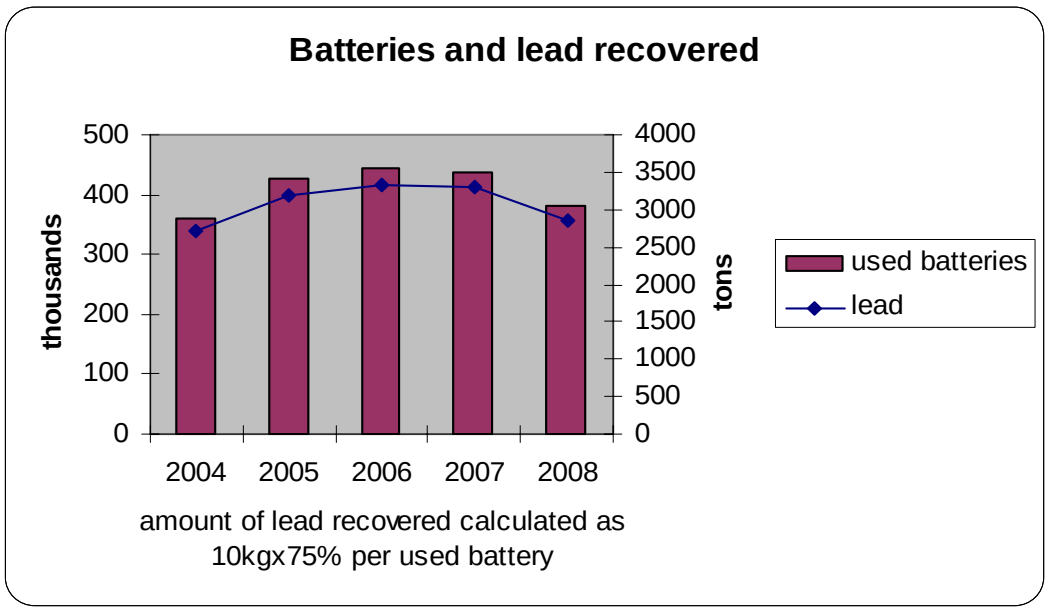


Figure 2.3.10: Honda-Batteries and Lead Recovered (2008)
(Source: Honda Environmental Annual Report 2008)

3. Mazda

Mazda Motor Corporation is a Japanese manufacturer and seller of passenger cars and commercial vehicles, founded by Jujiro Matsuda in 1920. Its' headquarter is located at Hiroshima, Japan.

Mazda has created a recycling and recovery process for end-of-life vehicles in cooperation with each automaker in Japan. According to the data of Mazda research and development division, approximately 80% (by weight) of an automobile consists of steel, aluminum, and other metals, which can be recycled. The remaining 20% is mostly plastics and glass, which is shredded before being recycled. Mazda is continuing research into automobile design and dismantling technologies oriented toward simplifying the recovery of parts and materials for reuse[163].

Mazda appropriately recovers three designated items -fluorocarbons, airbags and ASR[164] - as a result, the recovery ratio for end-of-life vehicles in 2007 was 95%.

In 2007, Mazda collected about 34,000 tons of ASR from approximately 200,000 vehicles. Of this total, they recovered 24,000 tons of ASR, reaching a recovery rate of 69%, in the same year; Mazda collected approximately 42,000 kilograms of fluorocarbons from approximately 138,000 vehicles and approximately 113,000 airbags from approximately 65,000 vehicles. The airbag recovery rate was 94%[165].

[163] Environmental Report, 2008, www.mazda.com
[164] Automobile shredder residue (ASR) is the residue that remains after the crushing/shredding of batteries, tires, fluids and other components needing processing; engines, bumpers and other items after the removal of valuable parts; and their separation and recovery as different metals., www.mazda.com
[165] Environmental Initiatives, www.mazda.com

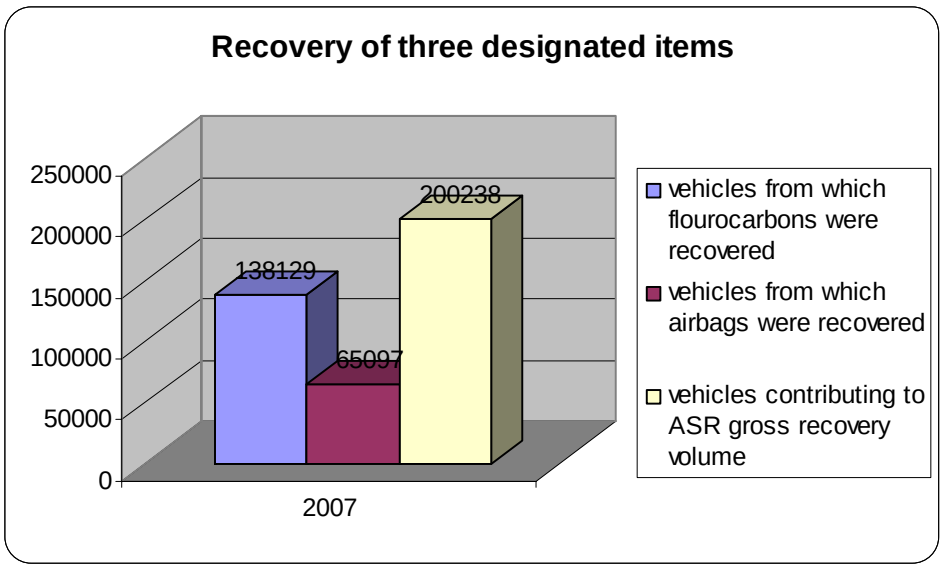


Figure 2.3.11: Mazda-Recovery of Three Designated Items (2008)
(Source: Mazda Environmental Report, 2008)

Mazda collects bumpers removed from vehicles for repair or replacement from its dealerships all around Japan, and recycles them into bumpers for new vehicles and other items[166].

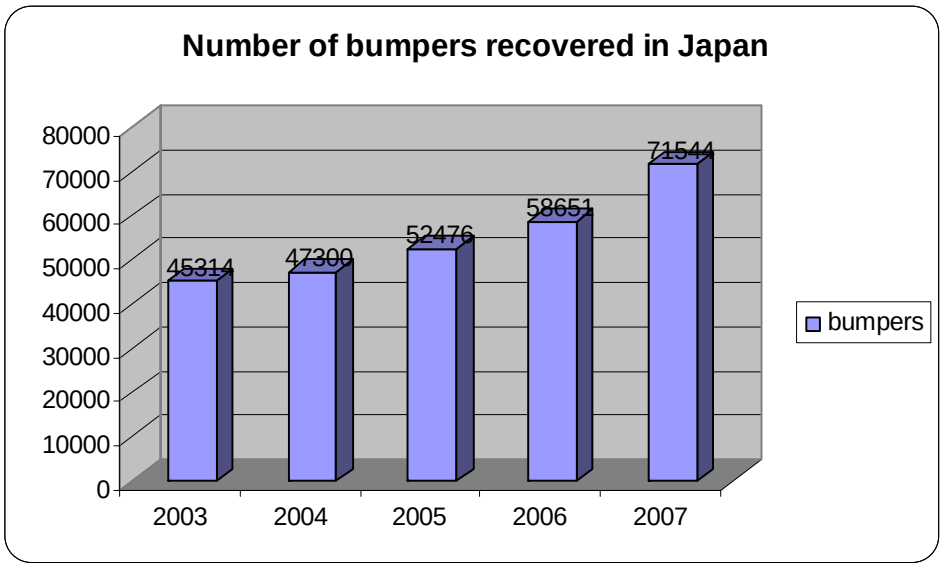


Figure 2.3.12: Mazda-Number of Bumpers Recovered in Japan (2008)
(Source: Mazda Environmental Report, 2008)

[166] Environmental Report, 2007, www.mazda.com

4. Toyota

Toyota Motor Corporation is a multinational corporation headquartered in Japan. Toyota is founded by Kiichiro Toyoda in 1937 and is the World's largest automaker, today. Toyota employs approximately 316,000 people worldwide.

In order to improve resource productivity, Toyota implemented various resource conservation measures such as improving steel and aluminum yields, reducing material loss due to defects, and reusing oils and fats by installing refining systems. As a result, the volume of waste not processed within TMC (Toyota Motor Company) was reduced to 1,802 thousand tons[167].

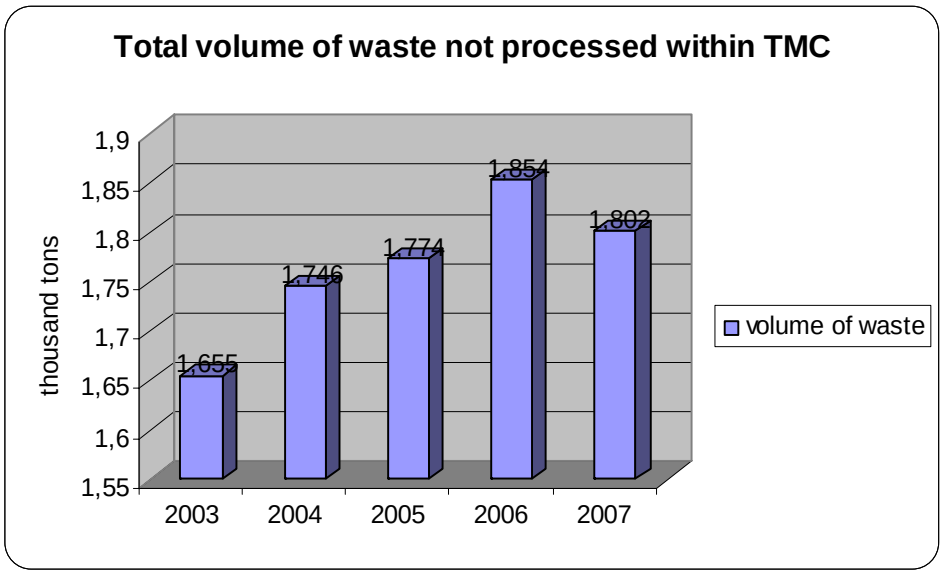


Figure 2.3.13: Toyota-Total Volume of Waste not Processed within TMC (2008)
(Source: Toyota Corporate Responsibility Report 2008)

In response to Japanese End-of-Life Vehicle Recycling Law of 2005, Toyota has been working with dismantling and recycling companies, and is reported to have made steady progress.

