Aalto University
School of Business

REVERSE LOGISTICS SERVICE DEVELOPMENT OF INDEPENDENT NON-PROFIT ORGANIZATION FOR REUSE OF COMPUTERS

Case – The Helsinki Metropolitan Area Reuse Centre Ltd.

Master's Thesis
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Abstract

Motivation for this thesis comes from the need to move towards circular economy, and the possibilities of better reuse of computers for the sake of the environment. Additionally, there is a clear lack of research concerning independent non-profit organizations in the reverse logistics arena.

The aim of the research is to fill that gap and to examine the opportunities in computer reuse. The research questions were formulated to find answers to the surfaced questions: What are the drivers for engagement in reverse logistics? What different kinds of service models are there in the reverse logistics field? How reverse logistics systems are implemented?

The methods used in this study are a literature review and a single case study method. First, a systematic literature review was conducted with the related search terms of product recovery management, reverse logistics, and third party logistics.

Single case study method was used to gain insight into the drivers for engagement, type of business model and implementation of reverse logistics of a non-profit company. The reverse logistics operations development project for the case company, The Helsinki Metropolitan Area Reuse Centre Ltd., allowed to answer the questions presented and to build relevant knowledge about the subject.

As a result, it was found that general characteristics of reverse logistics and its implementation apply no matter the circumstances. However, the case study shows that the drivers for engagement in reverse logistics of non-profit organization can differ greatly from traditional profit-seeking companies. For a non-profit company, the environmental and social aspects of the triple bottom line weigh more, and the financial incentives weigh less. Further, the independent role of a reverse logistics operator in the market imposes needs for active communication to reach consumers and collaborative companies alike, for the ends of acquiring more input products.

Keywords Reverse logistics, Triple bottom line, Non-profit organization, Third party logistics

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Tiivistelmä

Tämän tutkimuksen motivaatio kumpuaa tarpeesta siirtyä kohti kestävämpää kiertotaloutta ja tietokoneiden uusiokäytön mahdollisuuksista. Lisäksi käänteislogistiikkaa käsittelevässä kirjallisuudessa ei ole käsitelty juuri lainkaan itsenäisiä voittoa tavoittelemattomia toimijoita.

Tutkimuksen tavoite on täyttää tätä aukkoa ja tutkia tietokoneiden uusiokäytön mahdollisuuksia. Tutkimuskysymykset on valittu vastaamaan heränneisiin kysymyksiin: Mitkä ovat ne ajurit, jotka saavat yritykset ryhtymään käänteislogistiikkaan? Millaisia palvelumalleja käänteislogistiikkaan tarjotaan? Miten käänteislogistiikan järjestelmiä on implementoitu?

Käytettyinä tutkimusmetodeina ovat kirjallisuuskatsaus ja yksittäinen tapaustutkimus. Ensin järjestelmällisellä kirjallisuuskatsauksella etsittiin tutkimuksia aihealueista tuotteen palauttamisen hallinta (product recovery management), käänteislogistiikka (reverse logistics) ja kolmansien osapuolien logistiikka (third party logistics).

Yksittäisellä tapaustutkimuksella tutkittiin voittoa tavoittelemattoman organisaation ajureita toimintaan, palvelumallia ja käänteislogistiikan implementointia. Tietokoneiden uusiokäytön kehitykseen tähdännyt projekti Pääkaupunkiseudun Kierrätyskeskukselle tarjosi mahdollisuuden näiden asioiden tutkimiselle ja mahdollisuuden rakentaa tietoutta aiheesta.

Tuloksina löydettiin, että käänteislogistiikkaan pätee tietyt lainalaisuudet riippumatta sitä toteuttavasta tahosta. Kuitenkin tapaustutkimus paljasti, että ajurit käänteislogistiikkaan ryhtymiseen voivat olla hyvin erilaisia voittoa tavoittelemattomalla organisaatiolla verrattuna tavalliseen voittoa tavoittelevaan yritykseen. Kolmoishyödyn näkökulmasta voittoa tavoittelemattoman organisaation yhteiskunta- ja ympäristöhyötynäkökohdat painottuvat enemmän päätöksenteossa verrattuna taloudelliseen hyötyyn. Lisäksi toimijan itsenäinen rooli käänteislogistiikassa luo tarpeen aktiiviselle viestinnälle kuluttajien ja yhteistyökumppaniyritysten kanssa, jotta haluttavia tuotteita (tässä tutkimuksessa tietokoneita) onnistutaan hankkimaan.

Avainsanat Käänteislogistiikka, kolmoishyöty, voittoa tavoittelematon organisaatio, kolmannen osapuolen logistiikka

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1 Introduction

This thesis work is about reuse of computers, concentrating on the reverse logistics needed to accomplish this. Although reverse logistics will be the main topic, the issue is so complex that quite a broad take on different topics will be touched on to create a comprehensive view of the matter. Reasons for why computer reuse is important and how it is encouraged are covered. Reverse logistics in turn explain how the used computers are collected, fixed and put forward for reuse.

Motivation for this research is twofold. Primary motivation stems from the need to move towards circular economy, as the environmental benefits that can be achieved through the reuse of computers is substantial. Second motivation, which has to do with the existing research, is based on the fact that individual non-profit organizations are not mentioned in the reverse logistics literature.

The ever-increasing speed of technological development is a big factor in the growing environmental concerns the world is facing. The faster development of technology is making electronics cheaper and shortening the life cycles of products such as computers, creating more excess equipment. Generally, majority of these computers are not broken nor exhausted, i.e. they cannot be called as end-of-life products. This is important in that the computers still have reuse value even though the former user may regard them as obsolete and discard them.

To get computers backwards from the end-user (be it owned by a private consumer, company, organization or a municipality), recapture value, and channel them for reuse, reverse logistics is needed. Reverse logistics is explained broadly to give the reader an understanding of the ins and outs of the field. Although reverse logistics are a subcategory of supply chain management (SCM), it is important to highlight that the traditional forward supply chain does not support reverse logistics as is (Fleischmann & al., 1997).

In the EU legislation has been made to lessen the environmental impact. In February 2003 the first directive for Waste of electrical and electronic equipment (WEEE) was put to force. The directive’s aim is to increase the reuse and recycling of WEEE (Waste Electrical & Electronic Equipment, 2016). A plan towards Circular Economy was put forward in 2015 with rather ambitious targets for reducing waste and creating economic incentives for producing greener products (Circular Economy Strategy, 2016).

Even though the proper waste management of WEEE is increasingly important, it is yet more important to foster and develop the means for the reuse of electrical and electronic equipment that is not at end-of-life and thus should not be considered as waste. From an environmental perspective, more effective reuse of computers can save enormous amounts of energy and resources (Deng, Babbit, Williams, 2011; Williams, Yukihiro, 2003).

The reasons for a company to engage in reverse logistics vary and naturally these reasons are commonly overlapping. The reasons consist of economic factors, legislation, corporate citizenship, and environment and green issues.

When researching the reverse logistics literature, a research gap was found. Independent non-profit organizations were not mentioned. Also social sustainability dimension in reverse logistics context have been studied poorly. The Reuse Centre is a non-profit organizations which has interesting implications considering the Triple Bottom Line in that the environmental and social aspects are stressed over financial outcomes.

The objective of the development project is primarily to increase the input flow of used computers to refurbish and sale them to consumers. The means to achieve this was divided to two different target groups from early on. These target groups were private consumers, and then companies, municipalities and the like. With the consumers, a more passive approach was taken by launching a social media advertisement campaign to raise awareness of the environmental benefits of computer reuse, and the possibilities to give the obsolete equipment to The Reuse Centre. To find and build longer lasting partnerships with other organizations, a more active approach was needed to convince them about practical issues such as data security and overall convenience of the offered service. To build these relationships, e-mail exchange, phone calls, and meetings with the representatives were used to come to an agreement.

1.1 Aims of the study and the research questions

The aim of the research is to help fill the gap of independent non-profit organizations in reverse logistics literature. The research questions are:

- What are the drivers for engagement in reverse logistics?
- What different kinds of service models are there in the reverse logistics field?
- How reverse logistics systems are implemented?

Main aim of the case project is to develop B2B service for companies to offer them easy possibility to get rid of obsolete computers. Other aim is to increase the received computers from consumers. While working on these targets, the final aim from a research point of view is to answer to these questions:

- What are the drivers of The Reuse Centre for reverse logistics?
- What is the service model of The Reuse Centre for reverse logistics of computers?
- How is the reverse logistics system implemented at The Reuse Centre?

1.2 Methods

The methods used in this thesis are a literature review and a single case study. The literature review is divided into three schools that are in the order of presentation: product recovery management, reverse logistics, and third party reverse logistics. The case study was done as a project work for The Helsinki Metropolitan Area Reuse Centre Ltd.

The articles for the literature review were systematically selected from the top results of Google Scholar search engine for academic publications using the presented search terms. Additionally, reverse supply chain management was considered as one of the search terms, but the results yielded were about environmentally friendly, i.e. green supply chain management. As these results were off topic from reverse logistics, the search term was discarded.

Single case study method was used to assess the unique real life reverse logistics development project of The Reuse Centre. Eisenhardt (1989) argues that the case study method is especially appropriate in new topic areas and notes that this research strategy focuses on understanding the dynamics present within single settings. As the researcher was part of the development team, the evidence is principally gathered from the notes and documentation done by the researcher based on personal observation, site visits, and meetings as well as e-mail exchange during the project.

2 Literature review

When searching for relevant literature for the study, it came apparent that there are several terms with differing perspectives used for topics that all the same fall and can be discussed under the definition of reverse logistics. Consequently, three search terms were identified to cover the different perspectives on the topic.

The search terms used were: Product recovery management, Reverse logistics, and Third party reverse logistics. The literature was selected systematically from the top results of Google Scholar search engine for academic publications. The found literature is discussed in order by schools determined by the search terms and lastly a summary section is provided to summarize the findings. The selected and used literature is presented in Table 1.

Product recovery management literature is included because product recovery forms a substantial part of reverse logistics. Moreover, the term have been widely used at a time when the term and definition of reverse logistics was still taking shape. Reverse logistics was naturally used as a search term to find relevant articles in the field. Third-party reverse logistics literature is examined because the role of The Reuse Centre as a computer equipment collector is in effect one of third party logistics reverse logistics provider.

2.1 The points of interest

These points of interest are based on the research questions of this thesis. The results, except for the business models, are listed in tables. The tables are found in each summary section of the literature review.

2.1.1 The drivers for engagement – Triple bottom line and legislation

The articles were examined to find out what kind of drivers for engagement in reverse logistics. The Triple bottom line perspective (TBL) is used as a starting point to be able to compare the differences.

The Triple bottom line is an accounting framework used to evaluate the organization’s performance by taking into account environmental and social aspects in addition to traditional financial information (Norman & McDonald, 2004). Additionally, legislative drivers were looked to see if there are extrinsic motivators.

2.1.2 The business model

The different approaches in the research were studied to find what kind of business models these approaches reflect in the reverse logistics field. This is because in many studies the business models are not clearly presented, as they have a totally different perspective to the subject.

2.1.3 The implementation of the reverse logistics system

Case studies in the literature were sought out and examined to find out what kind of examples, if any, there are of implementation of reverse logistics systems. Although these examples may be very scarce, the can offer valuable information considering the subsequent case study.

2.1.4 Non-profit organizations

As the case in this research is one of reverse logistics process development of a non-profit organization, the literature is checked if there are any mentions or examples of non-profit organizations.

Table 1: List of the reviewed articles

	Author	Year	Name of the article	Publication
Product recovery management	Thierry et al.	1995	Strategie issues in product recovery management.	*California management review*, *37* (2), 114-135.
	Gungor & Gupta	1999	Issues in environmentally conscious manufacturing and product recovery: a survey.	*Computers & Industrial Engineering*, *36* (4), 811-853.
	Fleischmann et al.	2000	A characterisation of logistics networks for product recovery.	*Omega*, *28* (6), 653-666.
	Fleischmann et al.	2001	The impact of product recovery on logistics network design.	*Production and operations management*, *10* (2), 156-173.
	Guide et al.	2003	Building contingency planning for closed-loop supply chains with product recovery.	*Journal of operations Management*, *21* (3), 259-279.
	Toffel	2004	Strategic management of product recovery.	*California management review*, *46* (2), 120-141.
Reverse Logistics	Fleischmann et al.	1997	Quantitative models for reverse logistics: A review	*European journal of operational research*, *103* (1), 1-17.
	Carter & Ellram	1998	Reverse logistics: a review of the literature and framework for future investigation	*Journal of business logistics*, *19* (1), 85.
	Dowlatshahi	2000	Developing a theory of reverse logistics	*Interfaces*, *30* (3), 143-155.
	Rogers & Tibben-Lembke	2001	An examination of reverse logistics practices	*Journal of business logistics*, *22* (2), 129-148.
	De Brito & Dekker	2004	A framework for reverse logistics	(pp. 3-27). Springer Berlin Heidelberg.
	Fleischmann et al.	2004	Reverse logistics network design	In *Reverse Logistics* (pp. 65-94). Springer Berlin Heidelberg.
Third party Reverse Logistics	Krumwiede & Sheu	2002	A model for reverse logistics entry by third-party providers	*Omega*, *30* (5), 325-333.
	Meade & Sarkis	2002	A conceptual model for selecting and evaluating third-party reverse logistics providers	*Supply Chain Management: An International Journal*, *7* (5), 283-295.
	Efendigil et al.	2008	A holistic approach for selecting a third-party reverse logistics provider in the presence of vagueness	*Computers & Industrial Engineering*, *54* (2), 269-287.
	Min & Koh	2008	The dynamic design of a reverse logistics network from the perspective of third-party logistics service providers.	*International Journal of Production Economics*, *113* (1), 176-192.

2.2 School 1: Product recovery management

Thierry et al. (1995) define that "Product recovery management (PRM) encompasses the management of all used and discarded products, components, and materials that fail under the responsibility of a manufacturing company" and that "the objective of Product recovery management is to recover as much of the economic (and ecological) value as reasonably possible, thereby reducing the ultimate quantities of waste".

There is external pressure from both customers and authorities that demand that waste should be reduced, but also opportunities are seen by e.g. offering green products: 1. to attract and retain environmentally conscious customers and employees, and 2: to be better prepared for future changes in operating environment, such as legislation (Thierry et al., 1995). To meet the demand, waste can also be reduced by using discarded products as a valuable source of components and materials and to do this, effective Product recovery management policies are needed.

In their study, Thierry et al. (1995) present a conceptual framework that builds around options in PRM and how to acquire information to do informative decisions. The information is classified into four different categories which are information on: the composition of products; the magnitude and uncertainty of return flows; markets for reprocessed products, components, and materials; actual product recovery and waste management operations.

Based on the gathered information the company can make a decision what to do. The first higher level decision is if the returned products and components will be resold directly, recovered, or disposed (incinerated or landfilled). The recovery options consist of five levels which are in the order of required degree of disassembly: repair, refurbishing, remanufacturing, cannibalization, and recycling. All together, the eight options are presented in the Figure 1 to show how they are positioned in the supply chain. The goal in recovery options before recycling is to retain the identity and functionality of used products and their components as much as possible.

From a financial (i.e. economic) point of view, Thierry et al. (1995) summarize that "the importance of product recovery management to the profitability of the company depends on the ability to reduce the environmental impact of used products, the capability to recover as much economic value as possible out of the used products, the ability to use product recovery management as a marketing tool, and legislation."

