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Organising Product Recovery in Business Networks

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CHALMERS UNIVERSITY OF TECHNOLOGY

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ABSTRACT

The licentiate thesis includes an analysis of different ways of organising product recovery. The aim of product recovery is raw materials conservation, which is strongly related to sustainable development. The focus of this thesis has been on the physical flows from the disposers towards new end-users through different product recovery options that include recycling, remanufacturing, and refurbishing. In this thesis a framework for analysing different ways of organising product recovery in inter-organisational networks is developed. The framework applied in the study relies on the Industrial Network Approach (e.g. Håkansson et al., 2009). The analysis of empirical findings has been performed in all three network layers of the ARA model (Håkansson and Snehota, 1995), in the activity pattern, resource constellation and in the web of actors. The key research issue in the activity layer is to identify differences between activity structures with regard to principles of postponement and speculation, and activity interdependencies. In the resource layer, the research issue is to explore adaptations and tensions. With regard to the actor layer, the main research issue deals with how business relationships in terms of inter-organisational information exchange and the positioning of actors affect activity coordination and resource combining. In addition to the analysis through the models of the Industrial Network Approach, the concept of transvection (Alderson, 1965) is used as a complement to study product recovery to analyse various ways of organising product recovery. The concept of transvection regards all activities as either sorts or transformations with regard to identity, time, place, and form. Sorting is the decision aspect concerned with classification of objects and the direction of transformations of these objects.

A qualitative case study in the PC industry has been conducted, with a focus on an actor, who is performing and coordinating different product recovery activities and options together with third party logistics providers and retailers of used products, as regards disposers' different needs. The concept of transvections effectively elucidates various ways of organising activities with regard to principles of postponement and speculation as well as how sorting decisions direct and re-direct the objects in the network. Structuring of information in time, place, form, and identity dimensions supports sorting rules that steer objects into different product recovery options. This organisation of information facilitates sorting, activity coordination, and resource combining between firms. Information sharing provides possibilities for matching supply and demand of the reprocessed products and enhances resource utilisation. This thesis highlights the significance of a network perspective on organising product recovery, which adds to the literature on reverse logistics and Closed Loop Supply Chain Management. Analytical tools which were developed within the Industrial Network Approach can be applied to investigate organising product recovery. The results of this study can be useful for managers to understand the effects of integrating forward and reverse physical flows.

Keywords: *industrial networks, reverse logistics, closed loop supply chain management, product recovery, organising, activity coordination, resource combining, transvection, sorting.*

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Gothenburg, June 2012

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1 INTRODUCTION

In this chapter, the background and the research area of the study (product recovery), are presented with respect to their theoretical and practical significance. A discussion on the importance of taking a relational and network perspective on organising product recovery in this study outlines the aim of the thesis. Finally, this introductory chapter concludes with a presentation of the structure of the thesis, in order to provide the reader with an overview of, and guide to, this thesis.

1.1 Background

This thesis deals with organising product recovery, which is mainly related to the recovery and decrease of material resources in a sustainable manner. The most common definition of sustainability is the use of resources to meet the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). The three dimensions of sustainable development, *economy, environment and society,* constitute a framework within which economic growth goes hand-in-hand with environmental and social awareness (de Brito et al., 2008). The framework of sustainable development is emphasising the need for the recovery of products, by-products, and waste during production, distribution, use, and after utilisation[1]. Reuse, resale, repair, refurbishing, remanufacturing, and recycling are examples of the product recovery activities. By recovering consumed raw materials and returning them to the business systems and/or by decreasing material resource consumption within these settings, firms can improve the sustainability of their business (Lebreton, 2006).

Typical examples of products that have been recovered for centuries are high-value and low-volume items, such as locomotive engines (Guide and van Wassenhove, 2009). Especially during, and after the Second World War, product recovery experienced a boom (Sundin, 2006). This was caused by the lack of many raw materials needed for manufacturing. The increasing scarcity of the resources is making the environmentally sound reuse of natural resources more economically profitable (Porter and van der Linde, 1995; Romm, 1999; Flapper et al., 2005). In fact, even nowadays, approximately 40 percent of the global steel production, and 50 percent of the paper production originates from the recycling of these materials (Stena Metall, 2007). Guide and van Wassenhove (2009) argue that the current real examples, such as non-subsidised and/or not legislatively enforced remanufacturing, had pointed out the profitability, and value creation of the recovery activities.

A category of products that is frequently recovered in business networks are commercial returns, with the estimated annual costs of $100 billion in the United States (Stock et al., 2002). Home Depot, for example, experiences the commercial return rates of 10 percent of

[1] Product life is defined as the progress of a product from raw material, through production and use.

total sales or higher (Guide and van Wassenhove, 2009). PC assemblers have short life-cycle products that can lose 1 percent of their value per week and have high return rates (Guide et al., 2006). These product categories, closeouts and unsold stock items, represent an important potential for value recovery.

The reused resources may be whole products, parts, materials, energy, labour, and other assets that have been consumed in the production, distribution and use of the new products (Östlin et al., 2009). In most cases, unlike production, transportation does not represent the main share of the total environmental impact of a product during a product's whole life (Abrahamsson, 2009; Clift, 2003). From an ecological perspective, it is furthermore essential to reflect on life extension of items that incur the major environmental impact in the use phase (Bras and McIntosh, 1999), such as remanufactured fossil fuel engines that are not as environmentally friendly as the newly manufactured ones, or renewable fuel engines. However, in the computer industry and in the brown goods[2] industry in general, resource consumption during use is lower compared to during the stages of extraction and production (Grote, 1994).

In addition, electric and electronic waste represent the fastest increasing waste stream in Europe, growing at an annual rate of 3-5 percent, which is three times faster than the average increase in waste (Thomas et al., 1999). One of the reasons for this is the shortening of the sales life cycles[3]. As a consequence, environmental laws have been passed that provide for producers paying fees for the recycling and disposal of electric and electronic waste. Thus, the increasing cost of the disposal of the hazardous waste and recycling might become a supplementary motive to initiate other recovery processes of products that come from different stages and actors during the life of a product. This may often be more economically feasible than the passive financing of collection and recycling firms (Lebreton, 2006).

Stock (1998) states that the shift from selling products to selling sets of services (e.g. leasing), makes use, repair and recovery of materials, parts, and products more desirable and profitable to manage. When a manufacturer, in this way, attains a larger degree of control of the product throughout the value chain, it becomes easier to secure the supply and timing of the product flow aimed for recovery activities (Thierry et al., 1995; Defee et al., 2009).

Two customer demand trends recognised by computer manufacturers are the shrinking IT-budgets and the increased rationality of users who cannot afford new computers or do not consider it necessary to keep pace with every innovation cycle (Lebreton, 2006). That is why many computer manufacturers now also offer refurbished computers. Increasing the

[2] Electronic products such as computers, printers, and servers.
[3] The sales life cycle is defined as the progress of a product through the stages of introduction, growth, maturity and decline of sales (Cox, 1967). This life cycle also affects recovery decisions in case the product that is about to be refurbished is declining in sales. This, in turn, could mean that a product needs to be upgraded with new components and that a once standardised product after use may become a customized one, or vice versa if the upgrading does not take place.

environmental awareness of the population is also creating opportunities for marketing of the recovered goods (Stock, 1998).

To summarise, there are certain increasingly important aspects of the present business environment that contribute to the promotion of product recovery as an environmentally preferable alternative to disposal, within both the business and policy communities. The first aspect is the reduction of the environmental impact from firms in terms of waste reduction. Another important issue is the cost-minimisation of product recovery processes and the resources employed in these activities. Aronsson and Huge-Brodin (2006) emphasise that logistics costs and environmental impact often point in the same direction; a solution that lowers the cost of transportation almost always reduces pollution, as well. Legislative requirements to decrease the amount of hazardous waste disposed in landfills are forcing companies to commit resources to product recovery in terms of design for the ease in disassembly and recycling. Several needs and requirements of the business and private consumers may also be one of the factors that can turn product recovery into a source of profits and competitive advantage (van Hoek, 1999; Porter and van der Linde, 1995). All in all, product recovery research has practical importance for several stakeholders in society. This practical side of this topic and its connection to theoretical importance are outlined below.

1.2 Importance of product recovery and positioning of the study

Product recovery research started in the 1970s with reverse distribution literature (e.g. Zikmund and Stanton, 1971; Ginter and Starling, 1978; Guiltinan and Nwokoye, 1975). Until the mid 1990s, this dealt mainly with the operational processes of recycling of the collected ‘end-of-life’ products from end-users to reprocessing facilities. During the 1990s, product recovery research broadened its field to include other reprocessing activities, such as refurbishing. The trend of including other organisational and managerial disciplines, such as marketing and inter-organisational issues in the 2000s, evolved into the Closed Loop Supply Chain Management research that includes waste and other by-products from several supply sources during production, distribution and use.

Reverse logistics literature has mainly focused on efficiency, organisation, planning and effectiveness of coordination processes for financial, informational and physical flows in the reverse supply chain. These are enforced by legislation imposing producer responsibility for electronic waste and are established with the cooperation of the OEM[4] (e.g. Flygansvaer, 2006; Jahre, 1995). This type of research within the product recovery area is concerned with businesses and/or individual end-consumers as suppliers of the ‘end-of-life’ products, and how to organise logistics set-ups in order to increase collection rates (Jahre, 1995). This goal is to be achieved by organising and providing various logistics solutions to the disposers.

[4] Original Equipment Manufacturer

1.2.1 Organisational aspects in product recovery

Reverse logistics literature has identified several organisational challenges that need to be addressed in every study dealing with product recovery, with the most important of these being the uncertainty of supply (e.g. Fleischmann et al., 2001; Flygansvaer, 2006; Defee et al., 2009). Toffel (2004) discusses the lack and abundance of information attributed to supply uncertainty as factors that can reduce efficiency of product recovery. Uncertain information on timing, quantity, demand, and material properties, creates highly variable processing times. Furthermore, supply uncertainty diminishes the ability to achieve economies of scale in routings of materials for repair and remanufacturing. These uncertainties call for a higher degree of coordination of the reverse logistics networks (Blumberg, 1999; Fleischmann et al., 1997, 2000; Jahre, 1995; Krikke et al., 1999a, 1999b; Lambert and Stock, 1993; Yalabik et al., 2005). Therefore, prediction and control of the information about matching the demand with returns is a key success factor for profitable product recovery (Toffel, 2004). The lack of organisation and coordination in collection and transportation creates a large number of low-volume physical flows, which is both a costly and environmentally unsound practice (Fleischmann et al., 2001).