[167] Toyota Corporate Responsibility Report 2008, www.toyota.com

Table 2.3.1: Toyota- Recycling/Recovery Rate of Three Specified Items (2008)

Number of vehicles collected for ASR		961 000
Number of vehicles collected for airbag recovery		245 000
Number of vehicles collected for fluorocarbon recovery		705 000
Recycling/Recovery rate	ASR	76 %
	Airbags	94 %

(Source: Toyota Corporate Responsibility Report 2008)

Toyota has increased the ASR recycling/recovery rate, which reached 76% in 2007, surpassing the 70% standard required by the law for 2015 eight years in advance. As a result, Toyota has achieved the equivalent of a vehicle recycling/recovery rate of 96%, exceeding the company goal of 95% published in the Toyota Recycle Vision in June 2003.

Used parts and rebuilt parts are sold at dealers and parts distributors in Japan. To further promote the use of used and rebuilt parts, Toyota has also conducted market surveys, created response policies and distributed them to dealers and parts distributors. In 2007, 71 500 used parts and 28 600 rebuilt parts were sold.

Table 2.3.2: Toyota- Supply of Rebuilt Parts

Rebuilt Parts	**Number supplied**
Automatic transmissions	9 220
Power steerings	15 830
Torque coverters	3 513

(Source: Toyota Corporate Responsibility Report 2008)

In 2007, 874 000 end-of-life bumpers were collected and recycled (a recovery rate of 61.5%).

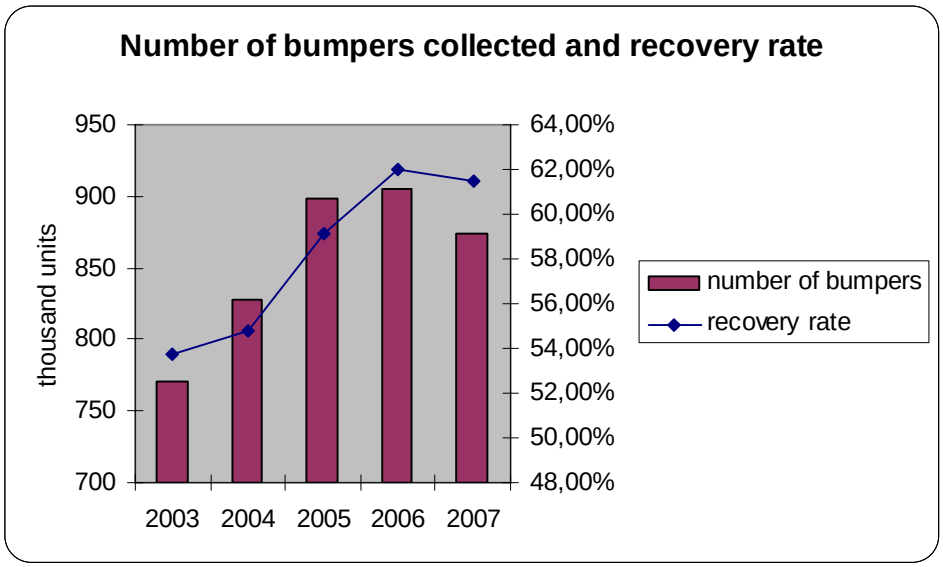


Figure 2.3.14: Toyota- Number of Bumpers Collected and Recovery Rate (2008)
(Source: Toyota Corporate Responsibility Report 2008)

D. COPYING AND IMAGING PRODUCTS

Copying machines and imaging products of various brands are another important example for remanufacturing. They are rebuilt or are subjected to upcycling (recycling by remanufacturing) either by independent remanufacturers or Original Equipment Manufacturers[168].

The remanufacturing activities of Kodak, Xerox and Lexmark will be analysed in this Section.

1. Kodak

Kodak was founded by George Eastman in 1880 and incorporated in 1901 in the State of New Jersey. Kodak is headquartered in Rochester, New York. Kodak's portfolio includes image capture and output devices, consumables and systems, and solutions for consumer, business and commercial printing applications.

Some of remanufacturing activities of Kodak are as follows:

- Kodak's single-use camera design has allowed nearly all camera parts to be reused or recycled in some manner. Even partially used batteries are offered to other companies for consumer reuse. In 2007, Kodak collected 120 million single-use cameras for remanufacturing. In fact, in 2007, virtually 100% of Kodak's single-use cameras were manufactured from recycled cameras and parts. Since 1990, 800 million Kodak single-use cameras have been remanufactured through the recycle program, and the surplus has been sent back to other manufacturers.
- Kodak also offers a "trade-in and trade-up" program for digital cameras. Partnering with DealTree (a provider of services and software products supporting product trade-in, returns management, product testing, and disposal and auction of over-stock, discontinued or returned merchandise), the program allows camera owners to trade in old digital cameras (regardless of brand) for a

[168] Steinhilper, 2006, pg. 75

cash rebate. The initiative, which began in 2006, results in digital cameras being re-used rather than discarded.

- Over the years, nearly 250 millions of pounds of mixed plastic and metal materials have been kept from the waste by recycling and remanufacturing activities.
- In 2007, Printer's Environmental Program (PEP) helped more than 400,000 customers find ways to avoid 42 millions of pounds of waste through recycling, reuse or refurbishment. The multi-faceted PEP initiative includes recycling/reuse programs for aluminum, equipment, parts, polyethylene terephthalate (PET), media, drums and totes, pallets, and end caps[169].

2. Xerox

Xerox Corporation is a document management technology and services enterprise. Xerox provides digital systems include color and black-and-white printing and publishing systems, digital presses, multifunction devices, laser and solid ink network printers, copiers and fax machines.

In the 1990s, Xerox pioneered remanufacturing for office equipment. Since then, remanufacturing and recycling of Xerox products have given life to the equivalent of more than 2.8 million document devices while diverting over 2 billion pounds of waste from landfills[170]. Xerox designs its machines for easy disassembly, durability, so as to contain fewer parts and control for chemical content. Equipment returned to Xerox at end-of-life can be remanufactured to as-new performance specifications.[171].

Equipment remanufacture and the reuse and recycling of parts diverted 147 million pounds of waste from landfills in 2003.

[169] Eastman Kodak Company 2007 Annual Report, www.kodak.com
[170] Environmental Sustainability at Xerox 2008, www.xerox.com
[171] Xerox Environmetal Overwiev 2009, www.xerox.com

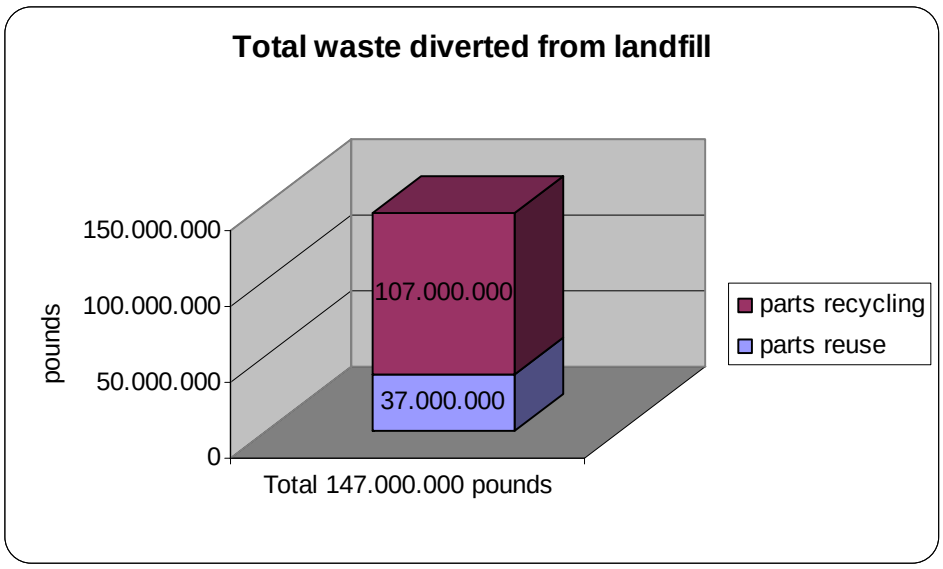


Figure 2.4.1: Xerox-Equipment Remanufacture and Parts Reuse/Recycle (2003)
(Source: Environment Commitment Brochure 2003)

Partnerships with customers have helped make the Xerox program a success. In total, Xerox's supplies return program prevented more than 17 millions of pounds of waste from entering landfills in 2003[172].