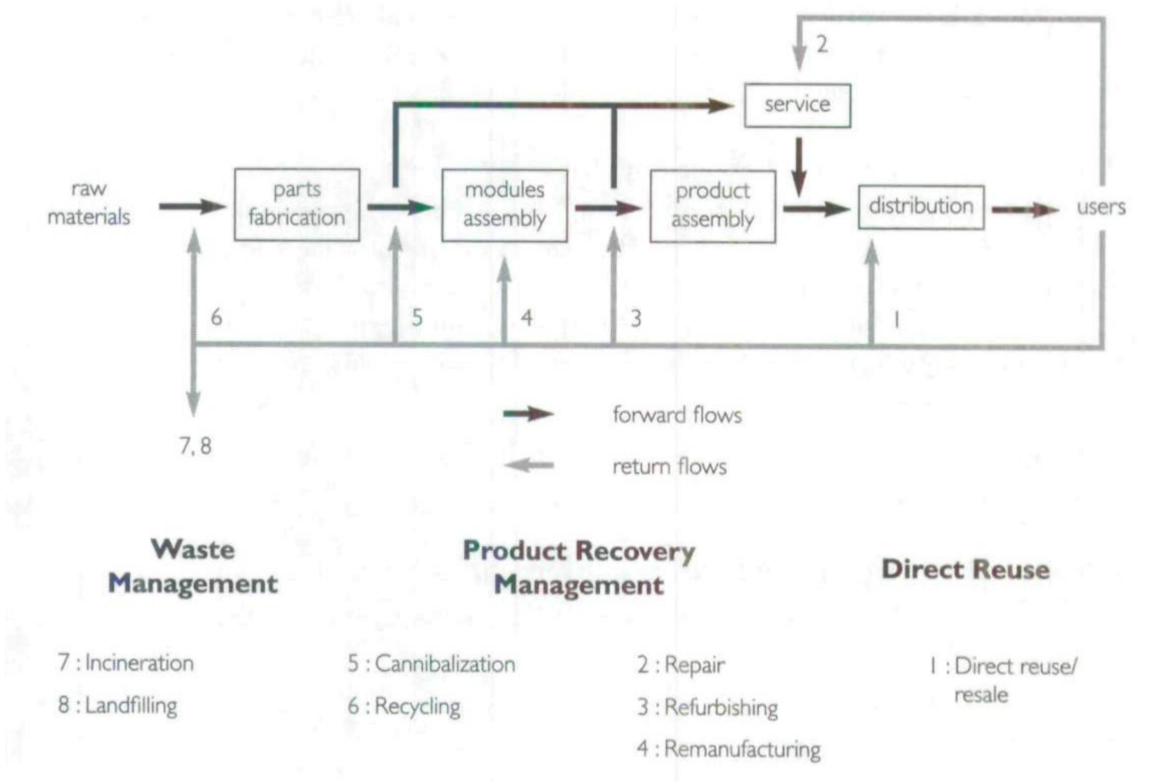


Figure 1. Integrated supply chain (Thierry, 1995)

Thierry et al. (1995) list eight major issues for manufacturers in Product recovery management. First, accurate information on products' quality and quantity is hard to acquire due to many stakeholders. Second, the most adequate recovery options are difficult to choose due to differences in products and their markets and the companies' know-how. Third, for the Product recovery management systems to be effective, measurable objectives have to be set. Fourth, in many cases the products need to be redesigned to be fit for later recovery. Fifth, closer cooperation is needed between the manufacturer and other organizations in the supply chain. Sixth, interesting cooperation opportunities arise from Product recovery management for companies that operate in the same market. Seventh, a wide range of abilities are needed of companies to successfully integrate Product recovery management in existing systems. Eight, more fundamental, strategic changes may be necessary to deal with Product recovery management, e.g. changes in network structure, acquisition of new skills, and implementation of new information systems.

Thierry & al. (1995) present three cases about companies that had been proactive in product recovery management at the time. The case companies are CopyMagic, BMW, and IBM. CopyMagic is a multinational copier manufacturer, BMW is a car manufacturer, and in this case IBM can be viewed solely as a computer manufacturer.

CopyMagic brings new products to the market, but also takes used products back from the customers, majority of which are off-lease products that CopyMagic has to take back after the expiry of their lease contracts. Earlier the company did not take any products back and they were disposed of, but later they had implemented extensive product recovery management system that encompasses remanufacturing, recycling, cannibalization, and repair operations. (Thierry et al., 1995)

Thierry et al. (1995) elaborate and explain that the development of the product recovery management system happened in four phases. In the first phase, CopyMagic began taking the products back, but still most of the copiers were disposed of, and only some were repaired to serve as temporary replacement for failed products and components. This repair process required spare parts, some of which had long lead times (up to four weeks) and consequently the company ended up maintaining large and expensive inventories to guarantee service.

In the second phase, Thierry et al. (1995) continue, CopyMagic began to cannibalize the returned used products and this way they could reduce the need for new spare parts. This was fairly easy to accomplish, but the reduction in waste was very limited, as less than 10% of the contents of the used products was reused through cannibalization, and the rest still had to be disposed of.

In the third phase, the company decided to engage in recycling because in the earlier phases the quantities of disposed products were considerable. This had numerous implications on the design requirements of the products: design for disassembly, standardization of materials, and increasing the recycled content of products and components. Now recyclable materials were used as much as reasonably possible and were selected on the basis on life-cycle costs and performance instead of purchasing and manufacturing costs only. CopyMagic used recycling in the "green marketing" of its products and convinced the customers that products containing recycled materials still fulfilled all requirements with respect to product quality. The supplier relations changed since after the material changes, and some relations turned into two-way relations where CopyMagic became a seller of used materials with some of its suppliers, in addition to buying new parts. (Thierry et al., 1995)

CopyMagic decided to go a step further and in the fourth step they implemented remanufacturing capabilities. The major difference with design requirements of remanufacturing compared to recycling are coding of products and components and the modular design, because remanufacturing focuses on components whereas recycling focuses on materials. Now the company is able to upgrade outdated modules with new and sell remanufactured products as new ones because of the quality control. Consequently the green image of the company has been enhanced even further.

For CopyMagic, the estimated benefits of remanufacturing were the largest of all product recovery options and in more general terms, product recovery management would also have been attractive without the threat of legislative and regulatory changes. The company lists the essential factors of the economic success of product recovery management: the high-value of the products, the modular design of the products, the ability to upgrade products by removing outdated components and adding superior new ones, the fact that most products are leased, the high quality image of CopyMagic which convinced customers that remanufactured products are indeed "as good as new," and the ability to integrate "new build" and product recovery operations in the fields of production and logistics management.

BMW had been conducting recycling research in a pilot vehicle disassembly plant in Landshut, Germany, since June 1990. Three major issues of the research were: recycling of materials from existing cars, reuse of high-value parts from existing cars, and design modifications for future cars. On average 10% of the weight of each car constitute of plastics. Materials recycling research concentrated on plastics and how to reuse these with aims to reuse 80% of all plastics. High-value components such as engines, starter motors, and alternators have gone through remanufacturing at BMW for a number of years. Each component is disassembled, tested, repaired, and reassembled according to strict quality standards and therefore the remanufactured components have the same quality and are sold with the same warranty as new parts, yet they are sold as "Exchange Parts" for 50% to 70% of new product prices. (Thierry et al., 1995)

According to Thierry et al. (1995), the design modifications made for improved product recovery included: reducing the number of materials used; avoiding composite components; marking parts and components; and using two-way fasteners instead of screws and glue. The BMW Zl is given as an example of a car that was specifically designed for disassembly and recycling with an all-plastic skin that was designed to be disassembled from its metal chassis in 20 minutes, and doors, bumpers, front, rear, and side panels were made from recyclable thermoplastics. BMW discovered that design for disassembly has resulted in cars with improved reparability.

IBM had set up product recovery management programs in various European countries such as Germany, Great Britain, and the Netherlands. In Germany, the company had reprocessed a vast amount of mainframes. In the UK, they had launched a take-back program for computers from its customers. In the Netherlands, IBM had set up a joint program with another computer OEM called DEC and a local equipment re-processor, to recycle used personal computer equipment. (Thierry et al., 1995)

In 1992 in Germany, the Recycling Department of IBM processed 3,200 tons of its own and 800 tons of equipment from its customers, consisting mainly of mainframes. The costs of reprocessing had actually risen in the past 10 years because of the significantly smaller amounts of precious metals in the newer designs of mainframes. Transportation and other collection costs formed the majority of the costs in reprocessing used mainframes.

Thierry (2005) continues explaining that the IBM's computer take-back program had started in the UK back in 1991. To cover the difference between processing costs and the value of the reclaimed material, IBM charged a fee from the customers. Since customers were not willing to pay for the reprocessing of used products, the result was that only a small proportion of used computers were collected and reprocessed. (Thierry et al., 1995)

In the Netherlands the majority of the equipment were off-lease computers that were collected by IBM and DEC. The companies also retrieved reusable components from the computers before sending the partly disassembled computers to the local re-processor for recycling of valuable materials and disposal of non-disposal materials. For this operation, IBM and DEC had to pay approximately 1$ per kilo for the re-processor company.

Gungor & Gupta (1999) present a review of the literature on a concept they call environmentally conscious manufacturing and product recovery (ECMPRO). Their general conclusions consist of why environmental issues are gaining ground, how to tackle the problem in manufacturing and through recovery processes, how technology should be used and decision tools developed to ease the process, and from legislative point of view what should be done to promote the environmental efforts. Lastly, the authors note that even though the research in the field is in its infancy and the research effort is growing fast, there is "a lack of sufficient analytical research and a lot of work still remains".

Governmental regulations and customer perspective on environmental issues are seen as the major driving forces for Environmentally Conscious Manufacturing and Product Recovery (ECMPRO) (Gungor & Gupta, 1999). Especially the changing consumer perspective have led to rapid developments as the consumers show more interest in buying products that are environmentally friendly, which in turn has prompted manufacturers to design and market green products to gain advantage in the marketing platform against their competitors. The interrelations between the responsible parties are depicted in Figure 2.

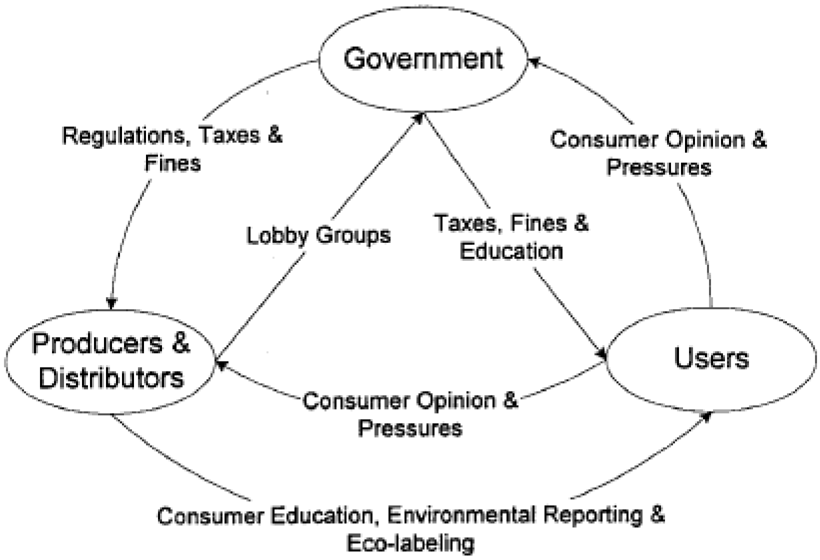


Figure 2. Interactions between government, users, producers and distributors (Young et al. 1997)

Gungor & Gupta (1999) note that also economic value can be gained through recovery processes and list the main reasons for product recovery as: (1) hidden economic value of solid waste, (2) market requirements and (3) governmental regulations. Material recovery's main purpose is to minimize the amount of disposal and maximize the amount of materials returned back into the production cycle, whereas in product recovery the recovered parts/products are used in repair, remanufacturing of other products and components and for sale to an outsider (Gungor & Gupta, 1999).

Gungor & Gupta (1999) state that environmentally conscious manufacturing consist of two key issues, which are understanding the life cycle of the product and its impact on the environment, and making environmentally better decisions during product design and manufacturing. The authors categorize the recovery process into material recovery (recycling) and product recovery (remanufacturing).

Fleischmann et al. (2000) studied the logistics networks in a product recovery environment. By reviewing case studies the authors found out that product recovery networks can be subdivided into a number of classes that each have their own typical characteristics: re-usable item networks, remanufacturing networks, and recycling networks.

Fleischmann et al. (2000) note that the perception of economy is changing from a 'one-way' economy towards a concept of material cycles. The authors mention that environmental legislation in some countries enforce responsible producers to pay for the whole life cycle of their products and take-back obligations have been put to use in several product categories, such as electronics, packaging materials, and cars. What is more, the customer expectations are changing and urge companies to reduce environmental burden and foster green image that can be used as an important marketing element (Fleischmann et al., 2000). Lastly, Fleischmann et al. (2000) state that “reuse may be economically attractive due to material and added value recovery”.

Figure 3 shows the recovery chain, where in the selection phase inspection/separation process is done to evaluate if a product is re-usable and in which way, and thus results in splitting the flow to re-processing and disposal. The re-processing options take different forms such as recycling, repair, and remanufacturing, but may include activities such as cleaning, replacement, and re-assembly, depending on the need. (Fleischmann et al., 2000)

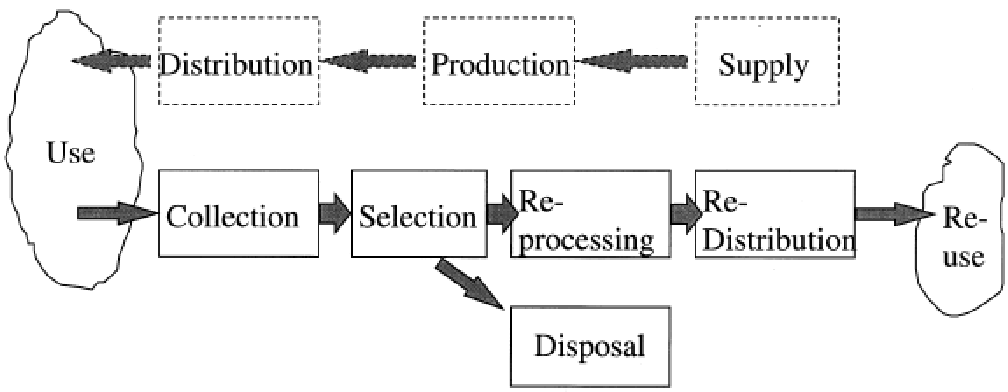


Figure 3. The recovery chain (Fleischmann et al., 2000)

Fleischmann et al. (2000) state that “important factors characterizing specific reuse situations include economical and ecological drivers, actors involved and their respective roles, and the technical form of reuse”. The authors come to a conclusion that the supply uncertainty in both quality and quantity appears to be a major distinction between product recovery networks and traditional production-distribution networks, and that this may be the reason for more complex network structure. Additionally Fleischmann et al. (2000) emphasize the need for specific quantitative models for product recovery networks separate from traditional facility location models used in forward logistics.

The main contribution of the study made by Fleischmann et al. (2000) is the classification of different types of recovery networks. The cases concerning bulk material recycling included sand recycling, carpet waste recycling, and recycling of industrial steel by-products. The authors conclude that high volumes are needed to achieve economies of scale because of the low value bulk materials and high investment costs of the advanced technological equipment needed to process these materials. The recovered material is not necessarily reused in the production process of the original product and consequently, material suppliers play an important role in these networks in addition to OEMs. Fairly simple network structure with small number of levels results from the limited number of recovery options and the fact that technical feasibility of material recycling is not that critically dependent on the quality of the collected goods. Although, the input quality may be a major cost determinant influencing the purity of output materials.