The focus of reverse logistics research is frequently on the supply side, describing, classifying, and explaining efficient systems for the collection, distribution, and reprocessing of products at the end of life. The assumption in this study is that there is a need to go beyond the supply side of the reprocessing phase. In this thesis, the end-user of a remanufactured or recycled product is therefore considered to be a part of a network.

Effectively matching supply of returns and users' demand is the most essential challenge in Closed Loop Supply Chain Management (Fleischmann et al., 2000; Toffel, 2004), as in other areas of Supply Chain Management. Thus, Krikke et al. (2004) add distribution to the second customer as an additional activity in their framework of reverse logistics. Fleischmann (2001, p. 19) argues that *"both at the front and the back-end the actual 'reverse' network is linked with other logistics structures that one would typically consider as 'forward' networks."* According to the article, product recovery configurations should not be perceived as isolated objects but rather as a part of some larger overall logistics structure.

Definitions are changing over time, and today the Council of Supply Chain Management Professionals defines *logistics system* as a system which facilitates *"the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements"* (Council of Supply Chain Management Professionals, 2010). However, from an historical perspective, reverse logistics literature was a forerunner of the Closed Loop Supply Chain Management research (Guide et al., 2003) which started to develop in the 1990s thanks to the research done on remanufacturing of fighter jets and Xerox photocopiers. A pioneering group of operations and production management researchers were mostly interested in the technical intra-firm recovery perspective within design, production and inventory management, which combined new and reused parts and products of Closed Loop Supply Chains, and acknowledged the uncertainties in supply of form, quality, quantity and time, across several parts of these networks (Thierry et al., 1995; Guide and van Wassenhove, 2002; Sundin, 2004; Ferrer and Whybark, 2001; van der Laan et al., 1999; Lund, 1984, 1996; Defee et al., 2009).

Nevertheless business issues like marketing (Jacobsson, 2000) had already been discussed in the early strategic product recovery literature. Jacobsson's results, later confirmed by Sundin (2004), indicate that an OEM, when providing a leased product with maintenance and repair, will reduce the uncertainty and ensure that follow-up of products'/parts' quality during a product's life and sufficient volume flow of goods for product recovery to be economically feasible. A number of researchers (Fleischmann et al., 2001; White et al., 2003; Lebreton, 2006) have recognised synergy effects of shared facilities, and decreased economic and environmental impact as a result of the consolidation of distribution of new products with the collection of the end-of-lease goods.

Thierry et al. (1995) show how Xerox saved money through well developed product recovery strategies. Their conclusion is that in order to be successful in product recovery, companies should work with suppliers on the durability of products, and design for disassembly and reprocessing[5], which includes component/material standardisation across present and future product lines and industries. These efforts, in turn, make assembly[6], maintenance, and repair more efficient and easily performed. This standardisation reduces the complexity and the abundance of information, which makes the recovery process more efficient. According to the article, product recovery is usually associated with a reduced number of the original vendors and decreased materials and parts purchasing costs.

During the first decade of the 21st century, many researchers within the product recovery field have been showing a growing interest in business management and organisational issues, such as strategy, organisational behaviour, supply chain management, marketing and the competitive advantage approach (Thierry et al., 1995; Jacobsson, 2000; Flapper et al., 2005; Lebreton, 2006). But this more-business oriented product recovery management research has not yet reached its full potential. Sharma et al. (2010) list a table of 33 articles about sustainable marketing and identify only six that in some way deal with business marketing and purchasing, arguing that marketing has been mainly concerned with targeting the customer segments for the new green products, and that very little attention has been given to business marketing and purchasing in a green supply chain, and its interface with environmentally-friendly manufacturing, reprocessing, distribution and operations.

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[5] For instance, the usage of the same standardised, easy-to-recycle, plastics within the automotive industry to avoid different process requirements of different kinds of plastics.
[6] Economies of scale, if standardised parts or modules can be used across future and present product lines

Identifying the need for more research on multi-agent networks, Srivastava (2007) writes that distribution networks of recovered products have evolved and became more differentiated as they now involve not only brokers, but also online and traditional auctions. Guide and van Wassenhove (2009, p.16) demand a more business management orientated research within product recovery arguing that Closed Loop Supply Chain Management "…*has begun to link other disciplines (i.e., marketing and accounting) to the OM perspective. If prices and markets are not fully understood, they become barriers, no matter how well the operational system is designed. A thorough understanding clearly requires an interdisciplinary approach.*"

The current broadening of the subject focuses of product recovery into the business management field is explained by the general lack of interest in the Closed Loop Supply Chain Management amongst the marketing and accounting research communities (Guide and van Wassenhove, 2009). This is one of the main reasons for the shift towards organisational orientation within this traditionally operations and production-oriented product recovery research community. In addition, the rationale for the shift towards a business management approach has also been driven by relatively large remanufacturing rates for some types of the refurbishing/remanufacturing segments that are approximately 20-30 percent or more of total consumption[7], ignoring the markets for recycled, used, overstocked or repaired products. Furthermore, the independent remanufacturing[8] sector in the United States, outside of the legally-regulated sector, employed 480,000 people and had an annual turnover of $53 billion which is comparable to pharmaceutical, computer, steel products, and consumer durables (appliances) sectors. Yet only the consumer durables sector employed as many people (Lund, 1996)[9].

In line with the new business management orientation of the product recovery research, Lebreton (2006) uses Porter's (1985) value system in order to explain when an OEM should engage in Closed Loop Supply Chain Management, and concludes that amongst the reasons are increasing waste management fees, high volume of goods or a large number of independent companies already in the recovery or second hand market. He takes a large tyre manufacturer as an example of how an OEM acquired two large tyre rethreading companies in the United States and European markets. Jacobsson (2000) and Flapper et al. (2005) describe that the initial perspective of the majority of OEMs is that product recovery, in terms of some type of reuse[10], would necessarily mean a cannibalisation of the sales of new products. Nevertheless, there are some indications in the research done by Ferguson and

[7] Copiers, truck and airplane tires, and auto parts (Lebreton, 2006).
[8] Without taking the account of other recovery options.
[9] The US pharmaceutical, computer and steel industries employed 200,000 to 300,000 people each. The petroleum refining industry shipped twice as much value in terms of sales, but employed only one-sixth the number of people.
[10] Recycling and incineration, for instance, mean that a product loses its original identity.

Toktay (2006) that since the reused/refurbished products are usually associated with lower prices, these products could be used to compete with the new low-quality/low-price copies or independently reconditioned products. Low price in combination with warranties on refurbished products could, in turn, also increase sales volumes and market shares for the OEMs, especially in developing countries (Fleischmann et al., 2001; Lebreton, 2006).

1.2.2 Inter-organisational issues in product recovery

While most of the product recovery and Closed Loop Supply Chain Management literature has been concerned with OEMs, Lund (1996) has taken the independent remanufacturing firms' point of view and their technical or supply challenges. A number of articles (e.g. Östlin et al., 2008; Östlin et al., 2009; Östlin, 2005) balance both the perspective of the OEMs, their remanufacturing partners and the "independents" involved in this process. However, the main focus is on how a manufacturer or remanufacturer should make decisions concerning their own activities.

It is apparent that most of the research and frameworks on product recovery have been dealing with a single reprocessing option or a single source (usually end-user) of products to be recovered from a single company's point of view. These studies are mainly conducted from the manufacturing/reprocessing or the supply perspective. Very little research with a focus on business relationships or inter-organisational issues has been conducted on the reverse side, and there is even less on closed loop processes and inter-firm topics, although Fleischmann et al. (2000, 2001) stressed the need for research on business relationships within the product recovery area.

The most notable exceptions are the studies by Östlin et al. (2008, 2009), Östlin (2005) and Flapper et al. (2005). Their work establishes initial building blocks in grounding remanufacturing within inter-organisational supply chain management. Two articles (Östlin, 2005; Östlin et al., 2009) identify product acquisition techniques and classify dyads between disposers and other suppliers of used items, independent remanufacturers, third party remanufacturers and OEMs in terms of reverse supply chain control and how uncertainty of product recovery and reverse logistics structures are handled from their perspective. Toffel (2004) analysed the connection of uncertainties to different dyadic inter-firm setups using both Resource Based View and Transaction Cost Economics, and argued that there is a need for more inter-organisationally focused studies within the predominantly operations oriented research field of product recovery and reverse logistics. Without information sharing on physical flows between organisations involved in product recovery, the lack and abundance of information creates a greater need for inventories at each step where evaluation, testing and grading need to be performed (White et al., 2003). This increases inventory and transportation costs (and thus environmental impact) if the large number of low volume physical flows is not coordinated, or if a product is unnecessarily transported to an inappropriate facility.

Srivastava (2007) writes in the conclusion of his literature review on green Supply Chain Management that more research is needed to create integrative frameworks in order to analyse the secondary markets[11] and the whole Closed Loop Supply Chain. This would include the effects of design and the installation of sensors that can transmit the information about the overall status and the age of the product with regard to sales life cycle, throughout the life of the product. Moreover, he identifies research opportunities based on effective data-sharing through collaboration and cooperation between brokers, customers, and producers of virgin materials, as these actors are not amongst frequently investigated actors involved in collection and reprocessing (ibid.). Daugherty et al. (2005) find that resource commitment to information technology leads to superior performance in product recovery processes.

Flapper et al. (2005) developed the most complete framework for the analysis of Closed Loop Supply Chains, while studying recovery processes at a number of large companies such as HP, Mercedes, Whirlpool, Heineken, and Rotterdam Port. The insight that products that can be recovered may come from, flow through and end up at the different stages of a product's life (e.g. fabrication, transportation, storage, reprocessing, and use) is the main strength of this framework. In addition, this framework allows a researcher to explore the movement of goods and people in inter-organisational relationships that involve maintenance, repair, and operations, as well as between actors that repeatedly exchange load carriers such as trucks, containers and other types of packaging. Moreover, the framework addresses the problem of abundance and the lack of information in an effort to decrease uncertainty and create greater uniformity. This could be a difficult task because there is a greater need to obtain, gather and handle data about the conditions, places, times, reports to the governmental regulators, grading rules, decision trees of different routings and recovery options, maximum stock levels and demand (ibid.).

Information and communication technologies (ICT) play a key role in the organising and integration of Closed Loop Supply Chain Management activities because they allow the reduction of uncertainties, and promote cost-efficient, and thus environmentally friendly, routings[12] and more efficient matching of supply and demand (Dekker et al., 2004). It is crucial to use sensors that can track increasingly complex products during their whole life and to build a knowledge base, as well keep track of experience, in order to improve performance of standard routines and procedures (Flapper et al., 2005). Stigler (1951) recognised the problem of coordination in multiple product firms undertaking a wide range of activities.