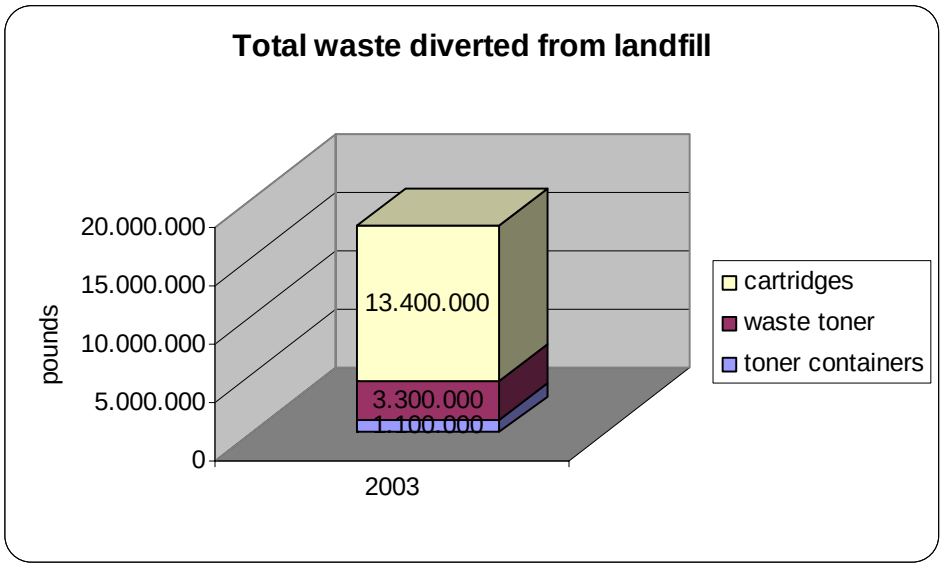


Figure 2.4.2: Xerox-Supplies Return Program (2003)
(Source: Environment Commitment Brochure 2003)

[172] Environment Commitment Brochure 2003, www.xerox.com

Through the Xerox Green World Alliance, consumers are encouraged to return toner cartridges and containers to Xerox for recycling. More than 2.7 million cartridges and containers are returned every year. Company process for reuse 1.3 million pounds of post-consumer waste toner[173].

The Xerox Green World Alliance reuse/recycle program has resulted in more than 1.9 million cartridges and toner containers being returned in 2007. Company processed 1.2 million pounds of post-consumer waste toner for reuse[174].

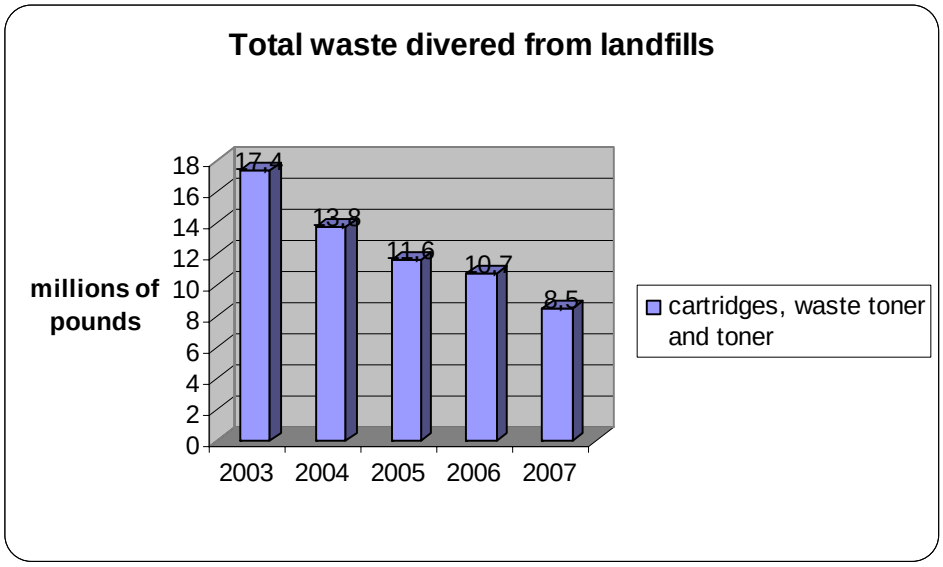


Figure 2.4.3: Xerox-Green World Alliance (2008)
(Source: Xerox Citizenship Report 2008)

[173] Environmental Sustainability at Xerox 2008, www.xerox.com
[174] Xerox Citizenship Report 2008, www.xerox.com

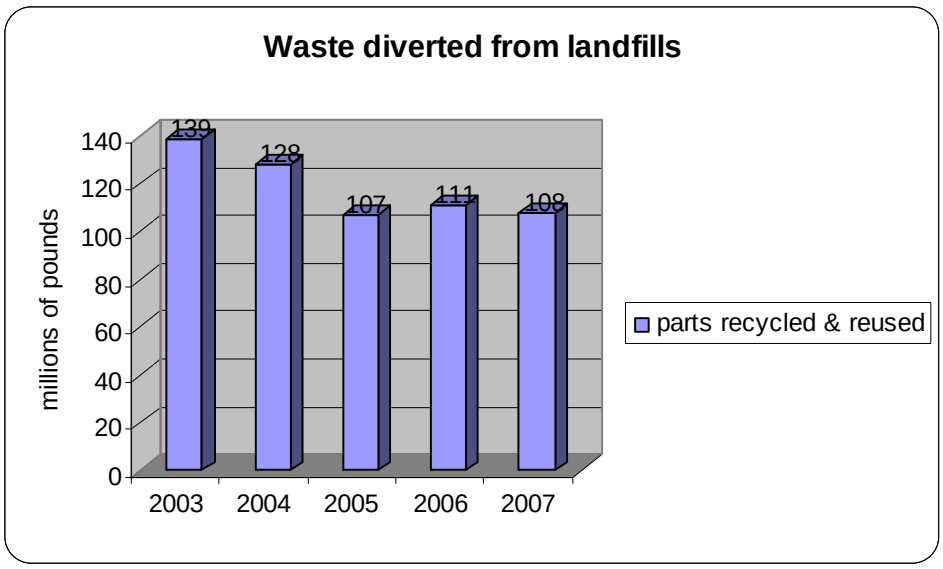


Figure 2.4.4: Xerox-Waste Diverted from Landfills through Parts Reuse/Recycle (2008)
(Source: Xerox Citizenship Report 2008)

The annual trend in reduction in waste diverted from landfills since 2003 is due in part to changes in product mix, design of lighter-weight machines and the growth of regulatory-driven local recycling schemes[175].

3. Lexmark

Lexmark International, Inc. is a manufacturer and supplier of printing and imaging solutions for offices and homes. Since separating from IBM in 1991, Lexmark's product line has expanded to include laser printers, inkjet printers, and multifunction devices, as well as associated supplies and services.

The Lexmark Cartridge Collection Program continues to divert millions of Lexmark toner and inkjet cartridges from landfills annually by enabling consumers to return used print cartridges to Lexmark free of charge for reuse or recycling[176].

[175] Xerox Citizenship Report 2008, www.xerox.com
[176] Lexmark Corporate Responsibility Report 2008, www.lexmark.com

From 1996 to 2008, the number of toner cartridges Lexmark collected grew 23 fold.

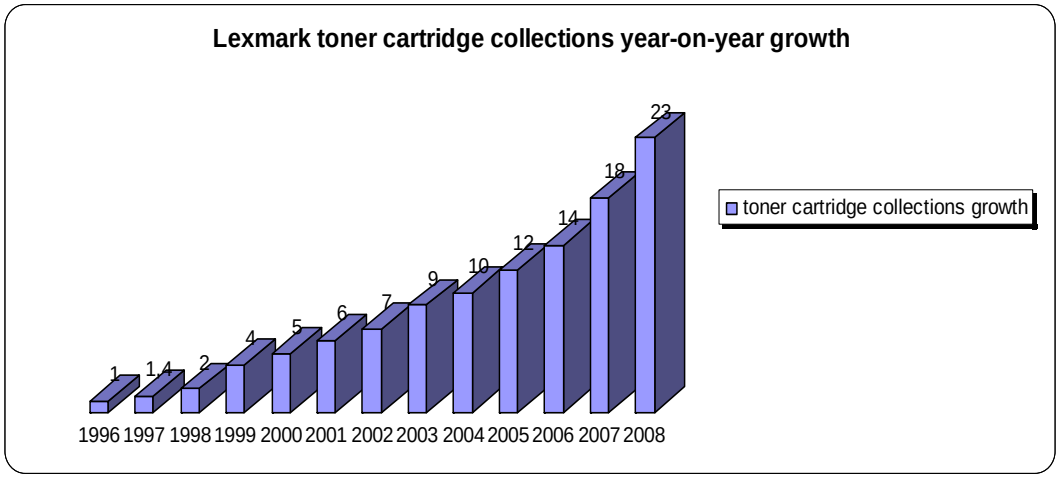


Figure 2.4.5: Lexmark-Toner Cartridge Collections Growth (2008)
(Source: Lexmark Corporate Responsibility Report 2008)

The percentage of inkjet cartridges Lexmark collects is reported to be growing steadily each year as well. Lexmark began collecting and recycling inkjet cartridges in 2004, and by 2008 it has reported to have achieved 830 percent of growth.