Product remanufacturing cases included companies that were dealing with copy machines, cell phones, and printed circuit boards. Here the parts or assembled products are of relatively high value and thus, the recovery of these products is mainly carried out by the OEM, and reuse and original use often coincide. Fleischmann et al. (2000) conclude that because added value recovery is the main economic driver, and because the corresponding recovery activities require intimate knowledge about the products, the recovery is often carried out by the OEM. The authors note, though, that if the market entry barriers are low, product recovery opportunities may also attract specialized third parties. The recovery network tends to be a fairly complex multi-level structure, which stems from the complex set of interrelated processing steps and options. Decentralization of certain activities such as testing and inspection may well be a viable option because the specific condition of the collected product determine the feasibility of recovery options and the sequence of later processing steps.

The only case of reusability in their study is about reusable transportation packages. Because there is no difference between original use and reuse, a closed loop system is natural, and in such a system determining the number of items required to run the system and prevention of loss are important issues. As there is no need for reprocessing, with the exception of some cleaning and inspection, the network structure is typically quite flat. The network is also typically decentralized, so that the depots are close to the customer for convenience. Fleischmann et al. (2000) note that in this context the timing of returns is an important element of uncertainty.

To answer to the stated need for quantitative models for product recovery networks (Fleischmann et al., 2000), Fleischmann et al. (2001) address the question: “how robust are traditional logistics networks when it comes to addressing product recovery activities?” This is done by considering the issue on both methodological and topological level. The former concerns the appropriateness of standard network design tools in a product recovery context, and the latter analyzing the impact of product recovery on the physical network structure.

As Fleischmann et al. (2001) have put it, “commonly recognized drivers for product recovery are threefold and include legislative, commercial and economic aspects”, and also specify that “driven by environmentally conscious customers, regulation, and economical benefits companies are taking back used products to recover added value and materials”.

To support network design for traditional forward logistics, mixed integer linear programming (MILP) models are used (Fleischmann et al., 2001). Based on their research of generic characteristics of a set of case studies, Fleischmann et al. (2001) propose a MILP recovery network design model (RNM), where an inspection and separation stage is highlighted as an essential element to determine the feasibility of recovery options for each returned product.

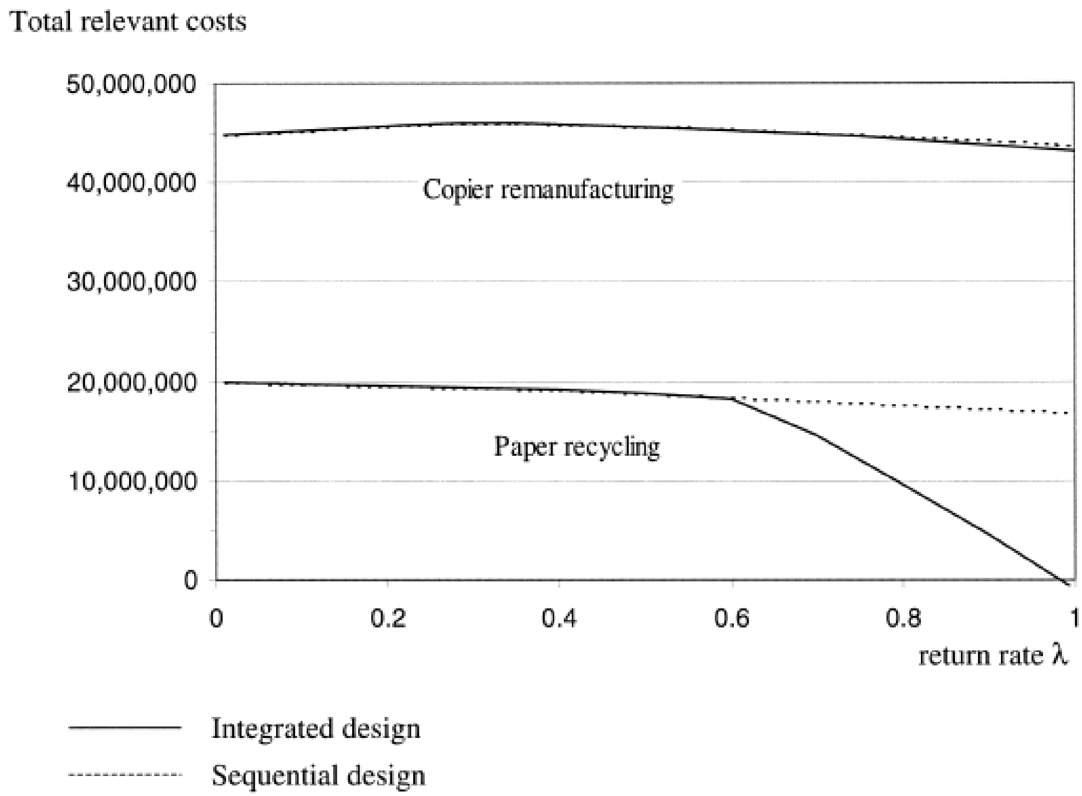
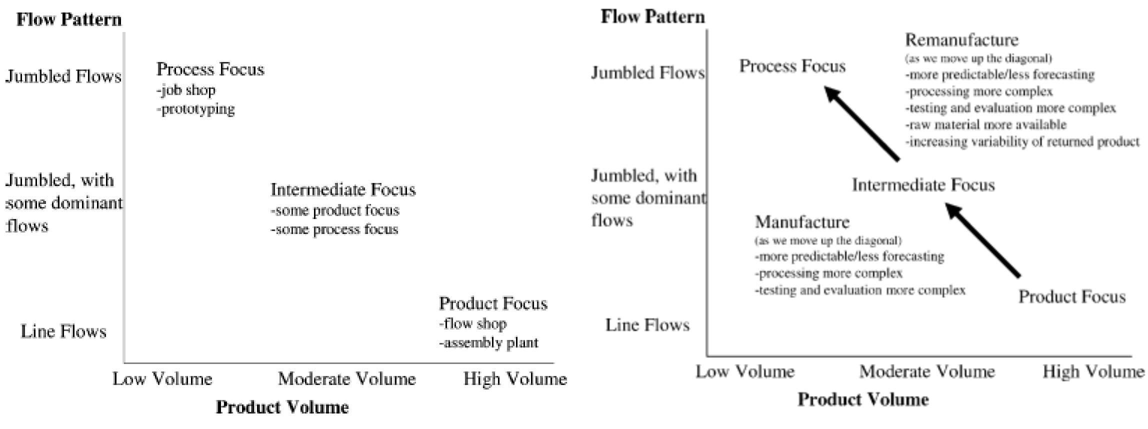


Figure 4. Costs as function of return rate (Fleischmann et al., 2001)

Fleischmann et al. (2001) use two examples to test their model. The first is built around several case studies of copier remanufacturing, and the second is motivated by European paper recycling business. As the paper is heavily quantitative, rigorous walkthrough of the process and results is not expedient here, but overall outcomes are as follows. In the copier remanufacturing, the authors found that the fixed forward network structure does not impose significant restrictions on the design of an efficient return network, which is good news for the manufacturer starting to engage into product recovery. In the paper recycling case, in contrast with the first example, optimizing the forward and return network simultaneously not only leads to a different solution than a sequential approach, but also results in a significant cost benefit. These results are visualized in Figure 4.

Guide et al. (2003) explored through three case works the factors that impact production planning and control for closed-loop supply chains that incorporate product recovery. The reverse flows of product recovery differs from forward logistics flows due to its specific characteristics. In their paper Guide et al. (2003) consider these differences and develop a framework that aligns product recovery with existing research on forward flow, and shows the common activities required for all remanufacturing operations. The authors point out that production planning and control for a remanufacturing environment depends on product volume and the nature of process, and thus a "one-size-fits-all" approach is bound to fail.

The framework used as basis is one that Hayes & Wheelwright (1979) had built for planning and control of manufacturing (Figure 5. a)), where product volume is depicted on the x axis and complexity of product flows on the y axis. With the three differing case works, Guide et al. (2003) develop the framework to be used in a remanufacturing setting (Figure 5. b)). The framework is to help in operations strategy for the planning and control of manufacturing involving reverse flows.



a) Planning and control framework for manufacturing (Hayes & Wheelwright, 1979)	b) Planning and control framework for remanufacturing (Guide et al., 2003)

Figure 5. The planning and control frameworks for manufacturing and remanufacturing

Guide et al. (2003) have chosen three cases specifically for their differences, representing Remanufacture-to-Stock (Kodak), Reassemble-to-Order (Xerox), and Remanufacture-to-Order (US Navy Depot). The dimensions used to characterize these different environments are: returns volume, returns timing, returns quality, product complexity, test and evaluate complexity, and remanufacturing complexity. The authors summarize and discuss the distinguishing features to highlight the differences in these three remanufacturing environments. Case evidence of the defining dimensions are illustrated in Figure 6.

Complicating characteristic	Case		
	Kodak	Xerox	US Navy
Uncertainty in timing	Low	Moderate	Moderate
Uncertainty in quality and quantity	Low	Moderate	Low
Balancing returns with demands	Easy	Moderate	Easy
Disassembly	Easy	Moderate	Difficult
Uncertainty in materials recovered	Low	Moderate	High
Reverse logistics network	Simple	Moderate	Simple
Materials matching	None	Limited	High
Routing uncertainty	None	Moderate	High

Figure 6. Complicating characteristics and the case evidence (Guide et al., 2003)

To summarize, the similarities in manufacturing and remanufacturing that Guide et al. (2003) list are the relationships between product volume and strategy; demand and predictability; and product, test and evaluate, and manufacturing complexity. The differences that create the challenges for remanufacturing arise from the variability of supply and the return quality, Guide et al. (2003) note.

As for drivers, both economic and political forces drive the need for product recovery planning. Guide et al. (2003) have made an observation that, at least in the United States, the legislation tends to encourage rather than mandate reuse activities. As an example, the recycling industry in the United States is such a system where legislation encourages reuse via tax credits. The authors mention that customer service considerations and laws pertaining to producer responsibility are on their part increasing product returns worldwide.

Toffel (2004) says that manufacturers are motivated by legislation to manage their products once they reach their end of life (EOL). Although the motivation for product recovery has a premise in legislation, voluntary motives for original equipment manufacturers for product recovery are identified and include things such as reducing their production costs, enhancing their brand image, meeting changing customer expectations, and protecting their aftermarkets. Besides these motives, companies want to prevent their scope from broadening and to preempt additional legislation. Also by launching a voluntary product take-back program a firm can also enhance their environmental reputation.

The author claims that managers contemplating product recovery strategies should consider which of these drivers currently apply to their company and industry. Information should be sought from a variety of functions, since knowledge about production costs, brand reputations, customer expectations, and legislative agendas is typically diffused across an organization.

Toffel (2004) points out that as a strategic choice, manufacturers may want to collect their products directly from customers to avoid intermediaries who may cherry pick the most valuable items and supply only the lower quality ones. Because of the supply uncertainty of reverse flows, the product recovery may induce heavy investments in technology.

Toffel (2004) lists capabilities of manufacturing that can be leveraged to product recovery. These capabilities include: manufacturing, service, and repair capabilities; acquiring tacit disassembly know-how, feeding back recovery know-how to designers, and Environmental reputation capabilities. Additionally, the author says that “various types of equipment and training can bolster the productivity of EOL product recovery by reducing the cost of assessing, disassembling, or identifying valuable components in EOL products”.

2.2.1 School 1 summary

The issue of Product recovery management has originally risen from the companies’ need to answer to the more demanding environmental legislation. Although this may be the starting point, companies have since understood the opportunities for better profitability.

Environmental, legislative and financial reasons were mentioned widely as the major drivers for product recovery. The drivers are somewhat overlapping and cannot be considered individually without the other. In many occasions, the environmental legislation may compel the producers to implement take-back programs for their products, but changing consumer environmental consciousness and the resulting green image issues drive manufacturers to engage in reverse logistics even without legal obligation. Along the road it has become also clear that efficient product recovery is also financially viable and further cannot only reduce costs but also increase profits of a company.

All together the contents in this section of the literature review are alike from the viewed perspective as seen in Table 2. The issue of social sustainability was conspicuous by its absence. Non-profit organizations were not mentioned either.

Table 2: Summary table of School 1 literature

	Article	Social	Environmental	Financial	Legislative	Non-profit	Company cases
Product recovery management	Thierry et al. (1995)	-	+	+	+	-	CopyMagic, BMW, IBM
	Gungor & Gupta (1999)	-	+	+	+	-	-
	Fleischmann et al. (2000)	-	+	+	+	-	Bulk recycling, remanufacturing, package reuse
	Fleischmann et al. (2001)	-	+	+	+	-	Copier remanufacturing, paper recycling
	Guide et al. (2003)	-	+	+	+	-	Kodak, Xerox, US Naval Aviation
	Toffel (2004)	-	+	+	+	-	-

A general note is made in several articles about what is the major difference between typical forward logistics versus product recovery. The uncertainty of both quality and quantity of recovered products and materials is so high that it affects greatly the design process of recovery systems (Thierry, 1995; Fleischmann, 2000; Guide et al., 2003; Toffel, 2004).

Thierry et al. (1995) presented five recovery options for products and components, if the products were not in a good enough condition to be resold directly, or conversely disposed directly. These recovery options are: repair, refurbishing, remanufacturing, cannibalization, and recycling.

Gungor & Gupta (1999) state that the two key issues in environmentally conscious manufacturing are understanding the life cycle of the product and the decisions made during product design. The authors categorize the recovery process simply into material recovery (recycling) and product recovery (remanufacturing).

Fleischmann (2000) made a clear distinction between three different kinds of recovery networks. Re-usable item networks, remanufacturing networks, and recycling networks all fit for a different kinds of products and thus different possible level of recovery. One specific note the author makes is that decentralization of testing and inspection phase in the reverse network is worthwhile considering to determine the feasibility of recovery options and the thus the sequence of later processing steps early on.

Fleischmann et al. (2001) developed a quantitative tool and concluded that in bulk material recovery (paper recycling), the forward and return networks should be optimized simultaneously. With the copier manufacturers, the existing forward network was not an obstacle for building a reverse network later on.

Guide et al. (2003) showed through three cases that the Planning and control framework for manufacturing (Hayes & Wheelwright, 1979) is also applicable to remanufacturing, taking into account the special characteristics of it. The authors stressed that the challenges for remanufacturing arise from the variability of supply and the return quality.

Toffel (2004) offers guidance for managers contemplating product recovery strategies. First the drivers for recovery that apply to the company and industry should be considered, including legislation as well as voluntary motives such as reducing production costs, enhancing brand image, meeting changing customer expectations, and protecting aftermarkets, as well as preempt additional legislation. Secondly, information should be sought across different functions of the company to gain a sound picture of the whole. Lastly the author note that manufacturing capabilities that can be leveraged to product recovery include: manufacturing, service, and repair capabilities; acquiring tacit disassembly know-how, feeding back recovery know-how to designers, and environmental reputation capabilities.

The CopyMagic case (Thierry, 1995) offers a great example how a reverse logistics business model was developed and implemented. The company gradually moved from not taking back any products, to light repair operation at first, then to cannibalize for parts, then began to recycle and lastly to remanufacture a substantial part of all machines.

In the first phase, the company faced a new problem of long lead times of spare parts needed for repair, and still majority of the products taken back ended up disposed. In the second phase, CopyMagic began to cannibalize the take-back products for the needed spare parts which alleviated the problem of lead times, but still over 90% of the returned products were disposed of.

Moving forward, in the third phase, the company engaged in recycling of the materials, which then had tremendous implications on the whole production scheme. The implications on design requirements led to: design for disassembly, standardization of materials, and increasing the recycled content of products and components. Now life-cycle costs and performance of the products were used as measures instead of looking at purchasing and manufacturing costs only. At this point the company took advantage of green marketing as their products were a lot more environmentally friendly.