The most important influence of the work of Flapper et al. (2005) in this study is that besides conventional processes in distribution, marketing and supply chain literature described, such as manufacturing, storage, transportation, there are also recovery processes (e.g. collection,

[11] However, they might be characterized and defined.
[12] Sorting and grading close to the source may reduce transportation costs and an early path determination (Fleischmann et al., 2001)

disassembly, remanufacturing, recycling). These interconnected activities need to be described as an integrated part of the business networks since there are use values created by the recovery activities, and customers of an initial end-product are only one type of suppliers of the products aimed for recovery.

The organising of integration and coordination of supply and demand of different inbound and outbound flows has been recognised as the key factor contributing to efficiency in product recovery (Fleischmann et al., 2000; Flapper et al., 2005; Yalabik et al., 2005). Interaction between players with different goals and market power, and their impact on the secondary markets and network structures has nevertheless been a largely neglected research area of the product recovery field (Fleichmann et al., 2001; Srivastava, 2007; Guide and van Wassenhove, 2009; Toffel, 2004). An example of research with a more behavioural focus on inter-organisational coordination of logistics systems for recycling is the work of Flygansvaer (2006), who demonstrated that different ways of organising affect efficiency of processes, and waste collection rates in reverse distribution systems. Even if Huge-Brodin (2002) has done work on different types of behaviour in relationships of the logistics systems for recycling, there is a gap in the literature that can justify more research about cooperative behaviour between organisations that deal with various product reprocessing alternatives such as repair, recycling and remanufacturing.

The holistic and systemic approach of Flapper et al. (2005) of a closed-loop process that could both be under a single firm's loose or tight control and/or jointly coordinated between different organisations is adopted in this study (ibid.). An element that deserves further elaboration in the framework of Flapper et al. is that organisational issues are only seen as one dimension, auxiliary to the technical, environmental and economical dimensions, and not as a major driver of change in the organising of business systems (ibid.). The integration and coordination of flows between different actors from the source to the end-user enhance efficiency and effectiveness in business networks, as emphasised in the Industrial Network Approach (Håkansson et al., 2009; Gadde and Håkansson, 2001) and Supply Chain Management literature (Christopher et al., 2002).

To summarise, there are several important issues which make the research on product recovery relevant. First of all, approximately 40 percent of the global steel production, and 50 percent of the paper production, originates from the recycling of these materials. Remanufacturing rates of certain products are between 20-30 percent and more, while the American remanufacturing sector, as early as in 1996, employed 480,000 people and had an annual turnover comparable to that of the pharmaceutical, computer, steel products, or consumer durables (appliances) sectors. A large number of firms, and most importantly, users, are involved in product recovery business. Another central factor is that companies involved in product recovery are intertwined with firms that are a part of forward production-distribution networks.

1.3 Aim and structure of the study

There is a need for more research on the role of inter-firm organising of product recovery. Several issues that deserve a deeper understanding and research have been identified with respect to organising product recovery. These issues regard, among other things, supply uncertainty of product recovery, which, in turn, requires inter-organisational coordination. Furthermore, organising and inter-organisational structures have an impact on economic outcomes of product recovery, which is an additional reason for investigation of organisational relationships in product recovery settings. The lack of inter-organisational coordination in collection and transportation creates a large number of low volume physical flows, which is both costly and environmentally unsound.

A supplementary aspect that influences the matching of supply and demand in product recovery is the handling of the lack, abundance and complexity of information. For that reason it also crucial to investigate how actors organise information flows of product recovery structures across business units, in order to support physical flows. The study of organising product recovery requires a holistic framework for analysis of business relationships where interactions among organisations should play an important role. This implies that there is a need to study organising product recovery from a more relational, and differentiated view that involves multiple reprocessing alternatives such as recycling and remanufacturing, and their connections to forward physical flows.

The aim of this study is to explore the organising of product recovery between firms, by developing a framework that allows for an investigation of organising product recovery in networks, from a relational perspective.

This introductory presentation of the background and the research field of interest articulate the aim of the thesis. In Chapter 2, the analytical framework that is going to be used in analysing empirical data is described. This frame of reference is based on previous research on product recovery and the Industrial Network Approach with its three layers: activities, resources, and actors. Methodological considerations of this thesis are discussed in Chapter 3. The method chapter describes the research process, the choice of methodological approach with respect to data collection/analysis, and the quality of the study. Chapter 4 discusses empirical findings, and presents a case description of the PC industry. In this empirical illustration, the focal actor is a firm that coordinates product recovery activities with regard to the different needs of disposers. These empirical findings are analysed in Chapter 5, by applying the analytical tools from the theoretical framework. The final chapter of the thesis, Chapter 6, includes concluding discussions related to organising issues in product recovery arrangements. Theoretical and practical implications are presented here, as well are recommendations for further research.

2 FRAME OF REFERENCE

This chapter provides the reader with the analytical framework for this thesis. The starting point and the first section of the chapter is an introduction of the context of product recovery in terms of characteristics, activities and typical supply and demand situations. Next, a rationale for adopting the Industrial Network Approach to studying product recovery will be given. This approach contains three layers: activities, resources, and actors which are elaborated in detail in sections 2.3, 2.4, and 2.5. After each section associated with a layer of the Industrial Network Approach, research issues are formulated.

2.1 Characteristics of product recovery

Many companies are involved in the physical flows of goods, materials, components, parts and products that might need to be recovered or disposed at waste sites. These items may appear in different locations or points in time, during or after use or at another stage of a product life, such as testing of a faulty component before the assembly or quality control of production defectives in a factory before shipping. During and after the use a customer can, for example, have her or his car repaired or sold to a car dealer who then may repair the car, so it can be sold or distributed to another customer. Other examples could be damaged items during materials handling or transportation, unsold/obsolete components or end-products in warehouses located at different geographical sites, owned by logistics service providers, distributors or retailers.

Organisations are involved in complex production, distribution and utilisation arrangements of business networks. Proliferation and uncertainty about the timing, quality of materials, and sources or supply of the products that could be recovered, depend on the quantity and variety of actors involved in production, distribution, and use. That is one of the causes of the various challenges related to uncertainty that firms involved in product recovery attempt to manage. Various aspects of uncertainty are often an important factor to consider for these firms. Fleischmann et al. (2000, p. 664) argue that *"Supply uncertainty both in quantity and quality appears to be a major distinction between product recovery networks and traditional production-distribution networks."* These uncertainties take the form of variability in volume or low degrees of economies of scale, variability in quality and the state of product or labour intensive selection/disassembly of products, parts and materials and the variability in the type of returned products or the allocation of products to different purposeful reprocessing facilities (Flygansvaer, 2006; Pohlen and Farris, 1992).

Guide et al. (2000) elaborate further about the nature of uncertainties. First, uncertainty concerning the timing and quantity of products available for acquisition is important. This reflects the nature of life of a product. Hence depending on the nature of the product, it can be more or less easy to know when it will be ‘ready’ for product recovery. This, in turn, is associated with the sales life cycle of products and the rate of technological change. Another uncertainty is the quality of the product. Two seemingly identical products entering the recovery system can turn up in several shapes and may need very different recovery options. The condition of the product is also a decisive factor in choosing the recovery option, and often this decision cannot be taken until the product has been more or less disassembled. The state of the product is age-, environment- and usage specific (Guide et al., 2000). Linked to this is the fact that products can be more or less difficult to disassemble, depending on their design (Bostel et al., 2005). Thus, the degree to which the product is designed for recycling or remanufacturing has a great impact on how product recovery can be accomplished (ibid.). How the products are collected and brought to the recovery centre is another uncertainty that needs to be considered. This can involve decisions regarding transportation modes and facilities, as well as the involvement of third party logistics providers (Guide et al., 2000). Furthermore, handling of packaging material and shipping material can be considered in this context. In order to handle these challenges, firms try to organise recovery activities in a way that reduces these uncertainties.

An additional uncertainty is the place or source at which the product to be recovered will be located, and how the recovery firm can connect to the source, in question. The sources can also be described in terms of customers, suppliers, brokers and manufacturer, as well as other third party vendors, which are all parts of forward physical flows. These forward physical flows of materials, parts, and products consist of the stages in the production, distribution, and use processes. . The life of a product is usually described as sequential phases through which raw materials are formed into new offerings. Borders between these three stages and the actors involved in them are blurred, and not as clear as they are portrayed in the oversimplified and primarily schematic Figure 2.1.

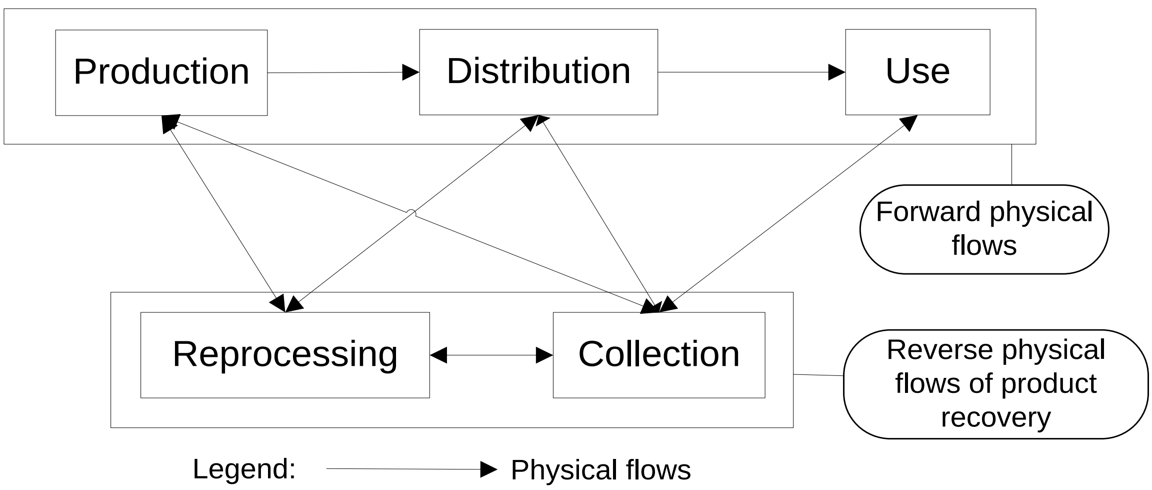

Figure 2.1 Closed loops related to different phases in the life of a product (adapted from Flapper et al., 2005, p. 5).