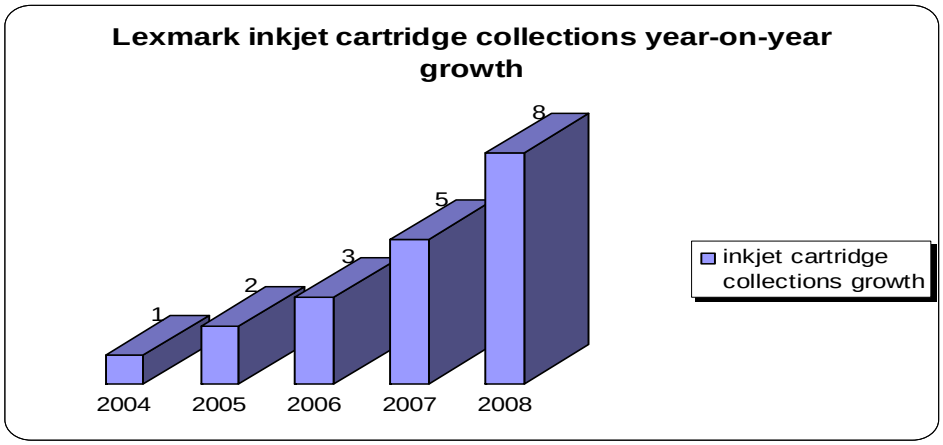


Figure 2.4.6: Lexmark-Inkjet Cartridge Collections Growth (2008)
(Source: Lexmark Corporate Responsibility Report 2008)

In 2008 alone, Lexmark recycled or reused more than 8,000 tons of plastic, metals and packaging.

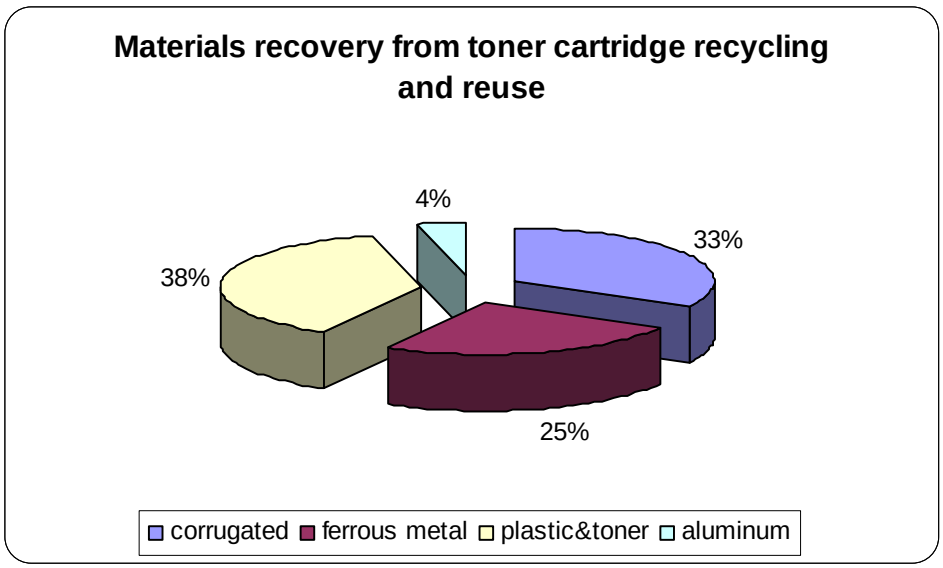


Figure 2.4.7: Lexmark-Materials Recovery from Toner Cartridge Recycling and Reuse (2008)

(Source: Lexmark Corporate Responsibility Report 2008)

E. ELECTRONIC PRODUCTS AND PARTS

If one were to look into the product return collection centers and used products' warehouses in the electronic industry, one could easily be impressed by the large quantity of products. Furthermore, these locations fill up with what looks like *new* electronic products. Used electronic products don't just look like new, in fact, 80% of them are still working. Personal computers, supermarket cashier equipment, cellular phones, etc. are the primary subjects for remanufacturing of electronic products[177].

Dell, Hewlett Packard and Nokia are the companies providing some of the finest examples of the remanufacturing activities in the electronic products and parts industry.

1. Dell

Dell Inc. was founded in 1984 by Michael Dell. It offers a broad range of products in the following categories: desktop computer systems, servers and networking products, mobility products, software and peripherals, and services[178].

Through Dell's Reduce, Reuse, Recycle (R3) program, all Dell manufacturing facilities have permanent reuse and recycling operations that are reported to have resulted in significant waste reductions. These sites collect more than 20 different materials including cardboard, office paper, plastics, metals, and pallets. In 1998, these R3 efforts increased global recycling and reuse by 14,667 tons over the previous year, diverting more than 75 percent of non-hazardous solid wastes from landfills[179].

[177] Steinhilper, 2006, pg. 76
[178] Dell Corporate Responsibility Report 2008, www.dell.com
[179] Dell Environmental Progress Report 1999-2000, www.dell.com

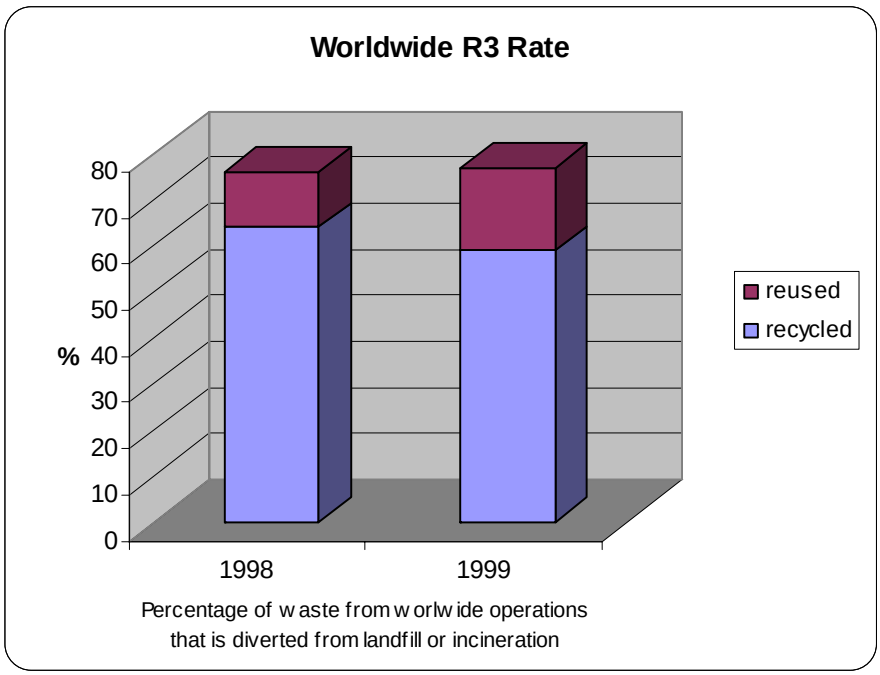


Figure 2.5.1: Dell-Worldwide R3 Rate (2000)
(Source: Dell Environmental Progress Report 1999-2000)

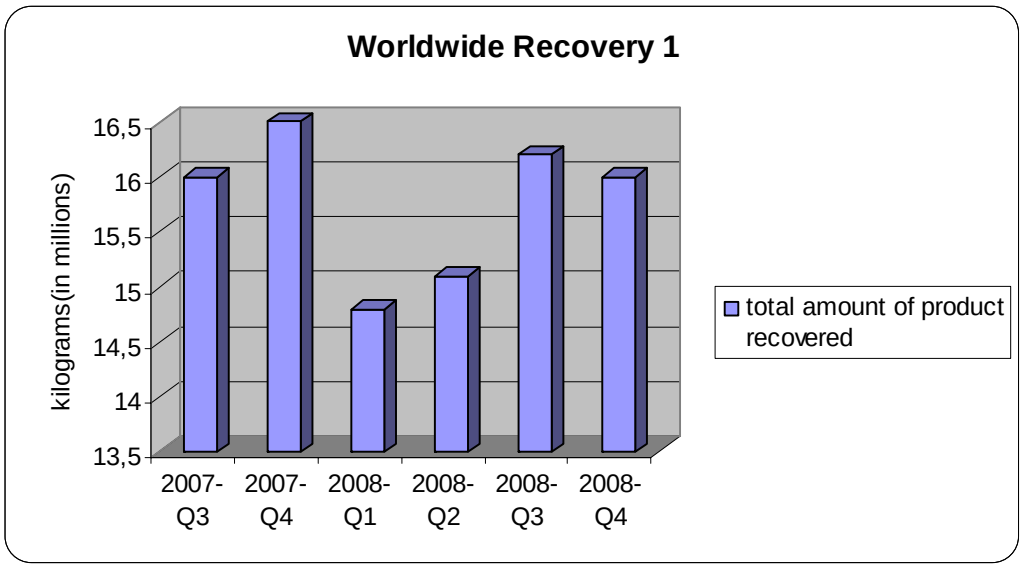


Figure 2.5.2: Dell-Worldwide Recovery 1 (2008)
(Source: Dell Corporate Responsibility Report 2008)

Figure 2.4.2, above, shows the total amount of product recovered worldwide by Dell, over the past six fiscal quarters; it includes all external (commercial and consumer)

take-back programs and internal recycling (for example, spare manufacturing parts); whereas Figure 2.4.3, below sets out the total amount of the customer product recovered in the same period. Dell offers consumer and business customers a variety of convenient options to reuse and recycle computer products[180].