In the fourth and last phase, CopyMagic began remanufacturing of their products which lead to further design improvements. Major differences to the recycling phase were coding of products and components and the modular design. By updating older modules and strict quality control, the company was able to sell remanufactured products as new, and at the same time further enhance their green image.

The estimated benefits of remanufacturing for CopyMagic were largest of all the options and was highly beneficial for the company even without the threat of legislative and regulatory changes. The company listed the essential factors of economic success of product recovery as: the high-value of the products, the modular design of the products, the ability to upgrade products easily, the fact that most products are leased, and the high quality image as well as green image.

The other cases presented in the articles in this school did not offer enough details about the actual implementation of the product recovery system. Thus, they are not discussed here.

2.3 School 2: Reverse logistics

In their survey Fleischmann et al. (1997) discuss the implications of the emerging reuse efforts, review mathematical models proposed in the literature, and point out the areas in need of further research for the three main areas of reverse logistics: distribution planning, inventory control, and production planning. Similarities and differences with classical forward logistics methods and production planning are given special attention.

The approach taken is tied with the original manufacturers, and how they can combine the reverse product or material flows to their logistics and production systems to gain new flow of input. The reverse distribution part, i.e. the collection and transportation of used products and packages, can take place through the original forward channel, through a separate reverse channel, or through combinations of the forward and the reverse channel (see Figure 7) (Fleischmann et al., 1997).

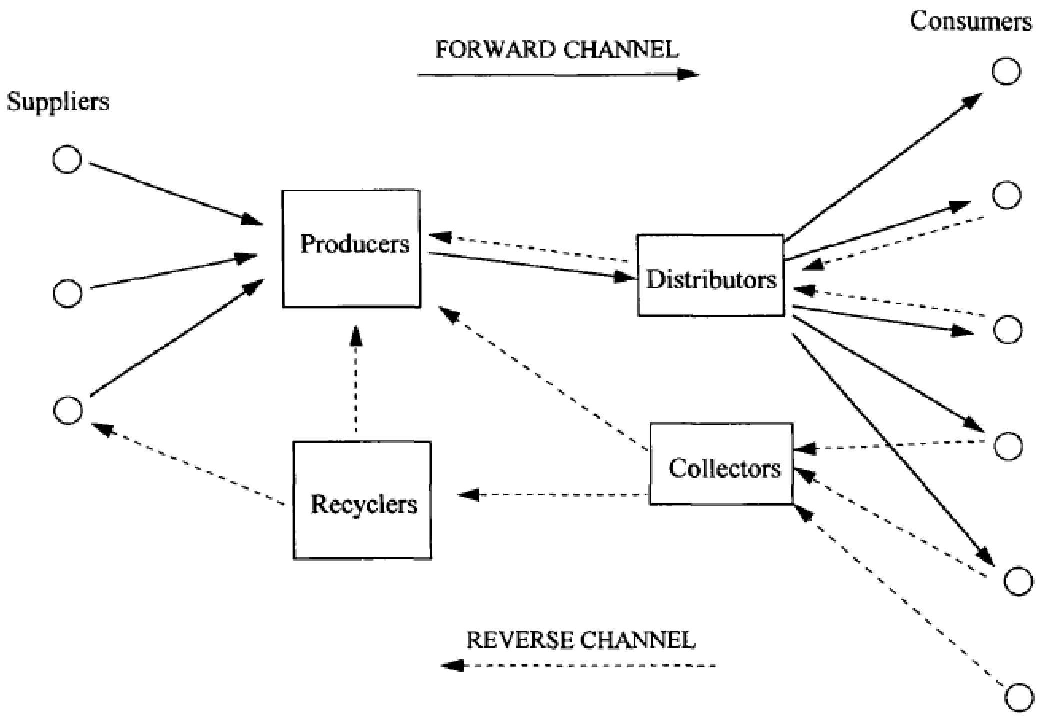


Figure 7. Reverse distribution framework (Fleischmann et al., 1997)

The authors conclude that in the addressed logistics of industrial reuse of products and materials, reuse occurs in a large diversity of forms and not all reuse activities necessarily require new planning approaches and that traditional methods from the fields of distribution planning, inventory control, and production planning can readily be applied to a number of planning problems. Nevertheless, they note that not all reuse activities fit into the traditional setting. Specifically, the interaction of the new reverse material flows and the traditional forward flows add complexity to the systems involved, as the two flows must be considered simultaneously. The uncertainty in systems concerning reuse is mentioned as a major obstacle, which arises from the fact that used products are a far less homogeneous and standardized input resource than traditional raw materials and new parts. Information technology is offered as a possible aid to handle this uncertainty that is seen as one of the major tasks in the planning of reuse activities.

Fleischmann et al. (1997) point out that the importance of industrial reuse activities is increasing rapidly due to environmental consciousness and legislation. Additionally, they note that "operational researchers can make an important contribution to carrying out the ecologically required changes in industrial production in an economically attractive way".

Carter & Ellram (1998) have made a literature review of reverse logistics and have identified gaps where future research is needed. The authors also present a framework to help guide further work. As for incentives for reverse logistics Carter & Ellram (1998) say that "in addition to environmental and cost benefits, a reverse logistics program can proactively minimize the threat of government regulation and can improve corporate image".

In their research Carter & Ellram (1998) have identified four environmental forces that affect a company's reverse logistics operations. These forces represent different dimensions of the task environment: suppliers as input, buyers as output, government as regulatory, and competitors as competitive dimension. Social aspects are mentioned only in passing in that social trends (along with political, legal, and economic trends) are part of the macro environment that affect the task environment of a company.

Carter & Ellram (1998) also present internal factors that act as drivers and/or constraints for reverse logistics. The most important factor, and the only one posited as a driving force is having at least one policy entrepreneur that undertakes responsibility for reverse logistics activities. The other factors are support from top management, stakeholder commitment and appropriate incentive systems, which are posited to constrain or prevent success if not present, but do not drive logistics activities per se.

Further, Carter & Ellram (1998) note that acting together, the internal and external drivers stimulate reverse logistics activities, so that without the external pressures not even the most savvy policy entrepreneur may not be able to convince others to commit to the undertaking. And conversely, they note, without a policy entrepreneur to drive the program followed by top management support, stakeholder commitment, and effective incentive system, the company may respond to external pressures my making only minor changes instead of implementing truly environmentally friendly programs.

Carter & Ellram (1998) conclude that most of the literature in reverse logistics is descriptive and anecdotal and examines only narrow aspects, such as recycling. Also they say that very few empirical studies have been done and most research is exploratory.

Dowlatshahi (2000) presents 11 insights for successful implementation of reverse logistics based on exiting literature and published case studies. These insights consist of strategic and operational factors that encapsulate the essence of reverse logistics. The strategic factors consist of strategic costs, overall quality, customer service, environmental concerns, and legislative concerns. The operational factors consist of cost-benefit analysis, transportation, warehousing, supply management, remanufacturing and recycling, and packaging.

According to Dowlatshahi (2000), especially when confronting intense competition and low profit margins, a firm can compete better in its industry with effective use of reverse logistics. For a variety of economic, environmental, or legislative reasons, products come to be recycled or remanufactured by the original manufacturers and product disposal may no longer be the consumer's responsibility, the author continues.

Dowlatshahi (2000) proposes that companies should explore and integrate reverse logistics as a viable business option in the product life cycle all the way from design through manufacture to consumer. Using reverse logistics companies can achieve goals of sustainable development, and the author stresses that maintaining the environment and making profits are actually complimentary because reverse logistics focuses on both environmental and economic goals. Thus, a holistic view of reverse logistics is essential for a profitable and sustained business strategy.

In their study "An examination of reverse logistics practices", Rogers & Tibben-Lembke (2001) interviewed more than 150 managers with reverse logistics responsibilities, and visited companies to examine reverse logistics processes. As mentioned by the authors, the main focus of the paper is on economic and supply chain issues, and green issues are only discussed briefly.

Rogers & Tibben- Lembke (2001) go through earlier descriptions and definitions of reverse logistics and present a definition the same authors have formulated a few years earlier. They had defined reverse logistics 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 consumption to the point of origin for the purpose of recapturing or creating value or proper disposal" (Rogers and Tibben-Lembke, 1999).

Rogers & Tibben- Lembke (2001) state that good reverse logistics management can increase revenues additionally to reducing cost, and that actually a lot of money can be made by focusing on improving reverse logistics processes. By managing the reverse flow cost-effectively, a lot of value can be obtained from material sometimes derisively referred to as junk.

The authors note that also strategic advantages can be gained through reverse logistics. These possibilities include: reducing the customer's risk when buying a product, because the customer knows that the product can be returned easily; making the firm more agile through quick disposition of unexpectedly slow moving inventory and simultaneously getting some of the cost back.

Rogers & Tibben- Lembke (2001) propose the reverse logistics should be structured using centralized returns centers or forward distribution centers to process returns, or some combination of the two. Both of the approaches have advantages and disadvantages and the choice how to handle returns effectively and efficiently depends on the life cycle and value of a manufacturer's products.

Social dimension as also non-profit organizations are mentioned in passing by Rogers & Tibben- Lembke (2001). The authors note that if a product of a company cannot be sold in its current state, and the company wants to avoid landfilling and it resists to sell it to a broker who would sell it on second-hand markets, the product can be donated to a charitable company. A tax advantage may be gained that can even be more valuable than the payment from a broker would have been. This way also a social benefit may be achieved, and the firm can “pride itself on being a good corporate citizen” when supporting a charity, Rogers & Tibben- Lembke (2001) conclude.

In their research paper de Brito & Dekker (2004) give an easy to understand and thorough overall picture of reverse logistics. They propose “a content framework focusing on the following questions with respect to reverse logistics: why? what? how?; and, who?, i.e. driving forces and return reasons, what type of products are streaming back, how are they being recovered, and who is executing and managing the various operations”. See Figure 8.

Brito & Dekker (2004) go through several definitions of reverse logistics and conclude that the perspective in the definition by Rogers & Tibben-Lembke (1999), also presented earlier in this study, keeps the essence which is logistics. They do, however, make a few remarks noting they do not refer to “point of consumption” nor to “point of origin”. This is because some products such as spare parts may not be consumed before going backwards in the supply chain, and because some products may go back to other point of recovery than the original.

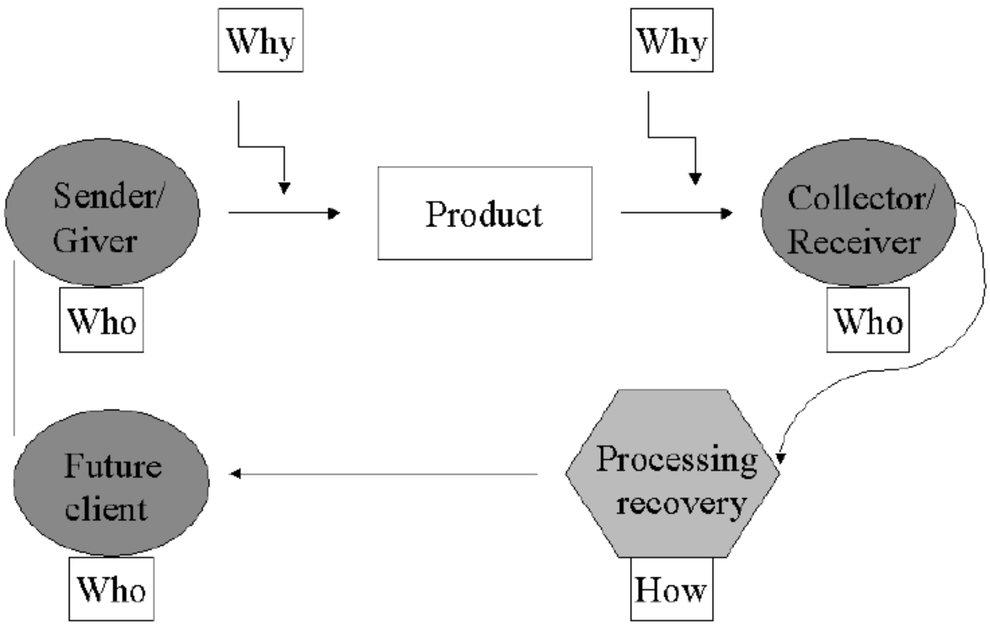


Figure 8. Why, how, what and who: basic interrelations (de Brito & Dekker, 2004)

The driving forces for reverse logistics listed by Brito & Dekker (2004) are economics, legislation, and corporate citizenship. The authors also elaborate on these forces, explaining that companies become active in reverse logistics because they can profit from it, or/and because they have to, or/and because they "feel" socially motivated to do it. Further, as pointed out by de Brito & Dekker (2004) the motivations for RL are not mutually exclusive and that in reality it is sometimes hard to set a boundary between them. The authors also stress that the economic gains from reverse logistics can be either direct, such as getting reused materials as raw materials, or indirect, such as gaining strategical advantage through anticipating or impeding legislation, market protection, green image, and improved customer or supplier relations.

In the section addressing the question who is executing and managing the various operations, Brito & Dekker (2004) list group of actors involved in reverse logistics activities, such as collecting and processing. These actors include independent intermediaries, specific recovery companies (e.g. jobbers), reverse logistic service providers, municipalities taking care of waste collection, and public-private foundations created to take care of recovery.

Charity organizations are given as an example of opportunistic players in the field, but non-profit organizations are not considered to further extent. See Figure 9.

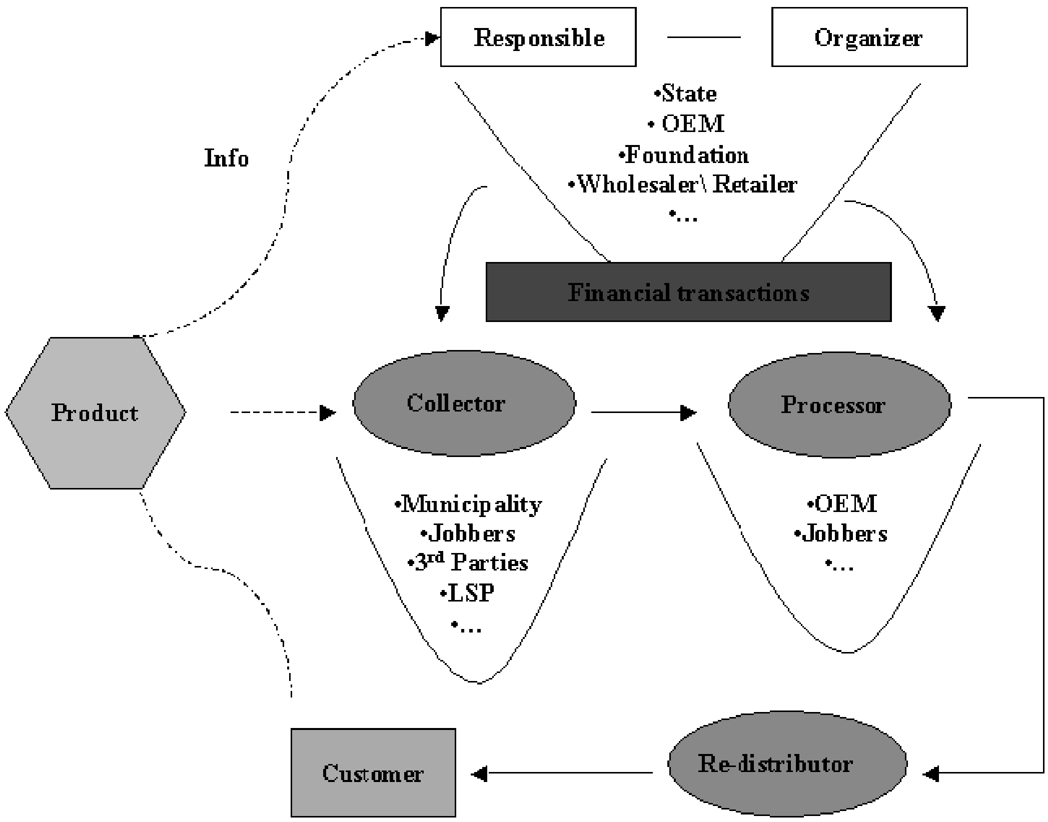


Figure 9. Who is who in reverse logistics (de Brito & Dekker, 2004)

In the section addressing the question what type of products are streaming back, De Brito & Dekker (2004) explain the product recovery process. After the collection there are several stages the products or materials go through (see Figure 10). The subsequent and combined inspection / selection / sorting process is an important phase since potential value maybe lost at this point. Following comes the recovery process that can be direct for products and materials that are functional for reuse as such, or indirect in which case some form of re-processing is needed. This is typically represented as a pyramid where the different levels show the possible actions from the most desirable to least desirable. In between there are different levels of re-processing: product level (repair), module level (refurbishing), component level (remanufacturing), selective part level (retrieval), material level (recycling), energy level (incineration).