Figure 2.1 illustrates that forward and reverse stages of physical flows can be combined in numerous ways at different points in time (Fleischmann et al., 2005). *Collection* and *reprocessing* are two stages that represent reverse physical flows in Figure 2.1. Prior to describing collection and reprocessing activities (e.g. recycling) of product recovery milieus, there is a need to explain what triggers reverse physical flows in space and time during production, distribution and use. As seen in Figure 2.1, product recovery might take place for a variety of reasons during a product's life (Flapper et al., 2005):

- *Production related (e.g. from manufacturing facilities).* Obsolete materials (surplus production, components or semi-finished products, production scrap), production defectives (products not conforming to some preset quality levels, and are scrapped or reprocessed to a level where they can be sold as initially intended, or as a lower quality product).
- *Distribution related (e.g. from distributors, retailers, third party logistics providers and users).* Commercial returns, order cancellations while the product is on the way to a certain customer, surplus stock, unsold stock returns, damaged goods/packaging, defective deliveries that don't conform to specifications, recalls (returns in the context of actual or expected problems with products).
- *Use related (from end-users).* The same or replacement products that should eventually be returned to the current users (repairs, warranties and recalls) or in cases where companies are offering repair, refurbishment or remanufacturing of the products, products returned to the supplier (end-of-lease products), and products returned at the end of their technical or useful life from the point of view of their current user or their original manufacturer, which may still start a new useful life in a different market.
- *End-of-life (from end-users).* Products returned to the distributor or producer because they reached the end of their useful life. Their components and materials may be reused in other products.

To exemplify this variety, Håkansson and Waluszewski (2003) note that waste paper may be collected from publishers, industrial converters, retailers and households. Consequently, there is a variety of sources of recoverable products. In this study, the primary focus will be on the users in their role as a source for product recovery.

Having discussed the sources of supply of materials that can be recovered, the next step is to consider different options for how this recovery can be accomplished. Fleischmann et al. (2005) note that same materials may flow through the production-distribution-use-recovery network in several cycles. Figure 2.2 illustrates one such alternative path through several cycles where returns from production and distribution stages are not considered.

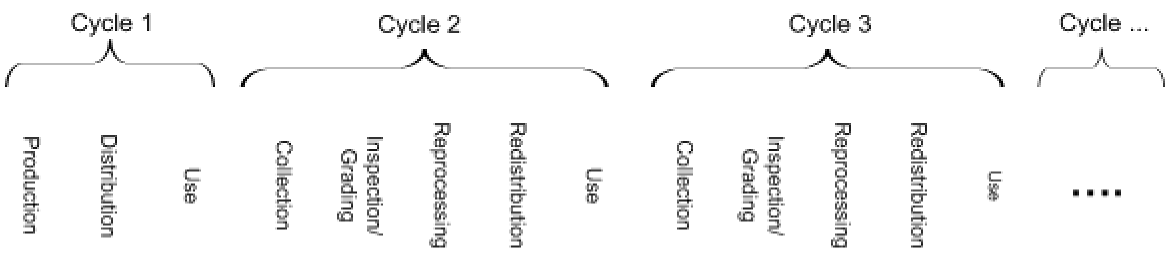

Figure 2.2 Production-distribution-recovery cycles (adapted from Fleischmann et al., 2005, p. 176).

Whenever an object (product, material or component) in the production, distribution or use phase, gets disposed, the recovery phase of *collection* is crucial as it enables the other stages to continue. Products which are collected from the disposal sites are transferred to facilities where they might be *inspected* and *reprocessed*. The recovery phase of reprocessing into material fractions or component parts will sometimes not be necessary, such as if the surplus stock of unsold items from a production facility is passed on to an actor specialising in the distribution of models the manufacturer regards as outdated. *Inspection* and classifications occur when there are uncertainties about the state of products, such as deciding which reprocessing option is most appropriate for the moment. *Reprocessing* is a part of the extended supply chain in Figure 2.2 that can be divided into several activities or sub-processes depending on whether products, components or materials are decomposed or disassembled into materials or parts (Thierry et al., 1995). A more elaborate description of these activities is presented below in section 2.3.1.

A variety of companies and organisations perform different steps of collection, inspection, reprocessing and distribution to new users in these arrangements. The next section provides an argument for applying a network perspective to how product recovery is organised.

2.2 A network perspective on organising product recovery

There are many sources of products that can be recovered, as well as, many users and potential uses of recovered products. These sources and users can be connected in a great number of ways. This requires organising efforts between specialised business units that are responsible for their resources and activities. Consequently, products, parts, components and materials that may be recovered can be collected from different sources at different times and be delivered to various actors. As previously mentioned, it is not obvious where a certain recoverable product will flow through, both with regard to how it is classified in the process from 'source to use' or where it will end up. Furthermore, this reverse flow can be more or less integrated with the forward physical flow (e.g. White et al., 2003; Flapper et al., 2005; Fleischmann et al., 2001).

All in all, the multitude of options available for product recovery and the complex organisational context in which it is performed calls for an integrated and holistic network approach for its analysis. Several authors (Sharma et al., 2010; Srivastava, 2007; Guide and van Wassenhove, 2009), who performed literature reviews of Closed Loop Supply Chain Management and product recovery, have noticed that there is a need for further research on business relationships, in order to gain an understanding about how the nature of relationships affects the operational design of product recovery in business networks. Toffel (2004) has analysed dyadic aspects of product recovery using a Resource Based View (e.g. Penrose, 1959; Grant, 1991, 1996), which mainly concentrates on the resources utilised by single firms, and Transaction Cost Economics (e.g. Williamson, 1975, 1985) with its primary focus on transaction costs or transaction activities in dyadic business relationships. A more inclusive framework is needed in order to conduct research on relationships between interconnected actors involved in product recovery and the type of resources that are combined in order to perform activities related to that recovery. Researchers and academics have done studies on business environments of complex network structures in forward physical flows (e.g. Anderson et al., 1997; Silveira et al., 2001; Gunasekaran and Ngai, 2005; Hertz and Alfredsson, 2005).

This study is therefore influenced by a network perspective on product recovery, with a point of departure in the Industrial Network Approach (Håkansson, 1987; Håkansson and Snehota, 1995; Håkansson et al., 2009). The rationale for utilising the Industrial Network Approach as a starting point in this study rests on the recognition that this approach offers a rich set of concepts reflected in three network dimensions of activities, actors and resources. Each dimension of the Industrial Network Approach will be more closely elaborated in separate sections, in order to illustrate interrelatedness between the layers within the context of product recovery.

The idea of network takes into account the dynamics of relationships in the wider business landscape (i.e. beyond single transactions or relationships). As the Industrial Network Approach is developed for the study of existing exchange relationships in several directions (Gadde and Ford, 2008), this approach is very well suited as a basis of a holistic framework for the analysis of relationships between firms that are involved in product recovery contexts. By conceptualising the process and outcomes of interactions, the Industrial Network Approach makes it possible to analyse business relationships in networks. In this way, the Industrial Network Approach enables an analysis of the current state and development of organisational relationships in business networks across company boundaries through three complementary layers: activity patterns, resource constellations and webs of actors (Activity-Resource-Actor model), which are portrayed in Figure 2.3.

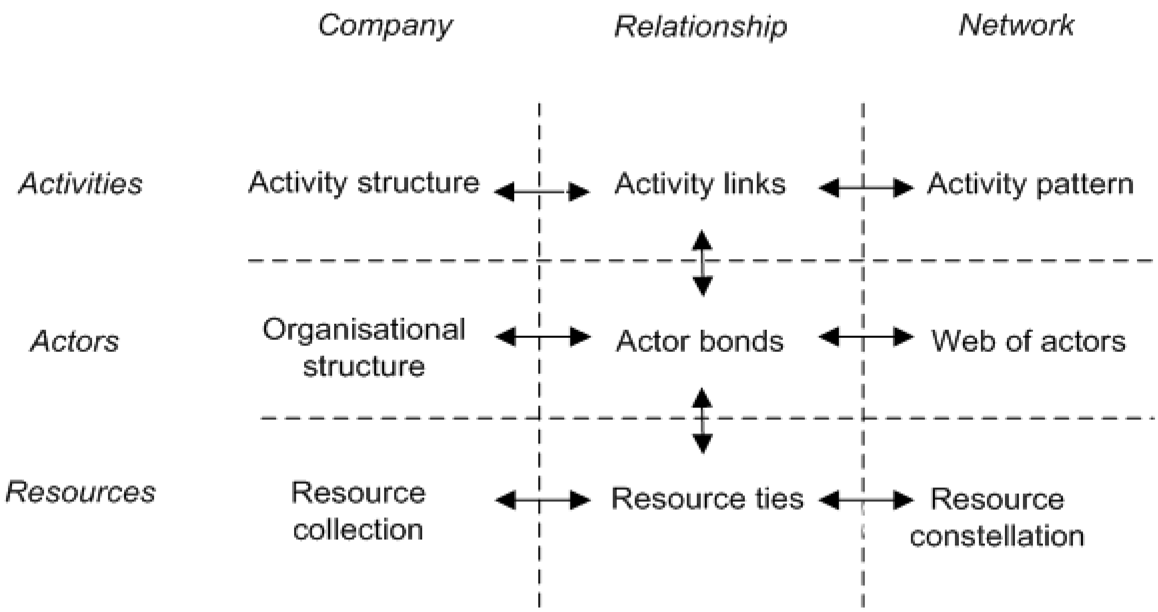

Figure 2.3 Scheme for the analysis of business relationships, the Activity-Resource-Actor (ARA) model (Håkansson and Snehota, 1995, p.45).

Each of the layers in Figure 2.3 influences, and is influenced by, the constellation of resources, pattern of activities and web of actors in a business network. As a matter of fact, all of these layers are interdependent but separate analysis is required to get a grip of the complexities of reality (Gadde et al., 2010).

The activity layer is used in the analysis of integration and linking of activities. It has been shown that a lack of integration and insufficiency in activity linking can have a substantial economic effect on interacting parties (Richardson, 1972; Dubois, 1994). An example of a situation in which activities are linked, is the coordination of the cutting of recyclable cables with the manufacturing of metals inside of the cables. Adjustments between activities may function as synchronisation mechanisms in the organising of physical flows, such as just-in-time production (Gadde et al., 2010).

The resource layer is related to adaptations that create resource ties between actors who are interacting in a network. These ties are intended to make resource utilisation more efficient (Håkansson et al., 2009). In addition, systematic combinations of tangible resources, such as physical items, and intangible resources, such as knowledge, are significant for the utilisation, efficiency and innovative combining of resources. Jahre et al. (2006) argue that adaptations in the resource layers between organisational units in reverse logistics networks have not been developed to the same extent as in other established logistics networks. This is due to the fact that recycling for many products such as electronics was not legally enforced until the last decade of the 20th century (ibid.). At that time, actors involved in the production of this kind of products were made responsible for taking care of these products at the end of their useful life.