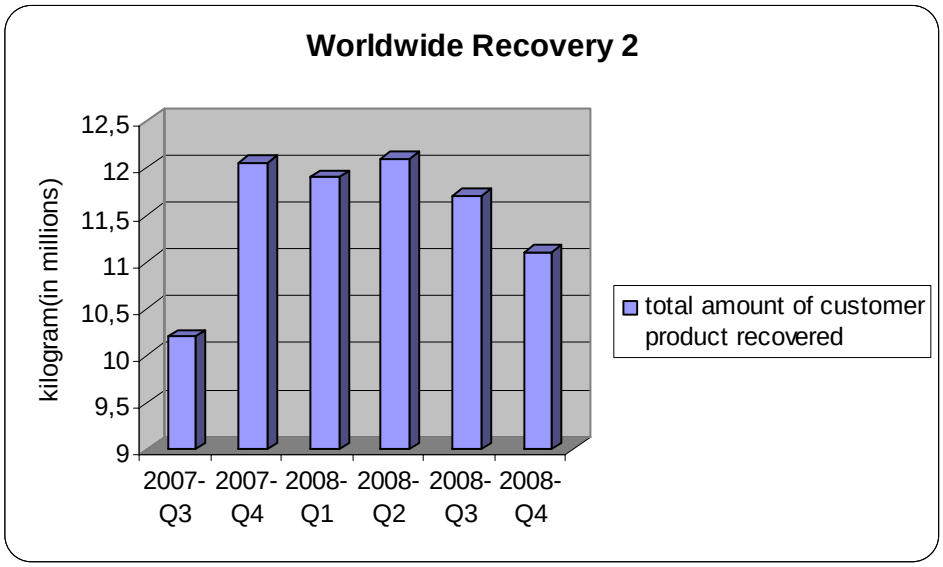


Figure 2.5.3: Dell-Worldwide Recovery 2 (2008)
(Source: Dell Corporate Responsibility Report 2008)

2. Hewlett Packard

Stanford University classmates Bill Hewlett and Dave Packard founded HP in 1939. Corporate headquarters are in Palo Alto, California and HP is among the world's largest IT companies, with revenue totalling USD 118.4 billions for the fiscal year of 2008. HP has three main business groups, namely, the Personal Systems Group, for business and consumer PCs, mobile computing devices and workstations, the Imaging and Printing Group, for ink, laser and commercial printing machines, printing supplies, digital photography and entertainment; and the Technology Solutions Group, for business products including storage and servers, EDS, managed services and software.

[180] Dell Corporate Responsibility Report 2008, www.dell.com

HP's repair and refurbishment programs are reportedly aiming at reducing environmental impacts and making IT equipment accessible to more people. Refurbished products come from various sources, including customer returns and cancelled orders, demonstration and trial units, overstocks, products damaged during shipping, and lease returns. These products are carefully inspected, refurbished or remanufactured, and re-boxed to offer a high quality, low cost solution with an HP warranty. HP is refurbishing colour LaserJet printers, black & white LaserJet printers, colour Inkjet printers, digital projectors, handhelds and PCs.

In 2007, HP collected approximately 3 million hardware units weighing 28,500 tons (63 millions of pounds) for reuse and recovering, with an increase of more than 31 % compared to 2006.

In 2008, HP:

- Recovered for reuse 3.5 million hardware units weighing 75 millions of pounds (34,000 tonnes), corresponding to an increase of more than 16 % when compared with 2007.
- More than 44,500 units of equipment collected (nearly 70 %) were remanufactured and resold, with the remaining being recycled. By reclaiming such a large percentage for reuse, HP saved more than USD 1.75 million.
- With a total of 1.71 billion pounds (775,510 metric tonnes) of electronic products and supplies recovered until date – HP is on track to meet its goal to recycle 2 billions of pounds (900,000 metric tonnes) of products by the end of 2010 (since 1987) and to reuse 450 millions of pounds (200,000 metric tonnes) of products by the end of 2010 (since 2003). HP has, until date, recycled 1.435 million pounds (650,000 metric tonnes) of products, of which more than 275 millions of pounds (125,000 metric tonnes) have been reused[181].

[181] HP Reports Social and Environmental Performance and Goals for Fiscal Year 2008, www.hp.com

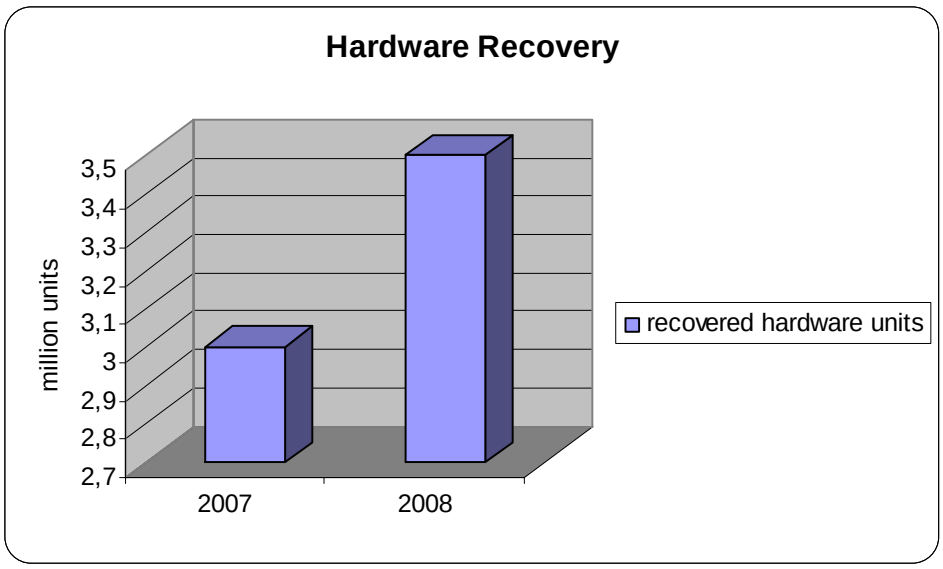


Figure 2.5.4: HP-Hardware Recovery (2008)
(Source: HP Reports Social and Environmental Performance 2008)

3. Nokia

Nokia Corporation is a Finnish multinational communications corporation headquartered in Keilaniemi, Espoo. The company founded in 1871 by Fredrik Idestam. Nokia is engaged in the manufacturing of mobile devices and in converging Internet and communications industries, with 128,445 employees in 120 countries and sales in more than 150 countries. It is the world's largest manufacturer of mobile telephones.

The company's reported goal in the remanufacturing activities is to reduce all waste to a minimum, especially the waste destined to end up untreated in landfills, as end-of-life handsets contain many valuable materials which can be recovered and reused in manufacturing new products. Up to 80% of the materials in an old phone can be reused in this way. Today, by resorting to the best available recycling techniques, everything can be recovered from a mobile phone and nothing goes to landfill[182].

In 2008 Nokia managed to decrease both the total waste amount and waste per device compared to previous year. Utilised waste includes waste that has been either

[182] Nokia Corporate Responsibility Report 2008, www.nokia.com

reused, recycled of which the energy has been utilised. Remaining waste has been either sent to landfill or incinerated without energy recovery.

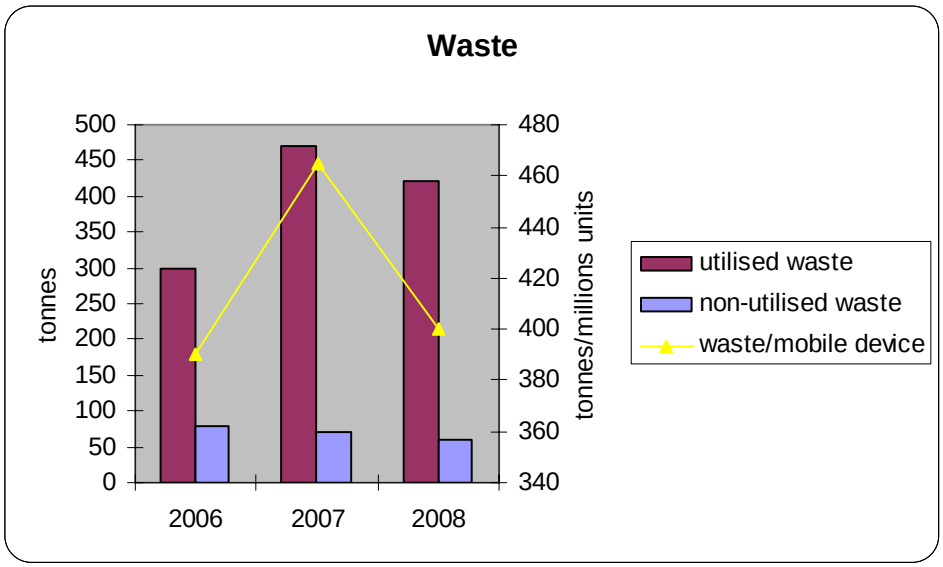


Figure 2.5.5: Nokia-Waste Key Data (2008)
(Source: Nokia Corporate Responsibility Report 2008)

Table 2.5.1: Nokia-Waste Data from Nokia Facilities

	2008	**2007**	**2006**
Waste	tonnes	tonnes	Tonnes
All Waste Total	48 250	52 830	36 330
Utilisation rate %	88 %	88 %	83 %
Solid Waste Total	48 000	52 500	36 100
Utilisation rate %	88 %	88 %	83 %
Other Waste Total	250	330	230
Utilisation rate %	52 %	63 %	62 %

(Source: Nokia Corporate Responsibility Report 2008)

In 2008, 88 % of the total waste reused, remanufactured or recycled by Nokia. It includes solid waste and other waste that are considered separate from solid waste streams because of their special nature.