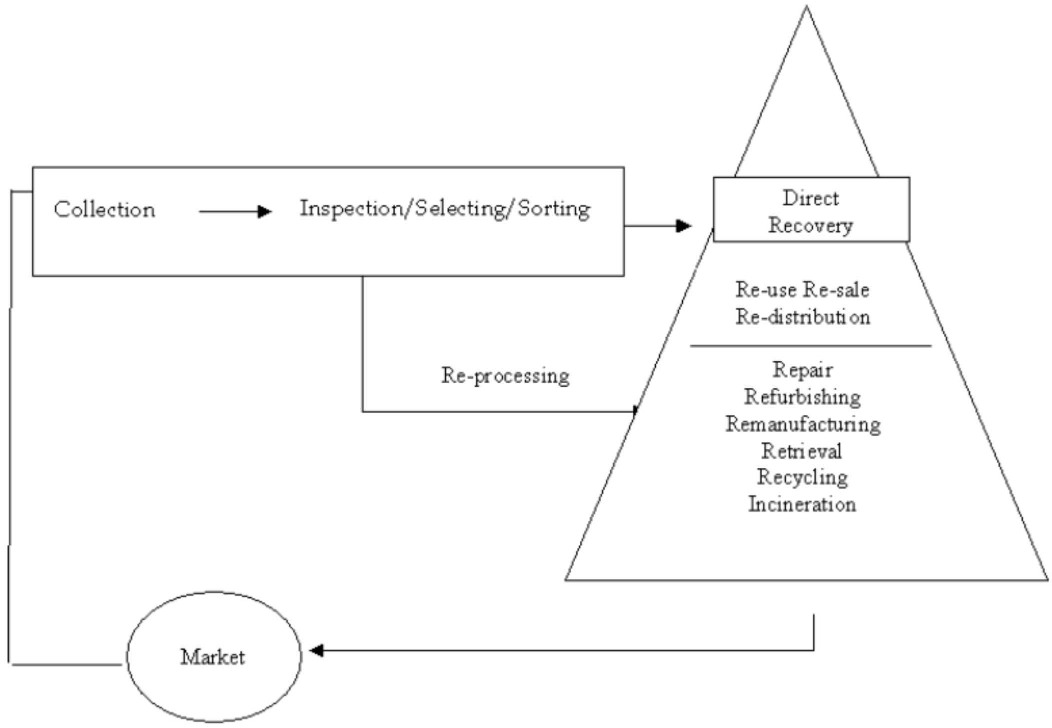


Figure 10. Reverse logistics product process (de Brito & Dekker, 2004)

De Brito & Dekker (2004) examined 12 case studies and present them by their content framework of why? what? how? and, who? of reverse logistics. The summary table of the results are presented in Appendix A. The number of occurrences in the Why drivers were 10 in economics, 5 in legislation, 3 in corporate citizenship and 1 corporate responsibility. This shows that in this sample of cases, financial and legislative reasons are the main drivers of reverse logistics. In the How column remanufacturing is the most common process, and reuse and direct resale were both mentioned once.

In a book chapter, Fleischmann et al. (2004) have considered the setting up of appropriate infrastructure by companies engaged in reverse logistics programs. The authors say that the network structure is a key determinant of the overall profitability of closed–loop supply chains.

Comparing to traditional forward supply, Fleischmann et al. (2004) emphasize that there are three important issues characteristic to reverse logistics networks: supply uncertainty, degree of centralization of testing and sorting, interrelation between forward and reverse flows.

2.3.1 School 2 summary

In Table 3 one can see the summary of the School 2. As well as the case with the first school in the literature review, all research articles in this second section have mentioned environmental, financial, and legislative aspects as drivers for reverse logistics. Nevertheless, in this section three articles mention the social dimension on some level. Two articles, which coincide with two out of the three articles mentioning social aspects, have also mentioned non-profit organizations on some level.

Unlike in the first School, in this section there were few, although quite vague references to social aspects, with the exception of De Brito & Dekker (2004). Carter & Ellram (1998) mentioned social trends (along with political, legal, and economic trends) as part of the macro environment that affect the task environment of a company. Rogers & Tibben- Lembke (2001) mentioned that “a social benefit” can be achieved when a company donates products it can’t sell in its current state to a charitable company.

Brito & Dekker (2004) on the other hand has listed corporate citizenship as a driving force along with economics and legislation. When elaborating more on these driving forces, the authors say if driven by corporate citizenship, they may “feel” socially motivated to engage in reverse logistics.

Non-profit organizations were mentioned twice in this school. On both occasions though, the given examples were charities (Rogers & Tibben-Lembke, 2001; Brito & Dekker, 2004), and non-profit organizations were not mentioned to further extent.

Table 3: Summary table of School 2 literature

	Article	Social	Environmental	Financial	Legislative	Non-profit	Company cases
Reverse Logistics	Fleischmann et al. (1997)	-	+	+	+	-	-
	Carter & Ellram (1998)	+	+	+	+	-	-
	Dowlatshahi (2000)	-	+	+	+	-	-
	Rogers & Tibben-Lembke (2001)	+	+	+	+	+	-
	De Brito & Dekker (2004)	+	+	+	+	+	Kodak, IBM, specialist recycler, Wehcamp, Volkswagen, Daimler-Chrysler, Xerox, Schering, Copier producer, Lead recycler, Refridgerator producer, Paper industry
	Fleischmann et al. (2004)	-	+	+	+	-	-

Fleischmann et al. (1997) stressed that in systems concerning reuse, the uncertainty arising from the rather not homogenous and standardized input is a major obstacle. To tackle this challenge, the use of information technology is proposed.

Carter & Ellram (1998) identified four environmental forces and internal factors that affect a company’s reverse logistics operations. The environmental forces are presented as dimensions of the task environment: suppliers as input, buyers as output, government as regulatory, and competitors as competitive dimension. The internal factors are a policy entrepreneur as a driving force, and top management, stakeholder commitment and appropriate incentive systems are presented as constraints if not present.

Dowlatshahi (2000) stress the importance of examining the total life cycle of a product all the way from design through manufacture to consumer to integrate reverse logistics to existing supply chain. With a holistic approach, goals of sustainable development can be achieved, when profits can be made while maintaining the environment.

By interviewing managers with reverse logistics responsibilities and field visits Rogers & Tibben-Lembke (2001) examined issues of reverse logistics come to a conclusion that by improving reverse logistics processes, costs can be reduced while increasing revenues. Strategic advantages found by the authors included reducing the customer's risk when buying a product and making the firm more agile. The authors point that for reverse logistics, centralized returns centers or forward distribution centers to process returns should be used, or some combination of the two, depending on the life cycle and value of the products.

De Brito & Dekker (2004) proposed a content framework for reverse logistics which constitutes of four determinants of: why? what? how? and, who? With the aid of quite unambiguous figures (Figures 8, 9, and 10), the authors are able to present a good overall view of the reverse logistics operations including the players and products involved, processes used, and reasons for engagement.

Fleischmann et al. (2004) pointed out that the network structure of a closed-loop supply chain is the key determinant for the overall profitability of the system. When comparing to traditional forward supply, Fleischmann et al. (2004) emphasized three important issues characteristic to reverse logistics networks which are supply uncertainty, degree of centralization of testing and sorting, interrelation between forward and reverse flows.

In their paper De Brito & Dekker (2004) analyzed 12 company cases using their framework revealing differences in reverse logistics practices across the cases.

2.4 School 3: Third party reverse logistics

Krumwiede & Sheu (2002) have reviewed the industry practices in reverse logistics and examined issues and processes that an organization should address to engage in the reverse logistics business. The authors develop a reverse logistics decision-making model for third-party companies, such as transportation companies, who would like to pursue reverse logistics as a new market. The model is developed to guide the process of examining the feasibility of engaging in reverse logistics.

The decision-making model by Krumwiede & Sheu (2002) consists of six steps. These steps are: 1. research existing reverse logistics issues and identify customers, 2. survey existing repeat customer needs, 3. survey competitors and competitors' customers, 4. conduct gap analysis, 5. perform feasibility study, and 6. develop a positioning strategy.

The first three steps are for gathering a good base of information and to understand the environment the company is willing to engage. In the fourth step, based on the needs of existing customers and competitors' customers, a gap analysis should be performed to be able to compare the company's and its competitors' current reverse logistics position in the market with the needs of current and future customers. In the fifth step, a feasibility study should be done to evaluate the costs and gained benefits of providing the extended service identified through the gap analysis. Lastly, in the sixth step, a positioning strategy should be developed to help understand what their position in the reverse logistics market will consist of. If the feasibility study indicates that with the available resources the company could enter the reverse logistics market, it should decide to proceed. (Krumwiede & Sheu, 2002)

Krumwiede & Sheu (2002) point out that "reverse logistics has had a significant economic impact on industry as well as society". As for drivers to engage in reverse logistics, the authors say that companies that see reverse logistics as an opportunity are able to maintain customer support which in their opinion is the "ultimate issue of profitability". They note that reverse logistics can be seen as an advantage with potential to capture market share, or detrimental for a company and should thus be avoided.

In their paper, Meade & Sarkis (2002) present a conceptual model for selecting and evaluating third-party reverse logistics providers. Even though the perspective is fixed on a company looking for third-party provider of reverse logistics, the paper offers good insights into reverse logistics in general.

Meade & Sarkis (2002) state that from a holistic environmental perspective, the definition of reverse logistics focuses primarily on the return of recyclable or reusable products and materials into the forward supply chain. They continue that reverse logistics is "necessary for the completion of the industrial eco-cycle". The general goal is to minimize any flow of materials to external environment and to keep them within the operational lifecycle (See Figure 11).

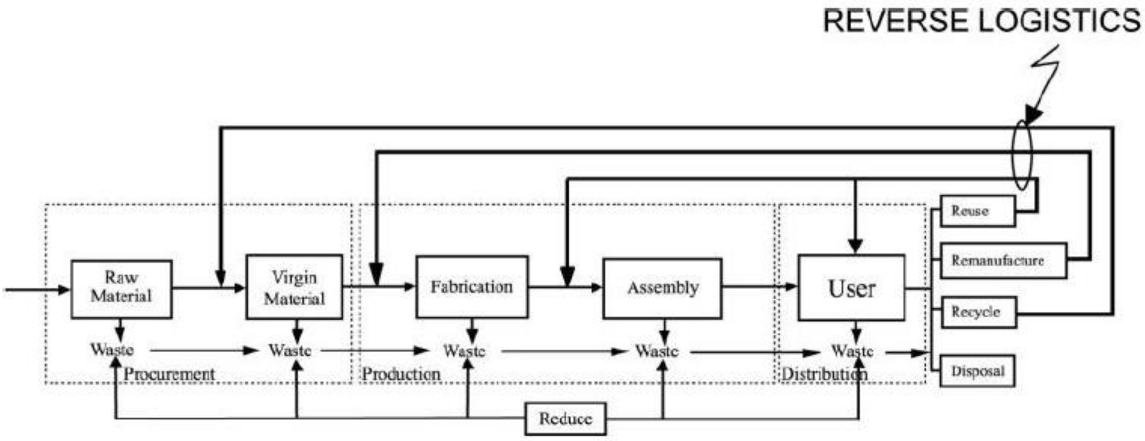


Figure 11. Operational lifecycle of a product and reverse logistics location (Meade & Sarkis, 2002)

The authors list four key characteristics of reverse logistics that create unique requirements. Firstly, the reverse process has the function of collection from many different sources and locations instead of a single supplier of a homogenous product. Secondly, the evidently sparse reverse logistics channels make it hard to evaluate and to achieve economically critical mass. Thirdly, the uncertainties with product and material life and return rates creates a substantial variation in supply. Fourthly, there is the issue what to do with the retrieved products; reclaim, recycle, remanufacture, reuse, take-back, or dispose.

The model for selection of third-party reverse logistics provider developed by Meade & Sarkis (2002) considers tangible, intangible, quantitative, qualitative, strategic and operational factors in the decision. The authors stress that it is beneficial to incorporate a broad variety of factors, especially strategic and operational considerations, to bring together decision makers from various levels and various functions within the organization. They add that in addition to being used as a mechanism to support a final decision for the logistics provider selection, the process and model are valuable knowledge and learning tools.

Meade & Sarkis (2002) point out that traditionally the reverse logistics function is delegated to the customer service function, and as such it is even more critical with the growing e-commerce arena. Nevertheless, the environmental corporate management dimension with focus on remanufacturing, recycling, and reclamation has diversified the research and practice in the field, and the authors think the argument is very convincing that the economic and environmental implications of reverse logistics will contribute to greening of the industry.

In their study Efendigil et al. (2008) propose a method for selecting appropriate and desirable third-party vendors of reverse logistics, taking the subjective requirements of the company into account. The authors state that companies usually consider conventional factors, e.g., price, quality, and flexibility when evaluating supplier performance. However, environmental considerations and performance of their suppliers should be taken into account in the decision making processes. The framework the authors present was developed through an analysis of environmental management practices and performance measurement metrics. Fuzzy logic and artificial neural networks were employed to incorporate both quantitative and qualitative attributes of suppliers leading to a more “effective and realistic vendor selection process”.

As for drivers, Efendigil et al. (2008) mention that significant return on investment as well as a significantly increased competitiveness in the market can be achieved with an efficient reverse logistics structure. Additionally, the authors say that by providing customers with the opportunity to return the warranted and/or defective products to the manufacturer, reverse logistics plays an important role in achieving ‘‘green supply chains’’.

Efendigil et al. (2008) note that most logistics systems cannot control reverse product movement due to lack of equipment. The complexity and cost of required operations for transportation, storage and/or handling of returned goods have different characteristics compared to traditional forward logistics. “In majority of the cases”, the authors state, “reverse logistics operations tend to require more sophisticated and problem specific approaches than their forward counterparts with higher distribution costs”. Due to these difficulties, Efendigil et al. (2008) continue that, in order to ensure efficiency, many organizations outsource their reverse logistics activities by engaging third-party logistics providers that implement reverse logistics programs designed to gain value from returned products.

Min & Ko (2008) studied the dynamic design of reverse logistics network from the third-party logistics service providers’ perspective. The paper aims to help determine the optimal number and location of repair facilities where returned products from retailers or end-customers are inspected, repaired, and refurbished for redistribution. The authors propose a mixed-integer programming model and a genetic algorithm that can solve the reverse logistics problem involving the location and allocation of repair facilities for third-party logistics providers.

Min & Ko (2008) point out that “the product return process entails the determination of the number and location/allocation of repair facilities for returned products so that total reverse logistics costs (e.g., warehousing and transportation costs) are minimized, capacity of repair facilities are fully utilized, and the convenience of customers who return products is maximized”. The actual reverse logistics problem then, the authors summarize, “is primarily concerned with determining which repair facilities and warehouses should be chosen as collection, consolidation, or trans-shipment points, which existing repair facilities and warehouses to expand, and which additional repair facilities and warehouses are needed to handle product returns”.