Activity and resource adaptations are made in the *actor layer* by interaction between organisations. Interaction between companies creates a great deal of diversity and differentiation among actors who perform activities using resources in larger groupings of networks identified as actor webs (Gadde et al., 2010). Furthermore, actors also develop bonds, which consist of mutual orientations, obligations, commitments and selective preferences (Håkansson et al., 2009). It is actors, such as business units, cross-functional teams, governments and corporations, which need to link activities and tie resources. Activity coordination and resource combining do not proceed in a vacuum (Gadde et al., 2010).

Business relationships are important in this respect because they provide actors with access to other organisations' resources and activities, creating mutual interdependencies (ibid.). By interacting in business relationships, firms can identify opportunities for combining resources and configuring activities configuring which may increase the economic value of a particular resource configuration and activity pattern. In addition, different resource constellations expose a resource to tensions that can create problems in the use of resources (Håkansson et al., 2009). On the other hand, these tensions may provide opportunities for resource development, as was demonstrated by Håkansson and Waluszewski (2003) in their study of a product recovery arrangement for the handling of disposed paper. Prior to 1990's, collectors of waste paper charged disposers for paper collection. When disposal and reprocessing were reorganised so that waste paper became an input product in paper production, the paper was collected for free or could even be sold to the collectors.

Thus, organising has a significant impact on the actor, resource, and activity layers of business networks. Therefore, this thesis regards organising by actors as activity coordination and resource combining in product recovery arrangements. These three layers of activities, resources and actors interact in a way that actors control and make use of resource combining and recombining when they perform and coordinate activities.

As mentioned earlier, research on product recovery has not been conducted from a network perspective of inter-organisational relationships. Thus, the following sections will relate the Industrial Network Approach to product recovery. In the next section, the activity layer of the Activity-Resource-Actor scheme for the analysis of business relationships in networks, *the ARA model*, will be discussed in relation to product recovery.

2.3 Organising product recovery in activity patterns

This section of the chapter outlines the theoretical frame of reference related to activities in product recovery arrangements is outlined. First of all, the reader will be introduced to processes of product recovery settings. Then, central features associated with activities, such as *interdependencies* and *adjustments* will be described. After that, analytical tools of this thesis will be described. Finally, research issues associated with organising product recovery in the activity pattern are presented.

2.3.1 Activities in product recovery

A set of several activities within product recovery and reverse logistics structures is discussed in this section. Flygansvaer (2006) divides overall reverse distribution activity structures into five levels: primary consumption, collection, transfer, reprocessing and secondary end-markets. Håkansson and Waluszewski (2003) exemplify the sequence of activities of collecting waste paper from businesses and households, in terms of classification, reprocessing, and distributing the product in the form of newspapers. Thus, primary and secondary users are linked by organising physical flows in collection, transfer or logistics, reprocessing and distribution activities (Fleischmann et al., 2005).

The product recovery processes in Figure 2.4 involve some general activities that need to be undertaken between the sources of recoverable products and the use of the recovered products (Krikke et al., 2004). The order and importance of these, however, may vary differ from situation to situation because they are highly intertwined. Krikke et al. (2004) and Thierry et al. (1995) define five such basic activities. First, product *acquisition* concerns how the acquiring firm acquires the products to be recovered. Second, product *collection* concerns how the product to be recovered is collected from the source. Third, product *recovery logistics* relate to the transportation from the source to the recovery facility. Fourth, *classification* is closely connected to, and a result of, testing and inspection. Classification means deciding on how to handle different products and components with regard to the recovery options discussed above. Fifth, the chosen *recovery option* (reuse, repair, refurbishing, remanufacturing, component retrieval, recycling, incineration, and disposal at the landfill) is undertaken. Sixth, the products are *distributed* either to new buyers, or used for the production of new raw materials.

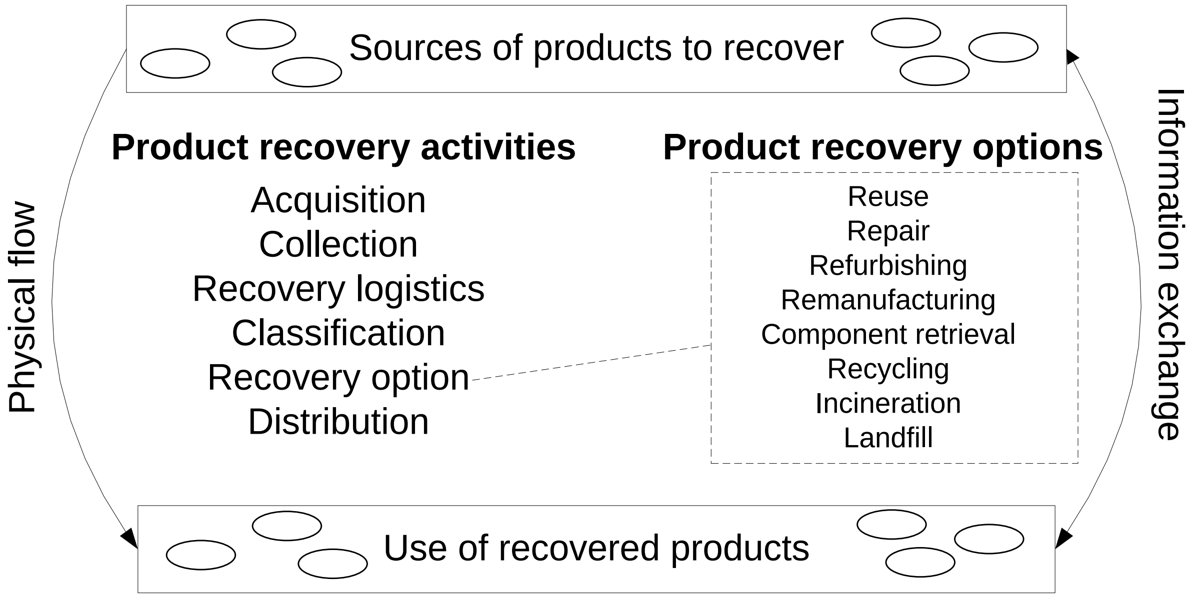

Figure 2.4 A framework of product recovery activities (adapted from Krikke et al., 2004).

Information exchange between firms is essential as a precondition for efficient coordination of product recovery processes in physical flows, as represented in Figure 2.4. Accurate information about the state of the product assists in the decision as to how to direct the products to appropriate facilities (Blackburn et al., 2004). In order for the acquired and collected product to be delivered to an adequate facility or a new buyer, it must go through the stage of reprocessing, on a product, component or material level. The aim of these reprocessing activities is to recapture value from returned products and components, with the most environmentally friendly alternatives topping the list in Figure 2.4.

Based on the models of Thierry et al. (1995) and Krikke et al. (2004) it is possible to distinguish between eight such product recovery and disposal options. First, *reuse* means checking on damage and cleaning the product. Second, *repair* aims to restore used products to working order by the repair and/or replacement of components. Third, *refurbishing* is related to bringing the quality of used products up to a specified level by disassembly, inspection and replacement of broken modules. Refurbishing could also involve technology upgrading by replacing outdated modules or components with technologically superior ones. Fourth, *remanufacturing* aims to bring the used products up to quality standards that are as rigorous as those used for new products. This is done by extensive inspection and replacement of broken/outdated parts. This option can also involve manufacturing new products from old parts. Fifth, *component retrieval* aims to recover a relatively small number of reusable parts and modules from the used products, to be used in any of the four operations mentioned above. Sixth, *recycling* aims at taking materials from used products and parts by various separation processes and reusing them in the production of the original or other products. The seventh and eight options are *incineration*, or energy recovery, and *landfill*.

After this discussion of activities within product recovery, it is time to address certain general features of activities portrayed in the Industrial Network Approach and the ARA model. This model makes certain assumptions with regard to central features of activities that are presented below.

2.3.2 Central features of activities

The activity layer of the ARA model enables a focus on a separate aspect of this complex reality. Business networks can be described in terms of patterns of interlinked and interdependent activities by focusing attention on the activity layer (Håkansson and Snehota, 1995). Here, activity interdependencies and activity adjustments will be illustrated together with the principles of postponement and speculation with the intention of connecting these concepts to product recovery arrangements.

Activity adjustments

Adjustments of activities are developed to handle interdependencies, and these established adjustments create incentives for increased integration between activities (Håkansson et al., 2009). An example of adjustment is the synchronisation of transportation and product recovery options. Hence, a truck may wait for a refurbishing operation to be finished in order to transport such the product in question to an intermediary or an end-user. Yet another type of adjustment may involve the modifications of administrative routines for offering, ordering, confirming and delivering notification, which is frequently the case when a business relationship is characterised by a an exchange of a large number of documents (ibid.).

Activity adjustments serve as a method to increase activity integration, as well as a means of handling interdependencies (Håkansson et al., 2009). An example of activity adjustment is a just-in-time solution. These solutions improve joint performance between companies, while at the same time, requiring substantial investments that might constrain adjustments between other activities (Bankvall, 2011). Increased interdependence in just-in-time solutions also implies that a customer company is dependent on the delivery reliability and continuous flow of inputs from a specific counterpart. Another constraint which is inherent in activity adjustments is the fact that a huge variety of requests from different customers leads to difficulties in reaping economies of scale (Håkansson et al., 2009). If all buyers decide separately what to order, without any extensive interaction with the seller/supplier, their orders can lead to considerable diversity in the supplier's activity structure. On the other hand, a group of buyers may jointly plan for the increased exploitation of a seller's economies of scale. Fundamentally, this is the problem of handling the combined requests for variety in particular purchaser's requirements of products and services, *diversity*, and cost efficiency or *similarity* which is related to economies of scale, presented below.

Activity interdependencies

A framework, inspired by Richardson (1972), for analysing interdependencies between activities that extend over a network of actors in business arrangements has been developed by Dubois (1998) and Dubois et al. (1999). The starting point of these authors' analytical framework is the dependence among the activities across and within firm boundaries. Therefore, single activities should not be studied in isolation. Accordingly, Gadde and Håkansson (2001, p. 59) state that: *"At a specific point in time the activities in the network are characterized by a certain division of labour among the firms involved."* Thereby, since activities are related to each other and performed by different actors, there will be certain prerequisites for efficiency within activity structures (Dubois, 1994). Dubois et al. (1999) argue that there are two types of dependencies which coexist at the same time, *sequential* and *parallel,* elucidated in Figure 2.5.