All of the quantitative data of different industries can verify the importance of remanufacturing for these companies, especially the efforts about to develop and spread these activities worldwide.

The remanufacturing business of Caterpillar, marked a growth of 110 %, from 2001 to 2007. In 2007, 141 millions of pounds of end-of-life materials have been received by Caterpillar and 93 % of the returns have been remanufactured. In the year 2008, 260,000 bumpers have been recovered in Japan by Honda; whereas in the year 2007, Mazda and Toyota (worldwide) had respectively recovered 71,544 and 874,000 bumpers. Honda, in the year 2008, recovered 27 % of all oil filters in Japan, and in 2007, the recovery rate of Mazda for end-of-life vehicles was at 95 %.

The above data relating to automotive and engine remanufacturing is a clear indication of the importance (in size) and the annual growth propensity of this sector. With the ever increasing consumer awareness, the demand for remanufactured parts is on the rise, and the return for remanufacturing of end-of-life or damaged or reusable parts to producers is becoming more and more common. Furthermore, companies institute various systems and cooperate for return of relevant products, announcing these to the consumers. They sustain the growth of this sector by subscribing to, and fulfilling statutory remanufacturing standards, before the timelines prescribed by the regulatory requirements.

In 2007, 120 million single use cameras were collected for remanufacturing by Kodak. In the same year Xerox collected 8.5 million pounds of cartridges, toner and waste toner. As a result of recycling, reuse or remanufacturing activities, each of Kodak, Xerox and Lexmark have kept from landfills, respectively 42 millions, 108 millions and 17 millions of pounds of waste, in the year 2007.

Technological advances realized by the manufacturers of copying and imaging products on the re-evaluation of reusable and remanufacturable parts prevent the disposal –as waste- of tonnes of products. A number of return systems have been developed and implemented and partnerships through the supply chain have been

instituted, to allow returns of reusable and remanufacturable parts by the consumers, to the producers. The design for remanufacturing approach implemented by the companies further facilitates these activities.

In 2008, approximately 72,000 tonnes of products have been recovered by Dell, whereas HP has recovered for reuse 3.5 million of hardware units. From 44,500 units of equipment recovered by HP, 70 % was remanufactured and sold. Nokia collected 48,250 tonnes of waste in 2008 and 88 % of the recovered waste has been reused, remanufactured or recycled.

Each year computer and mobile phone industry recovers tonnes of still usable products through various programmes and co-operations, free of any charge in general. As a result of these recovery efforts, many reusable parts and valuable materials are saved from being dumped into landfills.

Different data relating to these different sectors all point out the same conclusion: remanufacturing activities do not begin at the time of return of a product, but rather, these activities begin at the designing stage. In the event the remanufacturing of the components is taken into consideration while designing a product, remanufacturing activities can be performed on a more effective and cost efficient manner. In conjunction with the above, companies may further increase the efficiency of their remanufacturing activities by implementing co-operations processes.

CONCLUSION

Reverse logistics is not simply a process for disposition of returned products; it requires a thorough analysis as to why and how the products are returned and on the most efficient way of disposal, following which implementation of a combination of several complicated and difficult processes is needed.

Oftentimes, a single correct approach for reverse logistics functions does not exist, since an effective implementation of this function involves answering many questions, such as, does the returned product originate from the end customer or from another member of a supply chain; is the product concerned at the end of its useful life or is it "simply" damaged; which parts of the product concerned may be reused; does the product contain any valuable materials which can be recovered; can the product be re-used after repairs or refurbishing; is remanufacturing required; does it make sense to recycle the product, or, is disposal of the product concerned as waste material the only viable option. While companies may have several options, depending on the product and conditions, implementation of cost expensive and unprofitable practices on this domain also are in the realm of possibility, because of social responsibility concerns.

In conjunction with the above, divergent regulatory requirements give rise to differing reverse logistics practices throughout the World. Products which are recycled or dismantled to harmless elements in some countries are simply dumped, as is, into landfill zones, in others. Further, while some countries endeavour to increase consumer awareness on the subject matter, there is no work being done whatsoever in others.

Remanufacturing is –arguably- the most attractive aspect of the reverse logistics activities. In the course of remanufacturing, the product concerned is disassembled completely; following a thorough clean-up, damaged components are replaced and the

product is reassembled. This process allows restoration of a product which is at the end of its useful life to “like new” standards. It further prevents wasting of still-usable components of a product and allows a production with smaller amounts of energy and natural resources than what is required for a brand new product, thusly enabling significant reductions on the consumption of energy and natural resources.

The information obtained from TATKAP indicates that reuse of worn out tires after retreading helps delaying formation of deposits of junk tires, contributes to the protection of the environment and allows substantial savings in raw materials i.e. 120 liters of petroleum per tire. Furthermore, retreading allows up to 60 % of savings in costs for businesses. These points not only confirm the beneficial effect of remanufacturing activities for both the manufacturing businesses and the consumers, but also, demonstrate the positive impact of the same activities, on the economy and on the environment, on a more global level.

In conjunction with the foregoing, we note that remanufacturing activities performed by many corporations active in different sectors have greatly increased in the course of the recent years. Many consumers opt for remanufactured products because of their relatively reduced prices and, more importantly, because of environmental sensitivities; consequently remanufacturing is on the rise, in concurrence with the increasing consumer demand.

Notwithstanding the above, there are only a handful of remanufacturing practices in our Country. Current lack of legal background, coupled with the absence of awareness on the subject matter hinder any development of remanufacturing activities, which activities involve processes much more complicated than mere recycling. It is also worth noting that, despite its relative simplicity, recycling itself is yet to be systematically and widely implemented in Turkey.

To sustain remanufacturing activities, companies should establish structures for the collection, from the consumers, of products to be submitted for remanufacturing and concurrently create and sustain the demand, by informing the consumers that

remanufactured products have the same quality of standards than a new product. Consumer focused dimension of the activities set aside, companies need to adjust their production processes and perform researches so as to implement remanufacturing activities in the most efficient fashion.

Together with the governmental institutions' duties to enact regulatory principles and companies' duties of increasing the public awareness on this domain, an important part to play befalls on educational institutions. Waste disposal activities should be taught in detail as early as the elementary school and a consciousness should be formed on this topic. Environmental-friendly teachings like the need of disposal of recyclable materials (such as paper, glass, plastic and metal) or hazardous products (such as batteries) in particular places and in accordance with their specificities, should be infused to individuals as early as at the childhood. Individuals brought up with these notions affirming the importance of the protection of the environment and the preservation of natural resources would, undoubtedly, be much more sensitive to the importance and value of remanufacturing activities and to the usage of remanufactured products.

BIBLIOGRAPHY

Anderson, H., Brodin, M. H., "The consumer's changing role: the case of recycling", *Management of Environmental Quality: An International Journal*, Vol. 16, No. 1, 2005, Emerald Library

Autry, C. W., Daugherty, P. J., Richey, R. G., "The challenge of reverse logistics in catalog retailing", *International Journal of Physical Distribution & Logistics Management*, Vol.31, No.1, 2001, Emerald Library

Ballou, R. H., **Business Logistics/Supply Chain Management, Planning, Organizing, and Controlling the Supply Chain**, Pearson Education, New Jersey, 2004

Bayles, D. L., **E-Commerce Logistics and Fulfillment Delivering the Goods**, Prentice Hall, New Jersey, 2001

Bloomberg, D. J., Lemay, S., Hanna, J. B., **Logistics**, Prentice Hall, New Jersey, 2002

Bowersox, D. J., Closs D. J., Cooper, M. B., **Supply Chain Logistics Management**, McGrawHill, New York, 2002

Breen, L., "Give me back my empties or else! A preliminary analysis of customer compliance in reverse logistics practices (UK)", *Management Research News*, Vol. 29, No. 9, 2006, Emerald Library

Cain, R., **How to Turn Returns Into Revenue**, *Transport Topics;* Jan 21, 2008; 3776; ABI/INFORM Trade & Industry

Chopra, S., Meindl, P., **Supply Chain Management Strategy, Planning, and Operation**, Pearson & Prentice Hall, New Jersey, 2007

Coyle, J. J., Bardi, E. J., Langley, Jr, C. J., **The Management of Business Logistics,** West Publishing Company, USA, 1996

Dibenedetto, B., **Reverse Logistics: Be prepared**, *The Journal of Commerce*; New York, Sep 3, 2007, Business Source Complete

Doughton, M., **Incorporate Logistics Into Your Sustainability Goals**, *Food Logistics*, June, 2008, ABI/INFORM Global

Flygansvaer, B. M., Gadde, L.-E., Haugland, S. A., "Coordinated action in reverse distribution systems", *International Journal of Physical Distribution & Logistics Management*, Vol.38, No.1, 2008, Emerald Library

French, M. L., Discenza, R., "Returns in process industries: a managerial perspective", *Management Research News,* Vol 29 No.12, 2006, Emerald Library