Min & Ko (2008) say that the volume of returned products have increased dramatically due to increased online purchases, stricter environmental standards, higher quality standards, and more lenient return policies. The authors continue that increasing concerns over environmental degradation and increased opportunities for cost savings or revenues have prompted some researchers to formulate more effective reverse logistics strategies. This is to say that the drivers for reverse logistics are financial or environmental.

Table 4: Comparison between reverse and forward logistics (Min & Ko, 2008) (Adapted and modified from Shear et al. (2005))

	Reverse logistics	Forward logistics
Quantity	Small quantities	Large quantities of standardized items
Information tracking	Combination of automated and manual information systems used to track items	Automated information systems used to track items
Order cycle time	Medium to long order cycle time	Short order cycle time
Product value	Moderate to low product value	High product value
Inventory control	Not focused	Focused
Priority	Low	High
Cost elements	More hidden	More transparent
Product flow	Two way (“push and pull”)	One way (“pull”)
Channel	More complex and diverse (multi-echelon)	Less complex (single or multi-echelon)

The mounting costs of managing product returns have made many third-party logistics providers to consider mapping the process of reverse logistics involving product returns and creating opportunities for cost savings and service improvements. A third-party logistics provider can achieve competitive advantage by optimal handling of product returns since it can save a substantial amount of transportation, inventory, handling, and warehousing costs associated with product returns. The authors have adapted and modified a comparison table (Table 4) of forward and reverse logistics differences from earlier work of Shear et al. (2005).

2.4.1 School 3 summary

In this school, environmental and financial forces were mentioned to drive the decision-making on reverse logistics, although Krumwiede & Sheu (2002) did only mention financial aspects. Legislative forces were not seen as a driving force, apparently because the third parties are not legally obliged to handle the products, as the responsibility belongs to the manufacturers. Social motivation was not mentioned either.

There were no company cases in the literature chosen in this school. Neither were there any mentions of non-profit organizations.

Table 5: Summary table of School 3 literature

	Article	Social	Environmental	Financial	Legislative	Non-profit	Company cases
Third party Reverse Logistics	Krumwiede & Sheu (2002)	-	-	+	-	-	-
	Meade & Sarkis (2002)	-	+	+	-	-	-
	Efendigil et al. (2008)	-	+	+	-	-	-
	Min & Koh (2008)	-	+	+	-	-	-

Krumwiede & Sheu (2002) developed a model for third-party companies to guide the process of examining the feasibility of engaging in reverse logistics. The six steps in the model are: 1. research existing reverse logistics issues and identify customers, 2. survey existing repeat customer needs, 3. survey competitors and competitors' customers, 4. conduct gap analysis, 5. perform feasibility study, and 6. develop a positioning strategy.

The conceptual model presented by Meade & Sarkis (2002) for selecting and evaluating third-party reverse logistics providers considers tangible, intangible, quantitative, qualitative, strategic and operational factors in the decision and, the authors stress that it is beneficial to bring together decision makers from various levels and various functions within the organization to be able to incorporate broad variety of factors. The authors also listed four key characteristics of reverse logistics, which are the collection from many different sources, the sparse reverse logistics channels, the uncertainties of product and material life and return rates, and lastly what to do with the retrieved products i.e. what level of recovery is viable.

Efendigil et al. (2008) highlighted the importance of taking subjective requirements of the company, in addition to conventional factors, into account when selecting appropriate and desirable third-party vendors of reverse logistics. These subjective properties include environmental considerations and performance of their suppliers, while the conventional ones are such as price, quality, and flexibility. The authors note that due to lack of equipment most logistics systems cannot control reverse product movement, and that the complexity and cost are different compared to traditional forward logistics.

Min & Ko (2008) had created a mathematical model to help third-party logistics service providers to determine the optimal number and location of repair facilities. The authors point out that a third-party logistics provider can achieve competitive advantage by optimal handling of product returns due to efficiency in transportation, inventory, handling, and warehousing costs associated with product returns. Additionally, the authors presented a good comparison table (Table 4) of forward and reverse logistics differences, modified from earlier work of Shear et al. (2005).

2.5 Summary of the literature review

The summary of all the reviewed literature is presented in Table 6. It includes the mentions of different drivers for engagement in reverse logistics, such as social, environmental and financial drivers which forms the triple bottom line, as well as legislative aspects. Additionally, instances of non-profit organizations were checked as well as company cases.

Overall, the drivers for engagement were similar throughout the literature in all three Schools, which were product recovery management, reverse logistics, and third party reverse logistics. The major difference is in the third party logistics literature, where legislative reasons are not seen as a driver, because the legal obligation regarding the products and materials belong to the manufacturing companies.

Social aspects were mentioned in three articles, and only by De Brito & Dekker (2004) were they mentioned as one of the main drivers as in corporate citizenship and that companies may "feel" socially motivated to engage in reverse logistics. Carter & Ellram (1998) mentioned that social trends affect the company's task environment, and Tibben-Lembke (2001) mentioned that a social benefit may be achieved when donating products to charitable companies.

Table 6: Summary table of the literature

	Article	Social	Environmental	Financial	Legislative	Non-profit	Company cases
Product recovery management	Thierry et al. (1995)	-	+	+	+	-	CopyMagic, BMW, IBM
	Gungor & Gupta (1999)	-	+	+	+	-	-
	Fleischmann et al. (2000)	-	+	+	+	-	Bulk recycling, remanufacturing, package reuse
	Fleischmann et al. (2001)	-	+	+	+	-	Copier remanufacturing, paper recycling
	Guide et al. (2003)	-	+	+	+	-	Kodak, Xerox, US Naval Aviation
	Toffel (2004)	-	+	+	+	-	-
Reverse Logistics	Fleischmann et al. (1997)	-	+	+	+	-	-
	Carter & Ellram (1998)	+	+	+	+	-	-
	Dowlatshahi (2000)	-	+	+	+	-	-
	Rogers & Tibben-Lembke (2001)	+	+	+	+	+	-
	De Brito & Dekker (2004)	+	+	+	+	+	Kodak, IBM, specialist recycler, Wehcamp, Volkswagen, Daimler-Chrysler, Xerox, Schering, Copier producer, Lead recycler, Refridgerator producer, Paper industry
	Fleischmann et al. (2004)	-	+	+	+	-	-
Third party Reverse Logistics	Krumwiede & Sheu (2002)	-	-	+	-	-	-
	Meade & Sarkis (2002)	-	+	+	-	-	-
	Efendigil et al. (2008)	-	+	+	-	-	-
	Min & Koh (2008)	-	+	+	-	-	-

Non-profit companies were not really considered well in the literature. In two instances only charitable organizations were mentioned that are non-profit (Rogers & Tibben-Lembke, 2001; De Brito & Dekker, 2004), but the subject was not addressed to any larger extent.

3 Methodology

Eisenhardt (1989) has described the process of inducting theory using case studies. The presented process is highly iterative and tightly linked to data. According to the author, the case study method is especially appropriate in new topic areas and continue that the resultant theory is often novel, testable, and empirically valid. To simplify, the author notes that the case study is a research strategy, which focuses on understanding the dynamics present within single settings.

3.1 Single case study

The empirical part of this research was done as a single case study. The method was used to gain insight into the drivers for engagement, type of business model and implementation of reverse logistics of a non-profit company. The reverse logistics development project for reuse of computers of The Reuse Centre offered a possibility to examine these problems first hand.

As the researcher was part of the reverse logistics development project team, the evidence gathered in this study is based on notes and documentation based on meetings and e-mail exchange with the project development team and other stakeholders, as well as personal observations made by site visits and internet searches. Iterative process was used to learn fast and develop the ways of working during the project.

4 Case Helsinki Metropolitan Area Reuse Centre Ltd.

4.1 Introduction of the case company

Back in 1985 some eco-active people arranged “goods exchange days” around Helsinki. The success of the events surprised the organizers and gave them faith to keep pushing forward. Since organizing such individual events was quite laborious, the idea surfaced to design something more structured and more permanent – a recycling centre. With a permanent office they could also add other useful activities, such as renovation of the goods, as well as offer waste management and environmental advisory services. (Kierrätyskeskuksen historiaa, n.d.)

The predecessor of *Helsinki Metropolitan Area Reuse Centre Ltd* (Pääkaupunkiseudun Kierrätyskeskus Oy) was founded in December 1989. The non-profit organization succeeded in obtaining a grant from the Ministry of the Environment, more precisely to pay the rental costs of their premises. Finally, in late October 1990 The Reuse Centre, as it will be abbreviated from now on in this thesis, opened for the public good.

Today The Reuse Centre has two department stores and four smaller shops in the Helsinki metropolitan area, as well as an online shop. The main product categories are furniture, clothing and dishes. The Reuse Centre receives, sells and donates used goods. They fix and repair bicycles and electrical appliances. They produce Plan B – secondary products and sell recycled sewing and crafting materials. Additionally, they lend e.g. trailers and durable tableware.

Furthermore, The Reuse Centre trains and advises children, young people and educators, as well as companies and other organizations on environmental issues. The Recycling Centre produces their own environmental consultancy events and materials according to the available resources. They also offer useful work experiences and new opportunities to working life. As an employer they guarantee to act responsibly as a diverse workplace and also offer meaningful work for volunteers. Social good has always been in the heart of The Reuse Centre, and since the beginning it has helped in reintegration of the long-term unemployed back to the working life.

In the 26 years of its existence, the organization has grown considerably and it is noteworthy to point out that since 2010 there has been major growth in its operations. During this period the turnover has doubled to about €7.4 million, according to the annual report of 2016 (see Figure 12).

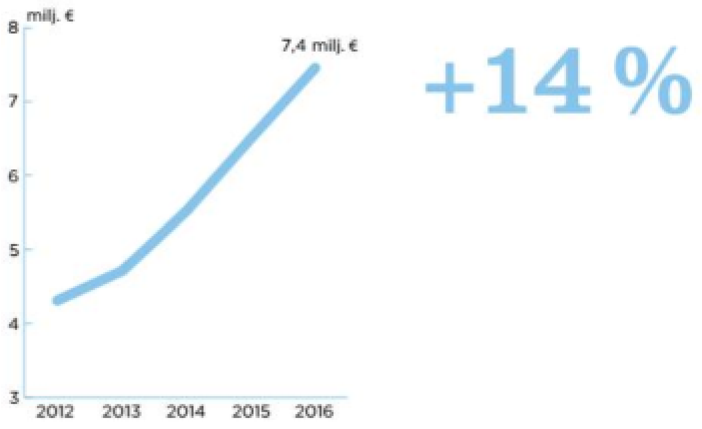


Figure 12. Turnover growth. Annual report 2016 Reuse Centre

The Reuse Centre has set three objectives that are to decrease the use of natural resources, to increase environmental awareness and the opportunities for participation and work. The first two objectives have an environmental focus and the third one has the focus on social good.

The Reuse Centre is a non-profit social enterprise and this has certain implications. According to Wikipedia, a social enterprise "is an organization that applies commercial strategies to maximize improvements in human and environmental well-being" ("Social enterprise", 2017). As a non-profit organization, The Reuse Centre does not share profits for their owners but uses the profits for maintenance and development of The Reuse Centre, in order to further achieve its purpose and mission of environmental work and to social good.

4.2 Status quo and preliminary development plan

The Reuse Centre had small-scale activities of fixing computers to begin with. In 2015 they had refurbished and sold about 500 used computers in total. The computers had come to The Reuse Centre from private consumers who had brought them there to get rid of their old equipment. As for there had not been too much effort done to get the computers, it seemed as there could be a lot more computers out there waiting to be fixed and sold. Furthermore, selling of the computers had never been an issue, which shows that there is clear demand for used computers. Therefore, as The Reuse Centre's focus is in saving the environment and the reuse of computers strongly supports this cause, it was only natural to make a decision to scale up the operations.

There are many aspects in The Reuse Centre's prior operations that support and help in developing the operation for promoting the reuse of computers. The company has already been fixing computers in some extent so there is knowledge about the inner process, they have their own pick up service that can be used for collection, and they have the selling network of department stores and shops that are also receiving computers. In addition, they work in close contact with the producer organization SERTY so they can rest assured that the recycling of useless parts is done by the best of terms.

The fact that The Reuse Centre had already been fixing computers in some extent is a good starting point, as the organization already has existing processes to do this, including people with needed expertise. Therefore, the operation can be developed within the company without the need of external help in the form of consultancy or the like, which is both cheaper and faster.

The Reuse Centre is cooperating closely with the producer organization SERTY, which takes care of the recycling of WEEE. The waste management includes comprehensive recycling practices. This is to say that The Reuse Centre is able to concentrate on the value recapturing through reuse of the computers while knowing that value from parts, components, or even complete computers that seem to have no reuse value is still recaptured to the best of knowledge through material recycling.

For now, the computers are received in all Reuse Centre's premises. They are treated as electrical appliances and go through the same chain of processes as lamps, for example. The Reuse Centre has a pick-up service for some valuable enough goods such as furniture and flat-TVs, but it is not offered for computers. On The Reuse Centre's webpage, the information about handing over the computers to The Reuse Centre's seem a bit incoherent.

4.2.1 The development plan

The main target of the project is to build up a service for companies or any organizations that have obsolete computer hardware. Then the plan is to find such companies or organizations and offer them a full service, where the Reuse Centre will pick up the hardware and related accessories and takes care of the reuse of the equipment to the best of terms. Important points here are the transportation, data security, refurbishing of the computers and selling them onwards to the customer market. Additionally, another target is to increase the amount of computers retrieved from consumers.

The Reuse Centre already has its own collection services from consumers for products such as furniture, home appliances, TVs, bicycles, etc. Transport coordinators run this service professionally, with multiple vans on the streets on weekdays. The collection of computers could probably be scheduled conveniently within this process. The only exception is that these runs need to presumably be done separately from other pick-ups because of data security reasons, but this should not represent any major issues.

4.2.2 Environmental dimension

The reuse value of computers was investigated and it was found that there lies enormous potential. The material reuse value of computers, i.e. mainly the material recycling of the precious metals, have been in focus when talking about environmental load of computers and how to mitigate it. Factual reuse of computers has been given less attention and should be put under more scrutiny. Further, ways to facilitate and foster the used computer market should be studied.

What could be learned from the literature revealed that the reuse of a computer could save up to 20 times natural resources versus buying a new one (Williams, Yukihiro, 2003). Another interesting point was that when counted with estimated typical computer life-cycle time of three years, up to 70% of the primary energy used in the computer's life cycle is already wasted in the manufacturing (Deng, Babbit,Williams, 2011).

To estimate the size of the used computer market in Finland, the sales figures of new computers were sought out. Updated figures were published in the spring 2016 and the sales for 2015 were 360 693 laptops and 61 682 desktop computers (GoTech.fi). With a rough estimate based on the population living in the Helsinki metropolitan area (~20%), this amounts to about 85 000 new computers sold yearly nearby in the sphere of influence of The Reuse Centre.

Consequently, it is only logical to assume that there has to be a myriad of used computers lying around the city. During the same time The Reuse Centre had fixed, refurbished and sold 500 computers. These figures give assurance that there are computers to be found and a lot to do in terms of getting those unused computers to use.

4.2.3 Social dimension

The Reuse Centre offers fixed-term jobs for unemployed jobseekers and support for further employment. The computer re-processing processes are not very complicated and the related job description offers good opportunities for hiring support employed. It was discussed in meetings and e-mail exchange that if the operations were to grow, this could offer great opportunities for employing new staff, thus promoting social good.