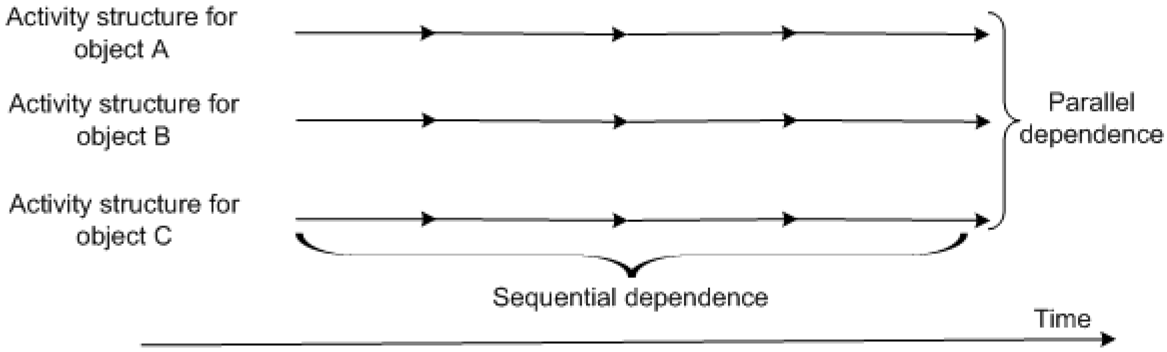

Figure 2.5 Parallel and sequential dependence of activities (Hulthén, 1998, p. 14).

One kind of activity dependency is the existence of *sequential dependence* (ibid.) or the fact that activities are *complementary* (Richardson, 1972), which stresses the fact that one activity is related to activities performed prior to, as well as after, it. Complementary activities need to be coordinated because such operations must be undertaken in a specific predetermined order (Gadde et al., 2010). In addition, *closely complementary* activities need to be coordinated to a larger extent since they are directed towards a specific counterpart. Such activities may exist partially or completely in an activity pattern and need to be planned through exchanges of information, such as orders, confirmations and delivery plans (Dubois et al., 1999). When closely complementary activities are undertaken by several firms it is necessary that *"organisations agree to match their related plans in advance"* (Richardson, 1972, p. 890). However, close complementarity, combined with an increased level of *diversity,* reduces opportunities for scale efficient operations, which is reflected in parallel dependence.

Parallel dependence, another type of dependency in the activity pattern, is related to common use of resources (Dubois et al., 1999). This involves *similarity* among activities. Similarities provide cost advantages due to routine reuse of knowledge. Routines are central to all activity patterns whether in manufacturing, banking, logistics or consultancy services (Håkansson et al., 2009). Similar activities are those that *"require the same capability for their undertaking"* (Richardson, 1972, p. 888). This means that activities performed on objects make use of same resources. Similarity may involve activities that use the same machinery and equipment, the same work-force capabilities, the same transportation facilities, and so on. Similarity is related to standardisation, which promotes specialisation (Gadde et al., 2010). Standardisation in forms such as standardised load carriers or comparable categories for information exchange create similarity in the activity pattern since it enables parties to economise on their scale of operations (Håkansson et al., 2009). In this manner, a pallet, trailer, container and business unit may be designed to facilitate parallel dependencies. This can be the case when an organisation orders products from a supplier firm, which are currently being produced, stored, or transported by a third organisation because these more tangible complementary activities must be performed in a sequence. All in all, firms try to manage economies of scale and sequential coordination of activities in order to keep inventory costs at a as low level as possible.

Nevertheless, the discrepancies between the operating ratios of the different activities that connect different steps in a network involving product recovery may create time discrepancies, which result in holding increased inventory. An example of interaction between these factors is portrayed by Bucklin (1965, p. 28): *"As the delivery time to be allowed increases, it becomes possible to reduce the safety stocks, increase the turnover and reduce the size of the facilities and interest cost."* The same effect for the receiver of the goods is available when frequent, speedy deliveries are introduced into logistics structures. Such factors have been studied using principles such as *postponement* and *speculation* in forward distribution (Abrahamsson et al., 1998; Pagh and Cooper, 1998; Waller et al., 2000; Hulthén, 2002; Jensen, 2009), in reverse logistics systems for recycling (Jahre, 1995; Huge-Brodin, 2002), and more generally, for commercial returns with several reprocessing options by Blackburn et al. (2004). These principles for analysing structures and efficiency of physical flows in business networks are portrayed in the following section.

Principles of postponement and speculation

The principles of speculation (Bucklin, 1965), postponement-speculation (ibid.) and the principle of postponement (Alderson, 1950) are descriptive of the archetypes of logistics structures. They provide rules for organising activities in time and the impact of distance and economies of scale on temporal structuring of physical flows of articles that are categorised and transported by freight forwarders through many inventories (Bucklin, 1965). More importantly, the principles of postponement and speculation treat the role of speculative inventories connected to the risks of ownership because such inventories need to hold uncommitted stocks with the risk for them remaining unsold (ibid.). Variables used in these principles are space, time, risk, uncertainty, inventory holding and differentiation. The aspects of uncertainty and differentiation of products into, for example, refurbishing or recycling should make these principles a suitable starting point for a detailed theoretical description of distribution activities within product recovery contexts.

Alderson (1950, p. 1) regarded the principle of postponement of differentiation as one of the most general methods *"which can be applied in promoting efficiency"* of a business network by postponing *"the changes in form, identity and location to the latest possible point in the marketing flow."* This means that the point in time at which activities become closely complementary is delayed. However, activity similarities and parallel independence among activities also need to be considered. Therefore, savings in the physical movement of goods through time can be achieved by sorting[13] products into large lots and relatively undifferentiated states. Risk and uncertainty costs are tied to the differentiation of goods through the principle of postponement because *"every differentiation which makes a product more suitable for a specified segment of the market makes it less suitable for other segments"* (Alderson, 1957, p. 424). That is to say, the properties of objects in time (e.g. delivery date), form (e.g. technical specifications), place (e.g. shelf space) and identity (end-user characteristics), are unchanged until an order is received. The *identity* dimension of a product is related to an actor, implying that the object is assigned to a certain actor (Hulthén, 2002). Hence, products are customised in order to be assigned the identity of an end-user or a specific counterpart (ibid.).

If computers and monitors are remanufactured speculatively to certain specifications in size, processor speed, memory and other form features, and are sent to a specific store in a specified country and city, this increases the risks of their not being sold, as it narrows down the number of potential secondary users. So a more or less generic product-service offering is stocked and additional features and options are added when an order is received. Delayed differentiation is introduced into the logistics network to avoid the costs of carrying separate inventories of all varieties of the final product.

As Alderson (1950) noted, the principle of postponement can be carried to absurdity if every activity is postponed until the latest point in time, as the user would then be handed raw materials[14] and asked to make best use of them. Therefore, postponement must be balanced with the principle of speculation. The principle of speculation is based on expectations of demand and states that *"changes in form, and the movement of goods to forward inventories, should be made at the earliest possible time in the marketing flow"* (Bucklin, 1965, p. 68). This temporal rule for organising activities leads to enhanced similarity of activities in order to reduce the costs of production, distribution, and stock outs. With regard to the buyer, whether an industrial or a private one, activities resulting from speculation are *sequentially interdependent* but not *closely complementary*. Speculative inventories are not assigned to any specific actor.

[13] This term will be elaborated thoroughly in section 2.3.3

[14] This could also apply to recycled raw materials.

Bucklin argues that channels in their totality cannot avoid speculative inventories because some institution or group of institutions must continually bear this uncertainty. Such inventories move risk away from those organisations which supply, or are supplied by, the inventory (Bucklin, 1965). Jahre (1995) and Blackburn et al. (2004) focus on operational issues in terms of using delayed or early differentiation of returns with respect to tradeoffs between efficiency of fill rates in collection and efficiency in sorting. For example, separation or differentiation of returns can be done early in a *decentralised manner* at disposers' premises. Differentiation of returns can also be delayed until goods arrive at a *centralised* inspection facility as various types of goods could be co-collected for efficiency in transportation and storage in order to be directed towards dedicated reprocessing or distribution facilities (Blackburn et al., 2004). See Figure 2.6 for an illustration of principles of postponement and speculation within product recovery settings.

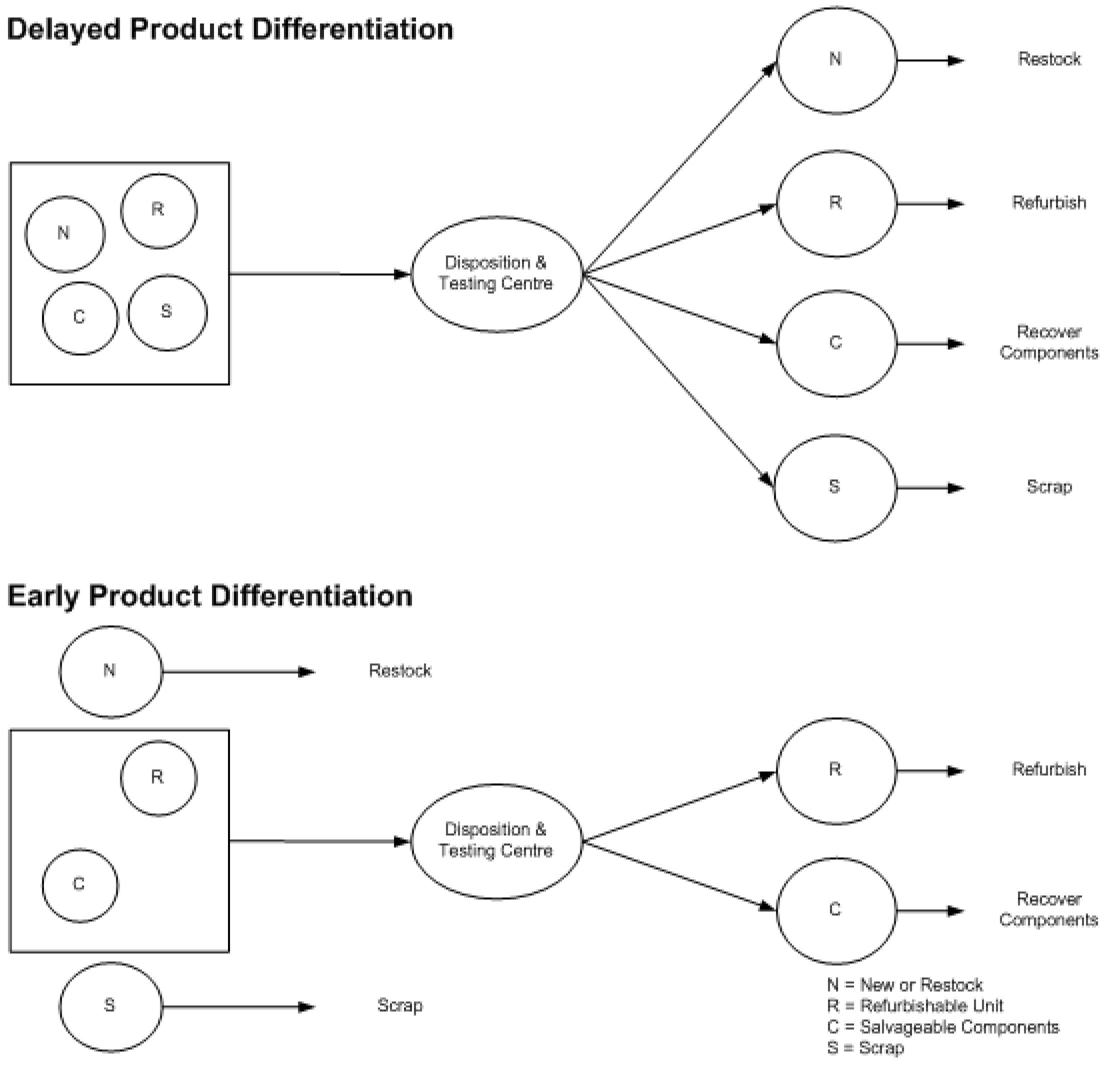

Figure 2.6 Principal distinctions between delayed product differentiation (postponement) and early product differentiation (speculation) (Blackburn et al., 2004, p. 15).