Gourdin, K. N., **Global Logistics Management A Competitive Advantage for the New Millenium,** Blackwell Business, USA, 2001

Gray, C., Charter, M., "Remanufacturing and Product Design", The Center for Sustainable Design, UK, 2007

Gujarati, D. N., **Basic Econometrics**, McGraw-Hill, New York, 2003

Gurtoo, A., Antony, S.J., "Environmental regulations", *Management of Environmental Quality: An International Journal*, Vol. 18, No. 6, 2007, Emerald Library

Halldorsson, A., **Reverse Logistics,** *Supply Management;* Jan 31, 2008; 13, 3; ABI/INFORM Global

Handfield, R. B., Nichols, Jr., E. L., **Introduction to Supply Chain Management**, Prentice Hall, New Jersey, 1999

Hindo, B., **Cleaning Up With Reverse Logistics**, *Business Week*, April 8, 2008, Issue 4094, Business Source Complete

Hoffman, W., **Dell in reverse**, *Journal of Commerce*, New York, Sep 4, 2006, Business Source Complete

Hugos, M., **Essentials of Supply Chain Management**, John Wiley&Sons, Inc., New Jersey, 2003

Johnson, J. C., Wood, D. F., Wardlow, D. L., Murphy, Jr., P. R., **Contemporary Logistics,** Prentice Hall, New Jersey, 1999

Kasilingam, R. G., **Logistics and Transportation Design and Planning**, Kluwer Academic Publishers, Netherlands, 1998

Kator, C., **The logistics of a recall**, *Modern Materials Handling*, Sept 2007, Business Source Complete

Kroon, L., Vrijens, G., "Returnable containers: an exemple of reverse logistics", *International Journal of Physical Distribution & Logistics Management*, Vol. 25, No. 2, 1995, Emerald Library

Lambert, D. M., Cooper, M. C., Pagh, J. D., "Supply Chain Management: Implementation Issues and Research Opportunities", *The International Journal of Logistics Management,* Vol. 12, No. 2, 2001, Emerald Library

Lin, B., Jones, C. A., Hsieh, C., "Environmental practices and assesment: a process perspective", *Industrial Management & Data Systems*, Vol. 101, No. 2, 2001, Emerald Library

Long, D., **International Logistics: Global Supply Chain Management**, Kluwer Academic Publishers, USA, 2003

Martinez, R., **Returns to Sender**, *Multichannel Merchant;* June 2008; ABI/INFORM Global

Mentzer, J. T., editor, **Supply Chain Management**, Sage Publications, Inc., USA, 2001

Mollenkopf, D., Russo, I., Frankel, R., "The returns management process in supply chain strategy", *International Journal of Physical Distribution & Logistics Management,* Vol. 37, No. 7, 2007, Emerald Library

Murray, S., **Hidden beauty of the 'uglies'**, *Financial Times;* London (UK): May 17, 2007; Business Source Complete

Newbold, P., Carlson, W. L., Thorne, B., **Statistics for Business and Economics**, Pearson Education, New Jersey, 2007

O'Connell, A., **Improve Your Return On Returns**, *Harward Business Review*; Nov 2007; ABI/INFORM Global

Prendergast, G. P., "The EC directive on packaging and packaging waste: current status and logistical implications", *Logistics Information Management*, Vol. 8, No. 3, 1995, Emerald Library

Rao, P., Holt, D., "Do green supply chains lead to competitiveness and economic performance?", *International Journal of Operations & Production Management*, Vol. 25, No. 9, 2005, Emerald Library

Richey, R. G., Genchev, S. E., Daugherty, P. J., "The role of resource commitment and innovation in reverse logistics performance", *International Journal of Physical Distribution & Logistics Management*, Vol. 35, No. 4, 2005, Emerald Library

Rogers, D. S., Lambert, D. M., Croxton, K. L., García-Dastugue, S. J., "The Returns Management Process", *The International Journal of Logistics Management,* Vol. 13, No. 2, 2002, Emerald Library

Rogers, D. S., Tibben-Lembke, R. S., **Going Backwards: Reverse Logistics Trends and Practices**, University of Nevada, Center for Logistics Management, 1999

Rushton, A., Oxley, J., Croucher, P., **The Handbook of Logistics and Distribution Management**, Kagan Page, Glasgow, 2000

Samii, A. K., **Strategic Logistique Supply Chain Management**, DUNOD, Paris, 2004

Sarkis, J., "Manufacturing's role in corporate environmental sustainability", *International Journal of Operations & Production Management*, Vol. 21, No. 5/6, 2001, Emerald Library

Skinner, L. R., Bryant, P. T., Richey, R. G., "Examining the impact of reverse logistics disposition strategies", *International Journal of Physical Distribution & Logistics Management*, Vol. 38, No. 7, 2008, Emerald Library

Skjoett-Larsen, T., "European logistics beyond 2000", *International Journal of Physical Distribution & Logistics Management,* Vol. 30 No.5, 2000, Emerald Library

Srivastava, S. K., Srivastava, R. K., "Managing product returns for reverse logistics", *International Journal of Physical Distribution & Logistics Management*, Vol. 36, No. 7, 2006, Emerald Library

Steinhilper, R., "Remanufacturing The ultimate form of Recycling", Fraunhofer IRB Verlag, Stuttgart, Germany, 2006

Stuart, J. A., Bonawi-tan, W., Loehr, S., "reducing costs through improved returns processing", *International Journal of Physical Distribution & Logistics Management*, Vol. 35, No. 7, 2005, Emerald Library

Tibben-Lembke, R. S., Rogers, D. S., "Differences between forward and reverse logistics in a retail environment", *Supply Chain Management: An International Journal*, Vol. 7, No. 5, 2002, Emerald Library

Tibben-Lembke, R. S., "Life after death: reverse logistics and the product life cycle", *International Journal of Physical Distribution & Logistics Management*, Vol. 32, No. 3, 2002, Emerald Library

Trebilcock, B., **Outsourcing reverse logistics**, *Modern Materials Handling*, June 2008, Business Source Complete

Turnbull, L., **the real reason for reverse logistics**, *Canadian Transportation Logistics*, Oct 2007, Vol. 110, No. 10, ABI/INFORM Trade&Industry

Walther, G., Spengler, T., "Impact of WEEE-directive on reverse logistics in Germany", *International Journal of Physical Distribution & Logistics Management*, Vol. 35, No. 5, 2005, Emerald Library

Wisher, J. D., Leong, G. K., Tan, K. C., **Principles of Supply Chain Management: A Balanced Approach**, Thomson South-Western, USA, 2005

Wu, H.-J., Dunn, S. C., "Environmentally responsible logistics systems", *International Journal of Physical Distribution & Logistics Management*, Vol.25, No.2, 1995, Emerald Library

INTERNET SOURCES

- Kanungo, A. K., **Remanufacturing: India needs to be alert**, 2008, www.rediff.com
- Council of Supply Chain Management Professionals, www.cscmp.org
- www.ism.sw
- Supply Chain Council, www.supply-chain.org
- Reverse Logistics Association, www.reverselogisticsassociation.org
- Reverse Logistics Executive Council, www.rlec.org
- Practising Law Institute, www.pli.edu
- Integrated Products Manufacturing Knowledge Transfer Network, www.integratedproductsktn.org.uk
- Production Engine Remanufacturers Association, www.pera.org
- The Remanufacturing Institute, www.reman.org
- Material Handling Management, www.mhmonline.com
- Automotive Parts Remanufacturers Association, www.apra.org
- National Center for Remanufacturing and Resource Recovery, www.reman.rit.edu
- www.en.wikipedia.org/wiki/Restriction_of_Hazardous_Substances_Directive
- http://ec.europa.eu/environment/waste/weee/index_en.htm
- http://ec.europa.eu/environment/waste/elv_index.htm
- http://ec.europa.eu/environment/waste/batteries/index.htm
- http://ec.europa.eu/environment/waste/packaging_index.htm
- TATKAP, www.tatkap.com.tr
- Türkiye İstatistik Kurumu. www.tuik.gov.tr/ulastirmadagitimimapp/ulastirma.241
- Caterpillar, www.cat.com
- Honda, www.honda.com
- Mazda, www.mazda.com
- Toyota, www.toyota.com
- Kodak, www.kodak.com
- Xerox, www.xerox.com

- Lexmark, www.lexmark.com
- Dell, www.dell.com
- Hewlett Packard, www.hp.com
- Nokia, www.nokia.com

APPENDIX 1 : The Data of Regression Analysis

Years	The amount of pre-cured tire retreading of TATKAP	The amount of pre-cured tire retreading in Turkey	The amount of new tire sales in Turkey
2000.1	1641	17845	73275
2000.2	1415	16223	72495
2000.3	1754	21089	78665
2000.4	1981	22712	99494
2000.5	2235	25307	101609
2000.6	2292	26605	114328
2000.7	2547	28876	116491
2000.8	2547	29525	126500
2000.9	2745	31472	125936
2000.10	2914	33418	143997
2000.11	3056	35041	150771
2000.12	3169	36338	146161
2001.1	1495	16901	76311
2001.2	1335	15090	58679
2001.3	1602	18108	81415
2001.4	1895	21428	85391
2001.5	2055	23239	103023
2001.6	2296	25955	104519
2001.7	2376	26860	118335
2001.8	2456	27766	112335
2001.9	2563	28973	127255
2001.10	2750	31085	126175
2001.11	2856	32293	141231
2001.12	3017	34103	138910
2002.1	1431	19564	73258
2002.2	1290	17625	56533
2002.3	1664	22736	84372
2002.4	1857	25380	83578
2002.5	1960	26790	98492
2002.6	2089	28553	94645
2002.7	2322	31725	115759
2002.8	2347	32078	106951
2002.9	2528	34545	125585
2002.10	2631	35955	120498
2002.11	2799	38246	138512
2002.12	2876	39304	132185
2003.1	1485	16002	75834
2003.2	1350	14548	60395
2003.3	1755	18912	88713
2003.4	1890	20367	85153
2003.5	2106	22694	105456
2003.6	2214	23858	100607
2003.7	2403	25895	119623
2003.8	2457	26476	112198