4.2.4 Financial dimension

It was estimated that profits can be made with selling of the used computers, but the financial requirements for the project are only secondary. Cost-effectiveness is naturally considered in the operations development. The financial requirements for the activities are only secondary so that even though financial sustainability is needed, a break-even situation is sufficient and acceptable as long as environmental and social benefits are gained.

4.3 The producer organizations

The collection of waste of electrical and electronic equipment (WEEE) is regulated and statutory in Finland. Consumers can take old electrical and electronic equipment for recycling free of charge. Recycling has been paid for in the device purchase price (recycling fee). The equipment may be returned free of charge at regional WEEE collection facilities. Moreover, a substantial part of the retailers receives waste electrical and electronic equipment.

Producer responsibility means that the electrical and electronic equipment manufacturers and importers are obliged to provide a free of charge reception network for used consumer electrical and electronic equipment. The producer responsibility can be transferred to a producer organization and in practice, these manufacturers and importers of electronic equipment are part of a WEEE producer organization which is then responsible for the proper recycling and waste management practices. To be clear, they do not do the recycling themselves, but are the responsible party to make sure that the WEEE will end up to proper WEEE processing plants.

In Finland there are five producer organizations, which are FLIP, SELT, ICT, ERP and SERTY. A company named Elker Ltd is a non-profit service company established by three of the producer organizations, FLIP, SELT and ICT, and its task is to manage the statutory obligation of producer responsibility. The operation of the producer organizations is based on EU directive and the waste act of Finland, and the supervisory authority is the Centre for Economic Development, Transport and the Environment of Pirkanmaa (Pirkanmaan ELY-keskus).

5 Analysis and results

5.1 The business model

The positioning of The Reuse Centre in the market is atypical in that even though they are in the reverse logistics business, they do not operate for any other company to accomplish their reverse logistics needs. This is illustrated in Figure 13. The Reuse Centre operates individually to accomplish their own goals, which are based on environmental and social benefits.

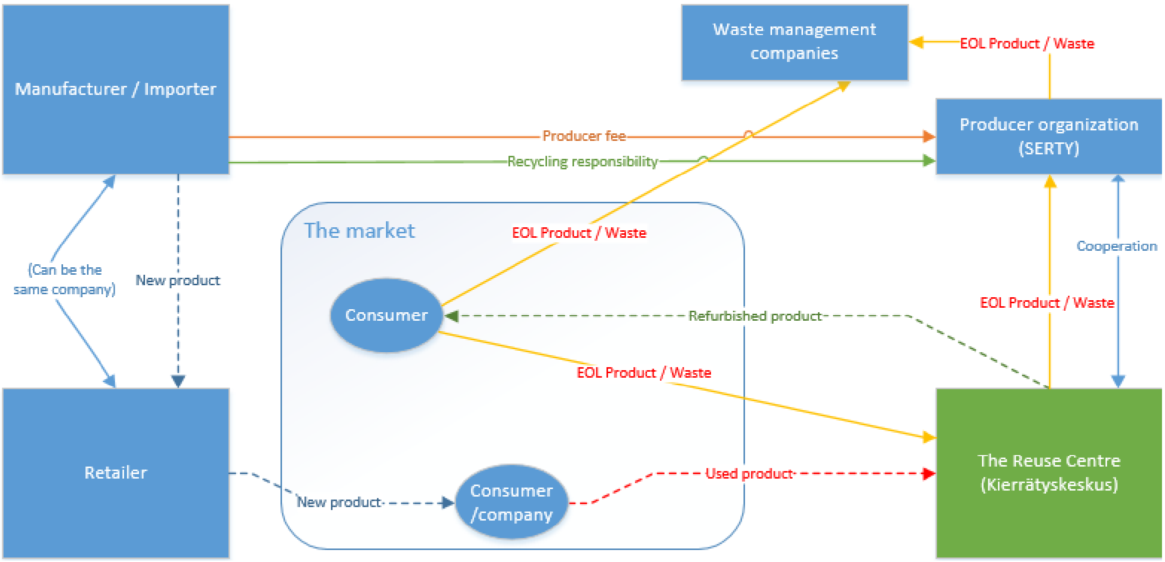


Figure 13. Positioning of The Reuse Centre in the computer market

The supply chain of The Reuse Centre for reuse of computers is illustrated in Figure 14. The Reuse Centre acts as the collector, re-processor, and the redistributor of used computers. The collection comprises of equipment collection from different Reuse Centre premises where the equipment is received, as well as from the potential future partners. As the inspection/selection/sorting and assembling/data erasure/software install processes are centralized in the Nihtisilta logistics center, all equipment is transported there.

In the inspection / selection / sorting process, a preliminary value assessment is done to the computers by their age, power, and overall working condition. If a computer is estimated valuable for reuse, it is inspected to see if it functions as is. When malfunctions are encountered, the computer’s components need to be inspected individually. If a computer does not seem valuable enough for reuse for anyone, it is scavenged for any still valuable components to be used in other assembled computers. These components need to be then inspected individually.

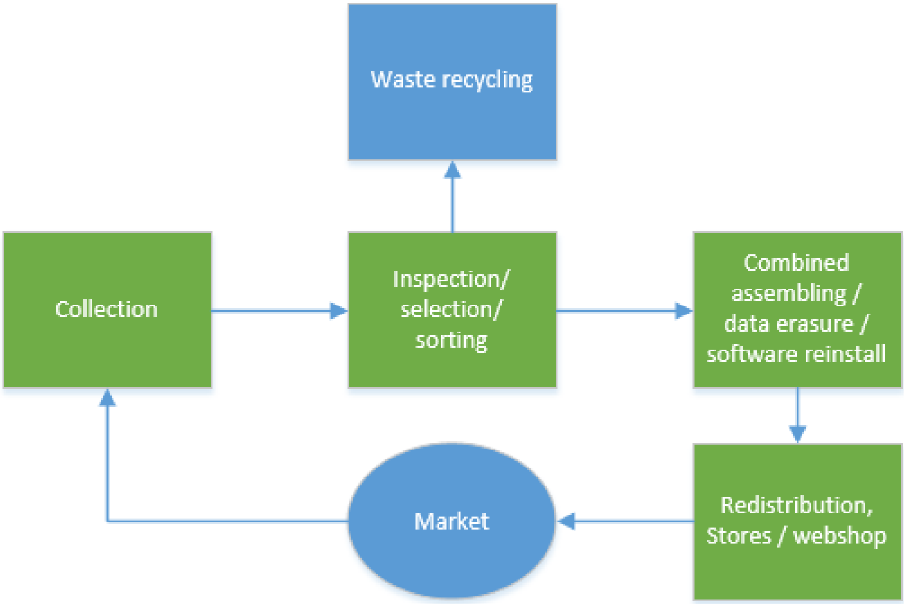


Figure 14. The Reuse Centre's supply chain for computer reuse

The Reuse Centre has limited capabilities for recovery of the collected computers that vary greatly in both quality and age. Due to the difficulty of remanufacturing the complex components if they do not work properly, The Reuse Centre cannot fix them and is limited to refurbishing the machines by changing the components. When a machine is in working order, the hard drive is formatted and operating system is re-installed along with other relevant software. Although this is done always as a normal procedure mainly for data security reasons, it can be considered as repair process if there had been something wrong with the software. The computer might have been infected with a virus, for example, which had left the computer useless as such.

Because of the data formatting and software re-installing, direct recovery of the computers is not possible and some work is always needed. In summary, functioning computers are assembled by removing bad components and replacing them with working ones. The computers are then formatted and a re-install is done. Then their selling price is evaluated and they are put for sale.

The fact that The Reuse Centre is acting for their own goals individually in the market and not for another company induces certain characteristics for their business. One fundamental difference comes from the fact that instead of having to fulfill product take-back obligations, The Reuse Centre has to reach actively to the consumers and companies to get used product input. Consequently, resources need to be allocated and used for this end. This offers the opportunity to measure the efforts used to getting new input with the processing capacity. Additionally, this may be very pragmatic when seeking growth, as efforts to gain new input can be increased gradually.

During negotiations with a partner it came up that some services that have earlier offered to collect electronic appliances for free, are actually moving toward a paid service. The information was not confirmed, but if true, this is good news for a new service provider entering the market that is offering the same service for free at least in the foreseeable future.

5.2 The implementation of the reverse logistics system

5.2.1 Computer acquisition through partnerships

The difficulty in acquisition of partnerships with companies and municipal actors represented a major obstacle for growing the input of used computers to the system. This problem should be prioritized and addressed by developing the process for acquiring partnerships to be more efficient.

It was discussed that in the long run the intent was to develop the computer pick up service for partners to be such that new parties would get interested and contact The Reuse Centre for inquiries about the service. This idea proved to be overly optimistic this early on and it became clear that the potential partners needed active and personal contact.

Nevertheless, the results of the computers acquisition through partnerships were positive alike. With the two parties who were willing to collaborate, an agreement was achieved to handle the collection and possible reuse of their electronic equipment. There were coinciding similarities with both parties in terms of the estimated amount of computers they would need to get rid of on a yearly basis, as also that at the very moment of the negotiations they did not have any computers lying around to be given.

Both of the partners estimated that they would have around 100 computers to give on a yearly basis. The clear advantages of the partnerships compared to the computer acquisition from the consumers is the superior and uniform performance of the computers given. This is to say that on average, the computers are newer and have more power than the ones from the consumers, and there are more identical computers.

5.2.2 Acquisition of computers through partnerships

Most of the effort in the empirical work was done trying to acquire willing partners. One tricky question was how to target the search. Other key issue was how to convey the message. The original plan was to send out information as e-mail message to see if there was any interest to hear more what we could offer. After all, we were offering a service to help the partnering companies to get rid of unused IT hardware.

A preliminary list of companies was drafted after the first meeting to begin the search for possible partners for cooperation. These parties included phone operators, computer manufacturers and computer stores. As the response rate was so low, it was obvious that a more active approach would be needed so I started to call the companies.

After a while, it was realized that the phone operators were managing their computers through leasing contracts. The computer manufacturers in turn were in some cases offering leasing contracts themselves, which meant that they had their own processes in place for the used hardware. One manufacturer had centralized all their decision-making of IT assets in Central Europe so no decisions could be made locally.

It came apparent that leasing companies, computer stores, and the manufacturers were, in fact, competitors in this matter so we had to change our aim as for looking for partners. A meeting was held to tackle this issue, and as we redrafted the contact list, we now chose companies in a wider range of industries.

Now we included different kind of companies, municipal actors and schools into the mix. Still as a procedure e-mail was sent in advance and was followed up by calling the subject. When possible, the contacting was targeted to employees responsible for IT, such as IT managers.

The contacting for partnerships was reviewed once again since it was known that there has to be interested parties out there somewhere, they just needed to be found. The search was yet widened and this time the message was scrutinized. The key point was to introduce The Reuse Centre and the business case first quickly during the phone call and leave out personal introduction and the fact that the project was part of a graduate thesis. The contacted personnel were not interested in such details and it came apparent that mentioning the school project only hindered the possibility of arousing interest. They were interested in the practical benefits they could gain with partnering.

Finally, after a wearing effort we began to receive some positive signals. Finally, two parties were interested enough to set up a meeting. Ironically enough, these parties were actually very keen on hearing what we had to offer.

5.2.3 Acquisition of used computers from consumers

To engage the consumers, we needed to raise awareness about the fact that The Reuse Centre receives used computers and that it is a very good deed for the environment. We started to plan a social media campaign to reach the consumers but first we had to make sure all was in order on The Reuse Centre's own webpage.

On The Reuse Centre's webpage, the information about computers handing them over to The Reuse Centre's were quite unclear and imprecise. The information was scattered under different titles under different pages. If and when we wanted to engage consumers to hand in more used computers, the information for doing so needed to be clear and easily found. In addition, a new page solely for used computers was needed to have all information about them at one location.

The content of the webpages was checked through and a checklist was made how to make the information about the used computers cohesive and precise. Further an own page for presenting the case of used computers and all related services was made. These were mandatory steps to take before we could go on to launch a campaign targeting the consumers through social media.

The computer acquisition campaign from consumers led to valid results. With quite simple effort of clarifying the terms of computer reception on the webpages and through the Facebook advertisement campaign, the audience was reached and consequently a clear spike in computer returns was observed.

During the first month after launching the Facebook campaign, about 200 used computers were brought to The Reuse Centre. Comparing the amount to the previous year, when 500 computers were given to The Reuse Centre during the whole year, the return amount was 480% higher when calculated with monthly average.

Although the effect of the campaign faded after the launch, the results were highly positive. Comparing the cost of the effort and the achieved results, it became clear that more resources should be allocated to the advertising to increase awareness of the public.

5.3 The drivers for engagement – Triple bottom line

From environmental perspective, the results were very positive as more computer were gained, fixed, and put to sale for reuse. Calculated by The Reuse Centre's natural resource savings metrics, hundreds of thousands of kilograms of natural resources were saved.

The social benefits achieved through the project were limited but nonetheless very valuable. As The Reuse Centre employs long-term unemployed, all additional work they have to offer benefits the society. Anyhow, the gained increment in used computer input was not large enough to increase the workload so that additional workforce would be needed to process them.

From financial point of view, the project succeeded well. As there were no high expectations on financial gains and the costs were kept low, the results were very promising for further development.

5.4 In summary

All in all, the development project can be considered as a success since concrete positive results were attained. Although many mistakes were made, these were only to hinder the progress that could have been achieved. The key for future development of the reuse of computers through the Reuse Centre is to learn from the project and refine the processes to reach further and faster.

In total, during the year of 2016 The Reuse Centre fixed 6437 computer related articles, an increase of 41% from the total of 4576 articles the previous year of 2015 (The Reuse Centre annual report, 2016).

6 Discussion

In the literature in general, reverse logistics is mainly posed as a problem that manufacturers need to address for various reasons. These reasons include legislative obligations of product take-back as well as anticipating or impeding legislation, financial opportunities through cost reductions and increased profits, and better environmental image to answer to customer pressures.

There are plenty of studies about third parties in reverse logistics, but the perspective is still locked on the manufacturers and mainly how they should choose the correct service provider to take care of their reverse logistics activities. Although this research is much needed, there are situations where the original manufacturer will not have anything to with the Reverse logistics operations taken upon their products. Such a situation may occur if some actor is willing to collect (used) products out of the market and trying to sell them. The Reuse Centre is exactly this kind of operator.

Computers are electronic appliances that are considered as Waste of electrical & electric equipment (WEEE) at the end of use. WEEE fall under producer responsibility, which means that the manufacturer or importer of the products is obligated to arrange the collection, and possible reuse and recycling of the materials. In practice, the companies join to a producer organization, pays a fee and the responsibility is transferred to them.

The IBM product recovery case (Thierry et al. 1995) shows that charging a fee for product take-back lessens the customers' willingness to hand over their computers. In order to avoid this the service should be free of charge. To further motivate people to bring their computers, it could be considered if a small fee could even be paid to the customers. This obviously has its own problematics such as how to value the equipment and how much it could actually increase the input, but looking into the future the idea should not be overlooked.

In the IBM case from the 90's it is clear that charging a fee from the customers affects negatively in the willingness of customers to take products back (Thierry & al., 1995). Consequently the only logical conclusion is that in order to maximize the amount of returned computers, the product take-back should undoubtedly be free of charge for the customer. From the customer's point of view this makes sense since he/she is only helping the other party and has to go through the trouble of transporting the equipment to a proper location. From the company's perspective, given that the prior is true, it makes sense not to charge from the take-back to obtain more input which in turn helps to develop the value recovery.

Additionally, aside from data security, The Reuse Centre do not have any contractual obligations towards the consumers and partnering parties after they have handed over computer equipment. Even though maximal reuse is pursued, and if not possible recycling of the materials is done to the best of terms, there is no contractual accountability for the results.