All in all, postponement is important in the minimisation of unnecessary carrying time while speculation is crucial in capturing similarities. These both principles, combined, serve to progressively reduce the cost of labour and investment per unit of product. The development of information technology has created the possibility of speculating information about supply and demand in a ‘stock’ accessible to all parties involved in the business network, which, in turn, enables increased application of the principle of postponement. Wu and Dunn (1995), as well as LaLonde and Mason (1988), explained that leading firms have replaced speculative inventories in several stages of business networks by adequate information sharing in collaboration with their partners. Similar findings in reverse distribution and product recovery arrangements have been demonstrated by Festus and Li (2010). Håkansson et al. (2009) arrive at the same conclusions, stating that efficiency in information exchange activities and activity patterns in logistics could serve as substitutes for storing and warehousing. This facilitates build-to-order production in accordance with individual customer requirements.

Investments in collaboration based technologies for information sharing have also been pointed out as an important factor for increased performance efficiency in reverse logistics (Srivastava, 2007). For instance, Bosch uses an inexpensive chip to record the time and the speed at which their tools have been operating (Blackburn et al., 2004). Test machines at retailers employ the chip to determine whether the tools which have been run under extreme conditions (operated above a certain number of hours) can be sent speculatively to a recycling centre directly (ibid.). The remainder that does not meet the requirements for recycling can be returned immediately to suitable remanufacturing plants.

Developments in technologies of transportation, materials and information handling, and efficient assembly, thanks to modules used in one or several product groups, reduce risk and uncertainty. As a consequence of these technological and managerial advances, the relative advantage of speculation over postponement has been decreasing. In a product recovery environment, postponement reduces the risk for obsolescence of used products by moving the differentiation nearer to the time of purchase. In addition, modular design increases possibilities for mass customisation in both forward and reverse physical flows as new modules and software can easily be installed to upgrade used or remanufactured items (White et al., 2003; Bostel et al., 2005). Shortening sales life cycles and fast price reductions (or faster innovation cycles) increase the risks for obsolescence of new, as well as used, products and modules. Blackburn et al. (2004) argue that product model returns for which price reduction rates are high and increasing towards the end of their sales life cycle, should be managed in a quick and responsive reverse supply chain. The path of these products to suitable facilities should be determined as early as possible, as extra delays during queuing, storing, separation, and inspection are connected with a decrease in price (ibid.).

In contrast, heavy, bulky and inexpensive raw materials, such as recycled paper, are likely to flow slowly through networks using scale-efficient transport modes, such as ships, rather than air transport. In the current state of affairs there is always a demand for raw materials, which are used in an increasing *diversity* of products, derived through requirements for differentiation coming from the demand side of the company (Håkansson et al., 2009). The successive differentiation of the raw material as it moves through time in the business network indicates that the heterogeneity of a resource, such as recycled steel, is progressively declining while the carrying costs and risks are increasing, since this raw material can be used as an input for manufacturing of products such as cars, bicycles, refrigerators, ovens, and construction materials. In this manner, recycled steel becomes more and more involved in progressive increase in complementarities (*sequential dependence*) while *diversity* is gradually being lost as this steel can be used for a decreasing range of products.

Activity features such as interdependencies, principles of postponement and speculation need to be connected to analytical tools for investigation of activity patterns. Therefore, the next part of the chapter will describe a set of analytical tools that are used to scrutinise principles of postponement and speculation in combination with activity interdependencies.

2.3.3 Analytical tools for activities

In this section, several analytical tools are discussed. These tools will be used to analyse empirical data with a focus on activity patterns of product recovery arrangements. The starting point for the analysis of activity patterns in this study is the concept of transvection (Alderson, 1965). This concept regards all activities as either sorts or transformations (ibid.). Hulthén (2002) implemented and developed further the concept of transvection by combining it with the Industrial Network Approach, in order to analyse variety in distribution networks. The following sections will describe some extensions of the framework developed by Hulthén, in order to make a connection between the concept of transvection and the product recovery context (ibid.). Furthermore, since transvections can be used for analysis of the processes, they should also be well adapted to the study of collecting, remanufacturing or recycling, distribution, and other activities associated with product recovery contexts.

Transvection

Alderson (1965, p. 92) defines the transvection[15] as *"a single unit of action of the marketing system. This unit of action is consummated when an end-product is placed in the hands of the ultimate consumer, but the transvection comprises all prior action necessary to produce this final result, going all the way back to conglomerate resources as they appear in the state of nature."* Furthermore, the whole business process, consisting of numerous transvections, is described by Alderson as *"the continuous operation of transforming conglomerates as they*

[15] The word stems from Latin's 'trans' and 'vehere' and was meant to express the meaning of 'flowing through', related to the movement of goods, people and information (Alderson and Martin, 1965).

occur in the state of nature into meaningful assortments in the hands of consumers" (ibid., p. 122).

As illustrated in Figure 2.7, each transvection consists of a series of sorts (item classifications), interspersed with a series of transformations affecting the conditions of products in time (e.g. storage), place (e.g. transport), and form (e.g. manufacture) dimensions under which the goods will eventually be brought to end-users. Both sorts and transformations can be arranged in different ways, added onto a current set-up or removed from it. In addition, at each step of the transvection, the costs of sorting and transformation are incurred (Alderson and Martin, 1965).

Figure 2.7 Illustration of sequential ordering of sortings and transformations in transvections (adapted from Alderson, 1965, p. 90).

The concept of transvections is an appropriate analytical tool for analysis of product recovery activities because Alderson (1965) made certain associations to this kind of business networks. In the original framing of the concept, he describes that at each branching point where lines in a network for the delivery of the product diverge from the perspective of a seller of used goods, there may be *waste* or *by-products* to be evaluated. *Waste* may carry a cost penalty for disposal while by-products may contribute some revenue to the main stream. Furthermore, he describes that goods have to be sorted in preparation for manufacturing processes in order to minimise the expensive and unnecessary production of discards and waste materials (ibid.).

The interlinked forward and reverse physical flows and the handling of waste from production are some of the essential elements of product recovery in business networks. This study primarily concerns objects that are discarded after disposal by an end-user. This situation takes place after the execution of the original transvection from raw materials in the state of nature to an end-user, portrayed by Alderson (1965). Thus, this thesis takes its point of departure in the concept of extended supply chains (Fleischmann et al., 2005) or, in other words, *extended transvections*, as the efficiency of recovery and reverse logistics operations depends on how end-users organise product recovery in collaboration with collectors and reprocessing companies (Flygansvaer, 2006). Original raw materials and other specifications that are a part of the products in the possession of an end-user have an influence in determining which paths these items will take after their disposal. Consequently, it is important to consider the link between the transvections from raw materials to end-users and post-use transvections.

An additional connection between organising product recovery and transvections concerns the collection activity, which is regarded as a crucial process for ensuring continuous and efficient supply. Alderson and Martin (1965) describe the efficient planning of the collection activity of parcels, which are later delivered to a minor consolidation centre. Moreover, transvections include the creation of form utility, which is well adapted for the study of multiple reprocessing activities such as recycling that alter the physical shape of an object. To sum up, in any transvection, sorts and transformations must alternate. In other words, a sort always occurs between any two transformations (Alderson, 1965). These two terms (i.e. sorts and transformations), will now be explained in a more detailed fashion.

Transformations

A transformation is a change in the physical form of a product, or in its location in time and place, which is expected to increase its value (ibid.). In other words, transformation adds utilities of form (e.g. wrapping, fabrication, repair, recycling) place (transportation), and time (e.g. storage, credit). At a specific point in time, a product can be considered as a bundle of various types of utilities which are not easily separated. Alderson (1957) notes a fallacy in breaking utility down into separate aspects, since it is an all-or-nothing proposition. For example, the form utility of an item in terms of its specifications is highly significant for the determination of the reprocessing option, and consequently for transformations in place and time. Products with factors that shorten sales life cycles, such as technical specifications of models in the electronics industry for which prices go down rapidly, require responsive reverse supply chains as unnecessary delays cause monetary value to erode (Blackburn et al., 2004). This, in turn, affects the choice of reprocessing alternatives.

Remanufacturing or other reprocessing activities represent a transformation or change in *form* utility of an item, such as when a new or used component is disassembled, cleaned and reassembled into an object. Yet another kind of form transformation is performed by retailers of used or refurbished products who can alter the total PC package, by adding buyer-adapted software suites, monitors, and new or refurbished components. Moreover, a dealer may provide installation, maintenance and repair services (Alderson, 1957) which is also the case with companies involved in distribution of used or refurbished products.

Further along the network, logistics service providers can be utilised by the dealers to transport these products to end-users by transforming the location of objects. These transformation processes change geographical locations of objects between disposers and reprocessors or end-users. Thus, *place utility* is mainly associated with shipment which is performed in order to overcome *discrepancy in space*. In addition, creation of *place utility* involves offering the goods close at hand for the customer, in order to cut down the distance (ibid.). This can be done by locating remanufacturing plants in suitable geographical locations, or by establishing inventories of used or refurbished products by having intermediaries in several countries.

Time utility can be created by intermediaries through such transformations as storage and credit. *"To be able to obtain the article at once instead of waiting is the essence of time utility."* (ibid., p. 215) When goods are placed into an inventory of items that are about to be recycled, they are transformed in time as collection and reprocessing could be separated temporally. This temporal distance refers to *discrepancy in time*, which can be bridged by credit, as well. Credit enables buyers to start utilising reconditioned equipment before it is possible for them to pay the full amount in cash. Furthermore, retailers and wholesalers transform objects and create time utility by holding inventory of products available to be drawn upon by buyers.