2003.9	2619	28222	129926
2003.10	2781	29968	127653
2003.11	2916	31423	144093
2003.12	3024	32586	139244
2004.1	1515	15695	77265
2004.2	1365	14140	60110
2004.3	1760	18241	88952
2004.4	1965	20362	88730
2004.5	2074	21493	103929
2004.6	2211	22907	100464
2004.7	2457	25452	122198
2004.8	2484	25735	113486
2004.9	2675	27714	132597
2004.10	2784	28846	128796
2004.11	2962	30684	146287
2004.12	3043	31532	140151
2005.1	1440	15630	73688
2005.2	1200	13025	52240
2005.3	1560	16933	79412
2005.4	1680	18235	75136
2005.5	1872	20319	94294
2005.6	1968	21361	88873
2005.7	2136	23185	106887
2005.8	2184	23706	99176
2005.9	2328	25269	116045
2005.10	2472	26832	112914
2005.11	2592	28134	128638
2005.12	2688	29176	123217
2006.1	1430	14924	73211
2006.2	1378	14382	61730
2006.3	1638	17095	83132
2006.4	1820	18995	81814
2006.5	2028	21165	101735
2006.6	2132	22251	96696
2006.7	2327	24286	115997
2006.8	2353	24557	107238
2006.9	2535	26457	125919
2006.10	2678	27949	122740
2006.11	2808	29306	138941
2006.12	2912	30391	133902
2007.1	1496	15477	76359
2007.2	1360	14070	79872
2007.3	1768	18291	89333
2007.4	1904	19698	85820
2007.5	2121	21949	107171
2007.6	2235	23141	101609
2007.7	2420	25045	120434
2007.8	2475	25607	113057
2007.9	2638	27296	130832
2007.10	2801	28984	128607

2007.11	2937	30279	145094
2007.12	3051	31573	140532
2008.1	1548	16095	68839
2008.2	1395	14500	71541
2008.3	1799	18705	80812
2008.4	2008	20880	100781
2008.5	2120	22040	96124
2008.6	2259	23490	112754
2008.7	2511	26100	114774
2008.8	2538	26390	126062
2008.9	2734	28420	125411
2008.10	2845	29580	139706
2008.11	3027	31465	149387
2008.12	3110	32335	143347
2009.1	1193	15549	61906
2009.2	1193	15549	51906
2009.3	1410	18376	72257
2009.4	1519	19789	67456
2009.5	1692	22051	85708
2009.6	1736	22616	77807
2009.7	1931	25160	96108
2009.8	1953	25443	88158
2009.9	2104	27422	105360
2009.10	2191	28553	99510
2009.11	2343	30532	116761
2009.12	2430	31662	110911

Years	**Price of new tire**	**Price of retreaded tire**	**The number of trucks registered in Turkey**
2000.1	410	135	379560
2000.2	410	135	380368
2000.3	410	135	381286
2000.4	410	135	382511
2000.5	410	135	383967
2000.6	410	135	358344
2000.7	410	135	386813
2000.8	410	135	381535
2000.9	410	135	389890
2000.10	410	135	391596
2000.11	410	135	393219
2000.12	410	135	394095
2001.1	492	172	394796
2001.2	492	172	395167
2001.3	492	172	324895
2001.4	492	172	394827
2001.5	492	172	395783
2001.6	492	172	391857
2001.7	492	172	396040
2001.8	492	172	396224

2001.9	492	172	396395
2001.10	492	172	396487
2001.11	492	172	396556
2001.12	492	172	396463
2002.1	522	183	396598
2002.2	522	183	396668
2002.3	522	183	396835
2002.4	522	183	397019
2002.5	522	183	397255
2002.6	522	183	397370
2002.7	522	183	397667
2002.8	522	183	397899
2002.9	522	183	398188
2002.10	522	183	398503
2002.11	522	183	398787
2002.12	522	183	399025
2003.1	545	196	399527
2003.2	545	196	399761
2003.3	545	196	399893
2003.4	545	196	399777
2003.5	545	196	399765
2003.6	545	196	399808
2003.7	545	196	400205
2003.8	545	196	400796
2003.9	545	196	401720
2003.10	545	196	403042
2003.11	545	196	404098
2003.12	545	196	405034
2004.1	565	203	406970
2004.2	565	203	407792
2004.3	565	203	409414
2004.4	565	203	410517
2004.5	565	203	411926
2004.6	565	203	411926
2004.7	565	203	414239
2004.8	565	203	638164
2004.9	565	203	640241
2004.10	565	203	642212
2004.11	565	203	646123
2004.12	565	203	647420
2005.1	578	220	648768
2005.2	578	220	649998
2005.3	578	220	650939
2005.4	578	220	653371
2005.5	578	220	656175
2005.6	578	220	658442
2005.7	578	220	660737
2005.8	578	220	663182
2005.9	578	220	667436
2005.10	578	220	671030

2005.11	578	220	674088
2005.12	578	220	676929
2006.1	595	226	683007
2006.2	595	226	685538
2006.3	595	226	688879
2006.4	595	226	692095
2006.5	595	226	695997
2006.6	595	226	698375
2006.7	595	226	700764
2006.8	595	226	703904
2006.9	595	226	706408
2006.10	595	226	708797
2006.11	595	226	710765
2006.12	595	226	709535
2007.1	619	229	710114
2007.2	619	229	710863
2007.3	619	229	713019
2007.4	619	229	714919
2007.5	619	229	717076
2007.6	619	229	717206
2007.7	619	229	718795
2007.8	619	229	721513
2007.9	619	229	723971
2007.10	619	229	725943
2007.11	619	229	728102
2007.12	619	229	729202
2008.1	650	254	732950
2008.2	650	254	734475
2008.3	650	254	736588
2008.4	650	254	783069
2008.5	650	254	739027
2008.6	650	254	739027
2008.7	650	254	739732
2008.8	650	254	742257
2008.9	650	254	744012
2008.10	650	254	745209
2008.11	650	254	745262
2008.12	650	254	744217
2009.1	670	268	744778
2009.2	670	268	744892
2009.3	670	268	745175
2009.4	670	268	744017
2009.5	670	268	741765
2009.6	670	268	738807
2009.7	670	268	737191
2009.8	670	268	735955
2009.9	670	268	735210
2009.10	670	268	734327
2009.11	670	268	
2009.12	670	268	

APPENDIX 2 : Excel Outputs

Excel output of first model of regression analysis

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,984888581
R Square	0,970005517
Adjusted R Square	0,968666478
Standard Error	95,18009362
Observations	118

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	32812785,87	6562557,175	724,4040086	1,6138E-83
Residual	112	1014636,025	9059,250221		
Total	117	33827421,9			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-155,0382321	176,6803002	-0,877507181	0,382089676	-505,1075883	195,031124
X Variable 1	0,022558154	0,00371218	6,076794453	1,72949E-08	0,015202946	0,029913362
X Variable 2	0,015520135	0,0009049	17,15121566	4,11051E-33	0,013727192	0,017313079
X Variable 3	1,119422646	1,109290553	1,009133849	0,315085639	-1,078494322	3,317339614
X Variable 4	-2,997242088	2,385576318	-1,256401678	0,211584642	-7,723955617	1,72947144
X Variable 5	0,00028561	0,000128888	2,215951245	0,028716786	3,02345E-05	0,000540985

Excel output of last model of regression analysis

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,984099633
R Square	0,968452087
Adjusted R Square	0,967903428
Standard Error	96,33205968
Observations	118

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	32760237,34	16380118,67	1765,124535	4,90695E-87
Residual	115	1067184,558	9279,865721		
Total	117	33827421,9			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0,836527039	37,89245488	0,022076348	0,982425312	-74,2211309	75,89418495
X Variable 1	0,018863007	0,003393487	5,558591404	1,78703E-07	0,012141163	0,025584851
X Variable 2	0,016502639	0,000807258	20,44282319	4,26571E-40	0,014903616	0,018101662

RESUME OF EZO EVRIM HARSA

Ezo Evrim HARSA (formerly, ACAR) was born in 1981. Following her freshman year at the Department of Political Sciences and Public Administration in Galatasaray University, she enrolled to the Department of Business Administration (2002), and graduated in 2006.

She attended PARIS IX-Dauphine University for the duration of one term as an exchange student and has had internship experiences at Elginkan Holding (department of marketing) and Turk Ekonomi Bankası (department of human resources), respectively in 2004 and 2005.

She is attending the Business Administration Master's Degree Program of the Galatasaray University Social Sciences Institute, as of 2006.