There is a fundamental problem with the use and meaning of WEEE as not all WEEE are actually waste. When speaking about managing reverse logistics cost-effectively, Rogers & Tibben- Lembke (2001) state that a lot of value can be obtained from material sometimes derisively referred to as junk. Products should be categorized as waste only if they no longer have any reuse value as an ensemble of its constituents.

Computers, if not technically too outdated, offer a great practical example. If one component of a computer is broken, it can still be refurbished by changing only the broken component, and thus it makes no sense to recycle the whole computer for its materials, such as precious metals, at this point. The value of a working computer is a lot higher as such compared to the material value gained through material recycling. As a rough but illustrative practical example, a perfectly good new product may be considered as waste, only because it has been placed “in trash”.

6.1 Theoretical contribution

The literature review showed the main drivers for reverse logistics are financial, legislative, and environmental issues. Social aspect were mentioned very scarcely. Additionally, non-profit organizations were poorly addressed in the literature, and the only examples were charities.

As there is a clear lack of studies of independent non-profit organizations in the reverse logistics field, this research helps to fill that gap. The general rules of reverse logistics apply no matter the operator. This is because the reasons that define relevant network structures and the level of recovery that is possible with a certain product are all the same, regardless of the reverse logistics operator. But this study goes to show that a different kind of business model is viable in terms of achieving profits,

The drivers for engagement in reverse logistics may differ greatly. Especially in the case of a non-profit organization, the financial incentives may be less important, although crucial for viability. Then, the other components of the triple bottom line, as in environmental and social impacts, are valued higher.

6.2 Managerial implications

This section offers suggestions for The Reuse Centre to further develop their created service and other propositions for future projects. Some of these points were discussed during the project work, but could not be implemented for varying reasons.

The profit margins of the used computers business are understandably thin and economies of scale should be targeted. As the case made clear, there is a great potential in the computer reuse market so that the efforts should be continued.

6.2.1 Partner acquisition

When developing the service, the idea was to make it attractive and well-known, enough so that companies would approach The Reuse Centre to get the service. While that takes time, raising awareness of the existing service needs effort and resources.

To find more customers for the service, someone at The Reuse Centre should be made responsible for the customer acquisition. Additionally, a systematic acquisition procedure should be developed to ensure efficiency.

6.2.2 Pick-up service for consumers' computers

The use of the already in-place pick-up service of The Reuse Centre for consumers' should be seriously considered to be extended for computer pick-ups. This might encourage more people to give their outdated equipment for The Reuse Centre, when the trouble of transporting the equipment to The Reuse Centre would be eliminated. An unofficial inquiry with several people backed up this claim, saying they have obsolete computers lying around and are willing to give them for reuse efforts, but have been reluctant to take the time and effort to transport the equipment to The Reuse Centre, or anywhere else for that matter.

The efficiency of The Reuse Centre's inner process should be examined. With growing input flows, the significance of smooth, continuous and efficient operation of the refurbishment phase increases. This has direct implications on the profitability of the total operation.

Similarly, as the input flows grow, the size of the market for reused computers should be estimated. At this point, as the demand had historically exceeded the supply, the whole question of demand was dismissed for later. However, looking to the future, it could form a tremendous pitfall to overestimate the demand while scaling up the operation.

6.2.3 Inner process development

The operation of fixing the computers would need to be separated from other electrical equipment. A specific process would need to be implemented to correspond to the specific needs of the computer fixing process and data security. Also the readiness for increasing input is valuable to have in consideration when making the changes.

For now the Reuse Centre is using freeware software DBAN to format the computer hard disks. It was assumed that this could be an issue regarding the high data security needs of companies and as a result a world leading data erasure specialist Blancco Data Security Group was inquired already during the project for their pricing, which turned out to be reasonable even for relatively small scale operation. It was calculated that if The Reuse Centre could get at least 200 computers per year with the assurance of using this software, it would be profitable to switch the formatting software. It is advised to keep this in mind, and when meeting with the possible partnering companies, the possibility to change to the Blancco software should be offered if seen necessary.

6.2.4 Project management development

From the view of the drivers and constraints of reverse logistics (Carter & Ellram, 1998) presented in the literature review, there are a few valuable takeaways that can help in future projects. All of these factors are considered shortly by level of importance. Policy entrepreneurs were mentioned as key internal driving force for reverse logistics activities. Their job is to undertake responsibility for the project. Top management support, stakeholder commitment, and incentive systems were posited as constraints if not present.

Very important point to make here, is that the responsibility for the project was not clearly given to any certain person, and in effect it was spread among the key persons. Carter & Ellram (1998) stressed that to succeed in reverse logistics implementation, a single policy entrepreneur is crucial to see through the whole project.

Top management support could only be evaluated indirectly since there was no direct contact with them during the project. But the fact that resources were allocated to the project, mainly as time of the employees involved, it can be read as necessary support. At least it did not occur at any moment that there would be a lack of support from top management.

In this particular case with very limited scope the need for managing stakeholder commitment is quite narrow. For example, there is no need for vertical coordination up and down the supply chain in a situation where the company does not have its own production and the product inputs are sought outside the company, and also where the repaired products are sold directly to consumers through existing shop network.

The incentive systems can only be commented on the part of the researcher, because no information was given about the Reuse Centre's inner incentives concerning the project. Although no information was given, an educated guess would be that there were no additional incentives for the employees working with the project and the work was done during the normal working hours. The researcher himself had been given a paid assignment to undertake the development project as part of his graduate thesis.

7 Conclusions

In this study the literature was examined to see: what are the main drivers for reverse logistics, how are non-profit organizations taken into account as reverse logistics operators, and how the reverse logistics operations are implemented. The case work showed a reverse logistics process development of a non-profit organization.

The main drivers for reverse logistics were financial, legislative and environmental aspects. Social responsibility was mentioned very scarcely. For The Reuse Centre, the main drivers for their operations are firstly environmental benefits and secondly social benefits, while maintaining a financial sustainability. The case work goes to show that a non-profit organization may well compete in the market.

Reverse Logistics play an important role in developing reuse of products and materials as they need to be gathered faster and more efficiently from the end-user to the location of reproduction or proper recycling.

Reverse Logistics of used computers is a viable business. In moving towards Circular Economy and more sophisticated systems in world economy such as environmentally responsible manufacturing, reuse should be taken more seriously and the surrounding possibilities should be taken advantage of.

It seems that there is a clear market for used computers but it may be hard to reach. The segment consists presumably of low-income population with scarce resources, who do not have the financial resources to purchase a new computer.

7.1 Non-profit company competitiveness

As well known in economics, money is always a scarce resource. Thus, the financials of an operations development project need to be evaluated, even though financial gains are not the primary target. The difference between a typical profit seeking company and a non-profit organization, the latter may be satisfied with a situation where the financials are even negative or just break even so that the activities of reverse logistics and value recovery pays itself. At the same time, as long as the organization makes a meaningful and positive environmental and/or social impact, the operations can be considered successful.

This may further offer advantage in the market place when looking for partners. As companies compete against each other and are meant to make profits for their owners, they may be very reluctant to help other companies just for good will. With a non-profit organization the situation is completely different, and companies may be very willing to help an actor that exists for the good of the environment and society. This offers a possibility to use the cooperation to promote good will for the good of the partnering company.

7.2 Topics for future research

What was very surprising to find was that there seems to be no clear general practices how companies get rid of their obsolete computers and accessories. This calls for further studying particularly in times when the cycle times of computers have only grown shorter. Computer leasing companies would naturally take away older computers from their customers while these were changed to newer ones, but it was left unclear what the leasing companies do then with these computers and thus it should be similarly studied.

In bigger picture it seems that a lot more can be accomplished regarding the reuse of computers in Finland. Consequently, the strain on the environment could be mitigated substantially. While the government as well as the EU have put forward plans for moving towards Circular Economy, concrete and more specific decisions to promote actual change should be done.

Even though the producer responsibility and WEEE aim for maximal reuse of products in theory, this does not hold true in practice as proved by the case evidence. Computers are a good example of how the reuse targets are not met and plenty of potential value goes to waste due to inefficient practices, which calls for further research.

References

Books

Fleischmann, M., Bloemhof-Ruwaard, J. M., Beullens, P., & Dekker, R. (2004). Reverse logistics network design. In *Reverse Logistics* (pp. 65-94). Springer Berlin Heidelberg.

Articles

Carter, C. R., & Ellram, L. M. (1998). Reverse logistics: a review of the literature and framework for future investigation. *Journal of business logistics*, *19*(1), 85.

De Brito, M. P., & Dekker, R. (2004). A framework for reverse logistics (pp. 3-27). *Springer Berlin Heidelberg*.

Deng, L., Babbitt, C. W., & Williams, E. D. (2011). *Economic-balance hybrid LCA extended with uncertainty analysis: case study of a laptop computer*. Journal of Cleaner Production, 19(11), 1198-1206.

Dowlatshahi, S. (2000). Developing a theory of reverse logistics. *Interfaces*, *30*(3), 143-155.

Efendigil, T., Önüt, S., & Kongar, E. (2008). A holistic approach for selecting a third-party reverse logistics provider in the presence of vagueness. *Computers & Industrial Engineering*, *54*(2), 269-287.

Eisenhardt, K. M. (1989). Building theories from case study research. Academy of management review, 14(4), 532-550.

Fleischmann, M., Beullens, P., BLOEMHOF-RUWAARD, J. M., & Wassenhove, L. N. (2001). The impact of product recovery on logistics network design. *Production and operations management*, *10*(2), 156-173.

Fleischmann, M., Bloemhof-Ruwaard, J. M., Dekker, R., Van der Laan, E., Van Nunen, J. A., & Van Wassenhove, L. N. (1997). Quantitative models for reverse logistics: A review. *European journal of operational research*, *103*(1), 1-17.

Fleischmann, M., Krikke, H. R., Dekker, R., & Flapper, S. D. P. (2000). A characterisation of logistics networks for product recovery. *Omega*, *28*(6), 653-666.

Guide, V. D. R., Jayaraman, V., & Linton, J. D. (2003). Building contingency planning for closed-loop supply chains with product recovery. *Journal of operations Management*, *21*(3), 259-279.

Gungor, A., & Gupta, S. M. (1999). Issues in environmentally conscious manufacturing and product recovery: a survey. *Computers & Industrial Engineering*, *36*(4), 811-853.

Krumwiede, D. W., & Sheu, C. (2002). A model for reverse logistics entry by third-party providers. *Omega*, *30*(5), 325-333.

Meade, L., & Sarkis, J. (2002). A conceptual model for selecting and evaluating third-party reverse logistics providers. *Supply Chain Management: An International Journal*, *7*(5), 283-295.

Min, H., & Ko, H. J. (2008). The dynamic design of a reverse logistics network from the perspective of third-party logistics service providers. *International Journal of Production Economics*, *113*(1), 176-192.

Norman, W., & MacDonald, C. (2004). Getting to the bottom of “triple bottom line”. *Business Ethics Quarterly*, *14*(02), 243-262.

Rogers, D. S., & Tibben-Lembke, R. (2001). An examination of reverse logistics practices. *Journal of business logistics*, *22*(2), 129-148.

Srivastava, S. K. (2007). Green supply-chain management: a state-of-the-art literature review. *International journal of management reviews*, *9*(1), 53-80.

Thierry, M., Salomon, M., Van Nunen, J., & Van Wassenhove, L. (1995). Strategic issues in product recovery management. *California management review*, *37*(2), 114-135.

Toffel, M. W. (2004). Strategie management of product recovery. *California management review*, *46*(2), 120-141.

Williams, E. D., & Sasaki, Y. (2003, May). *Energy analysis of end-of-life options for personal computers: resell, upgrade, recycle*. In Electronics and the Environment, 2003. IEEE International Symposium on (pp. 187-192). IEEE.

Internet-references

Circular economy. (n.d.) In *European commission.* Retrieved February 5, 2017, from http://ec.europa.eu/environment/waste/weee/index_en.htm

Kierrätyskeskus (n.d.) In *Kierrätyskeskus*. From http://www.kierratyskeskus.fi/

Kierrätyskeskus vuosikertomus 2016. (30.3.2017) In *Issuu.* Retrieved April 15, 2017, from https://issuu.com/kierratyskeskus/docs/kierke_vsk_2016_painoon_issuu

Kodintekniikkaindeksi. (29.1.2016) In Eläketurvakeskus. Retrieved May 15, 2016, from http://gotech.fi/2016/01/29/joulumyynti-piristi-kodintekniikan-kauppaa-vuoden-2015-myynti-jai-silti-14-prosenttia-miinukselle/

Social enterprise. (n.d.). In *Wikipedia*. Retrieved May 5, 2017, from https://en.wikipedia.org/wiki/Social_enterprise

Waste Electrical & Electronic Equipment (WEEE) (n.d.) In *European commission.* Retrieved February 5, 2017, from http://ec.europa.eu/environment/circular-economy/index_en.htm

Appendix A: Reverse logistics: 12 case studies (de Brito & Dekker, 2004)

Table A1: Reverse logistics: 12 case studies (de Brito & Dekker, 2004)

Table 1: Reverse Logistics (who, why, how and what): 12 case studies

Who	Why- drivers	Why- return reasons	How	What
Kodak case (Toktay et al., 2003)				
Kodak Photo-finishing lab	Economics (Corporate Citizenship)	Service	Remanufacturing	Consumer good (single-use camera)
IBM case (Fleischmann et al., 2003)				
IBM; Other manufacturers, municipalities (NL) Charities (USA)	Legislation Economics	B2B commercial returns Service End-of-use (End-of-lease) End-of-life	Reuse Repair Remanufacturing Recycling	Consumer and industrial goods Spare parts (electronic goods)
The case of a specialist recycler in the UK (Beullens et al., 2003)				
Specialist recycler in the UK Car repair centres; return centre	Economics (Legislation)	End-of-life	Recycling	Ores, oils and chemicals (batteries)
The Wehkamp case (De Brito and De Koster, 2003)				
Wehakmap, a mail order company in the Netherlands	Economics (also customers relationship); Legislation	Reiumbersement	Re-sale	Consumer goods (clothing and hardware products)
The Volkswagen case (Van der Laan et al., 2003)				
Volkswagen Car dealers	Economics	Service	Remanufacruting	Spare-parts (car parts)
The Dailmer-Chrysler case (Kiesmüller et al., 2003)				
Daimler-Chrysler Car dealers	Economics	Service End-of-life	Remanufacturing	Industrial goods (Mercedes-Benz engines)
The Xerox case (Inderfurth et al., 2003-)				
Xerox	Economics (also Corporate Citizenship)	End-of-use	Remanufactruing	Industrial goods (professional copiers)
The Schering case (Inderfurth et al., 2003)				
Schering, pharmaceutical manufacturer in Germany	Economics Corporate citizenship	By-product	Retrieval (of valuable substances)	Ores, oils and chemicals (pharmaceutical)
The case of a copier producer /remanufacturer (Teunter and van der Laan, 2003)				
Copier producer/manufacturer	Economics	End-of-use (+ incentives)	Remanufacturing	Industrial goods (professional copiers)
Lead manufacturer in Greece (Pappis et al., 2003)				
Lead recycler company in Greece; wholesalers; collectors	Economics (Legislation)	End-of-life	Recycling	Ores, oils and chemicals (batteries)
The case of a Japanese producer of refrigerators (Bloemhof-Ruwaard et al., 2003)				
Japanese producer of refrigerators (in Europe)	Legislation	End-of-life	Repair, retrieval, remanufacturing recycling	Consumer goods (refrigerators)
The case of the pulp and paper industry in Europe (Bloemhof-Ruwaard et al., 2003)				
Paper industry in Europe EU (policy-making)	Legislation Corporate responsibility	End-of-life	Recycling	Other materials (pulp and paper)