Transformation of identity between retailers and buyers, for instance, refers to changes in ownership or operating control of products. Each of these buyers represents an *identity* towards which sequential activity interdependencies throughout a transvection have to be established. Such activities need to be coordinated in advance through exchanges of information about qualitative and quantitative properties of objects, such as in orders, confirmations and delivery plans between organisations (Dubois et al., 1999). Plans regarding qualitative aspects of inputs and outputs must be matched so that division of labour between firms proceeds as efficiently as possible. Inter-firm differences between quantitative input and output ratios can be handled by intermediaries that break bulk or buffer the products in order to bridge this *discrepancy in quantity* (Rosenbloom, 1995).

To summarise, transformation in form is usually achieved in product recovery arrangements by repair, refurbishing and recycling on dedicated machines. In addition to form utility, time, place, and identity utilities are created by transformations along differentiated paths that used goods and materials take on their way to secondary end-users. Between each transformation, sorting has to be performed so that transformations in time, place, form and identity can be carried through in an orderly manner. The concept of sorting will be explored in detail below.

Sorts

Sorting is reclassification, and involves the creation of subsets from a set, or of a set from subsets (Alderson, 1965). This classification is always related to an already existing collection. Sorting is the decisional aspect of the business process whether seen from the standpoint of the supplier/seller or the purchaser/user. There are two main kinds of sorting, *assignment and selection*. Assignment represents the seller's or sender's perspective as they assign items to classes which are to be transformed in different ways thereafter. Selection is done by a buying /receiving organisation and/or an individual, who selects an item to be included in their assortment in relation to what their assortment already contains.

Sorting can be applied to goods, people and information. An example of information sorting is the sorting of orders. The larger the size of customers' order and the more standardised order specifications are, the lower is the ratio of sales to the fixed costs of billing and customer contact. Sorting of information or search must precede the sorting of goods and people. The function of searching is to locate items which belong in specified classifications. For instance, real estate parcels may be sorted into residential and commercial categories and assigned to separate salesmen for different periods of time. Sorting may also relate to distinctive promotional methods for sales of recycled materials or refurbished goods. Internal customer segmentation is a form of sorting (ibid.) and it can categorise industrial buyers and users of second hand products by industry, by location or by type of products consumed.

To exemplify the process in connection with product recovery, an end-user assigns goods to be placed in a container for disposal. A reason for disposal may be that these goods do not have any use value for this consumer. To guide sorts and transformations, a number of classifications or sorting rules are established for metals, plastics, paper and other materials in the waste disposal room. A waste management company assigns materials fractions to trucks for economical transportation. A recycling company may in its turn select certain materials like steel from several localities, including the raw materials from mining, initiating the processing. Then the steel producing company may assign different products in different batches adapted to one or several truck or container loads. Selection can be done later on in the process, such as when a car manufacturer buys parts necessary for the vehicle assembly process.

This phenomenon is called the *discrepancy of assortments* and relates to the most convenient or constructive association of goods at each stage in the physical flow of merchandise (Alderson, 1957). Differences in applied technologies at successive levels in product recovery processes are the basis of this association. Therefore, used products and recycled materials can be associated for transportation because of physical handling characteristics and common origin and destination.

With regard to product recovery context for used goods, processes of grading, classification and testing of items are treated as crucial activities for determination of paths for products, components and materials in reverse logistics, Closed Loop Supply Chain Management, and product recovery literature (Guide and van Wassenhove, 2002; Flapper et al., 2005). The activity of classification of product properties is decisive for the selection of multiple recovery options, as well. Hayek (1952, 1978) stresses the importance of categorisation as a knowledge problem that consists of identifying properties ("what are goods?") and prices ("how scarce or valuable are they?"). Both Hayek (1988) and Alderson (1965) treat price as one of the properties of a product that is used to register change through interactions, such as a single unit, quantity price or delivery price. Alderson (1965) reduces price to a datum of information that usually needs to be known about the product, and Hayek (1988) refers to prices as further superimposed means of classification. The list of more general purpose or collective classification mechanisms for registration of change includes calendars, addressing systems, postal codes and International System of Units. Every transport buyer has to state weight, volume, collection and delivery location (i.e. distance in kilometres).

Depending on various item properties and sorting rules, such as appearance, technical specifications, state of the product, price, etc., an item may be recycled or refurbished. Some attributes of products or materials such as size and weight are more easily determined and measurable than others (e.g. eye appeal) and lend themselves more readily to distinguishing one class from another (Alderson, 1957). Sorting rules such as grading mechanisms are hard to maintain as they have to be adapted to changing supplies, processing requirements and customer needs. Sorting rules are mechanisms for registering change, and are themselves subject to change. For example, previously sub-standard raw materials may become usable due to improvements in processing. In the product recovery context, items may keep their initial specifications insofar as sorting rules for refurbishing are concerned. If a decision is made to recover constituent raw materials in an object, this may change their identification according to the sorting rules for material recovery (i.e. recycling).

Various organisations are specialised in these inputs, based on the properties or specifications of raw materials of which they are made. In other words, activities towards these actors are complementary or closely complementary. At the same time, firms try to utilise economies of scale in order to minimise the costs of their operations. This is another way of saying that sorting rules and classifications are established to create and capture different kinds of *uniformities* among objects which can be transformed in a likewise fashion. There are uniformities in form (e.g. same recycling machines), time (e.g. same storage space in a warehouse or truck), identity (e.g. same organisation or specific counterpart), and place (e.g. same object/load carrier with the same geographical pick-up or delivery location) (Hulthén, 2002). In order to achieve economies of scale in operations, a number of uniformities can be utilised in the network. Thus, used or recycled items in standardised pallets that have different technical specifications can be stored in the same warehouse regardless of whether they are new or used.

The function of sorting rules is to create partial uniformities by identifying similar characteristics of an object’s form, time, place, and identity dimensions in the business process, which is done for the sake of temporal economies of scale in transformations. This exploitation of *parallel dependence or activity similarity* in transformations is done in a collection centre or a terminal. Such a facility can be used for storage of pallets of several kinds of products that are transformed in time in order to be sorted by the time and place dimension to a certain destination at a later point in time. Items in transportation are classed, packaged and treated similarly or differently according to several categories with respect to weight and overall dimensions. Hence, objects that are quite different in use value may be classified similarly during transportation according to weight, physical characteristics, overall dimensions, destination, date of possession, transfer, and type of installation.

Actors must distinguish objects by certain features in order to qualify them as belonging to distinctive groups. Routines require similar informational classification mechanisms (attributes) to identify commonalities and differences among objects. The standards and properties for identifying the size of used monitors are examples of this kind of classification mechanism for registration of change. Organising of activities in product recovery is aided by these mechanisms with respect to identifying differences and uniformities between objects.

2.3.4 Research issues related to organising activities in product recovery

Organising of activities means coordinating collection, product recovery options, and distribution in order to achieve a balance between economies of scale and scope. Activity patterns feature specific mixtures of similarity/diversity and complementarity/close complementarity. Uniformities in transvections are generated in form, time, place, and identity dimensions for the sake of economies of scale or similarities among activities. Temporal coordination of activities in product recovery and its connection to risk and uncertainty can be analysed using principles of postponement and speculation. Product recovery contexts are usually associated with uncertainties of supply in timing, volume, type and state of the product.

The exploration of organising product recovery in the activity layer is based on the concept of transvection. The central research issue here is identifying transvections that represent various forms of product recovery options (from reuse to recycling). The sorting and transformation activities in these transvections are then analysed with regard to the occurrence of:

- Parallel dependencies and similarities
- Sequential dependencies and complementarities
- Postponement versus speculation
- Uncertainties in time, place, form, and identity

Besides providing a framework for analysing activities in industrial networks, the ARA model (Håkansson and Snehota, 1995) emphasises the interrelatedness between activities and resources. Central features of resources and analytical tools for the analysis of the resource layer of the ARA model are discussed in the next part of this chapter.

2.4 Organising product recovery in resource constellations

The Industrial Network Approach takes a holistic perspective on resource interaction as it can be applied to analyse resource interaction across multiple inter-organisational boundaries (Håkansson et al., 2009). Heterogeneity and adaptations are central features of resources in the models and frameworks of the Industrial Network Approach (ibid.). These main properties of resources together with analytical tools and issues related to organising of resource constellations in networks are discussed in this part of the theoretical framework concerned with resources. In the section discussing analytical tools, there will be an elaboration on the 4R[16] model (Håkansson and Waluszewski, 2003) and the concept of the *object*, as developed by Hulthén (2002), is related to the notion of product in the 4R model. This section is concerned with the resource dimension in business networks, and ends with a discussion about organisation of resources in product recovery and research issues related to the resource layer of the ARA model.

2.4.1 Resources in product recovery

Resources are crucial since they contribute to the efficient undertaking of activities in product recovery arrangements. Several types of resources are required to perform the product recovery activities described in section 2.3.1. These assets could be trucks, trains, pallets, containers, recycling machines, and inventory facilities. Typical activities and processes in reverse logistics are acquisition, collection, logistics, classification/inspection, reprocessing (e.g. recycling), and distribution to other organisations that might use these items in their facilities.

First of all, the product itself is a resource that needs to be collected, remanufactured or recycled, and distributed for novel use is a resource. Knowledge about the state of the product and its general status is a precondition for accurate direction and therefore transformations in the movement of goods towards suitable facilities for dismantling, testing and reassembly. For instance, waste paper needs to be de-inked for paper production, while used computers need to be tested, and disassembled into parts appropriate for raw materials manufacturing.

During disposal and acquisition, both disposers and the organisations that are involved in product recovery options must be capable to classify products. As Jahre (1995) points out, disposers must possess some type of knowledge in order to categorise products. This is due to the fact that they always perform some type of separation of goods at their facilities (ibid.). When buying and selling used and/or reprocessed products, sales and purchasing expertise regarding the product in question is essential in order to balance supply with demand.

Collection and physical distribution require logistics resources. Examples of these resources are enterprise planning systems utilised for information exchange, organising and route planning of physical resources that are involved in distribution processes. In her study on coordinated action in reverse distribution systems, Flygansvaer (2006) recognises a set of different kinds of physical resources. Thus, cages and dismantling facilities are regarded as more context-specific than other resources for more general purposes, such as standardised

[16] This model classifies resources into products, production facilities, organisational units and organisational relationships.

containers and transportation vehicles, which are utilised in these logistics networks. The primary function of these resources refers to time and place transformations in transvections.

Examples of resources that are used for sorting of objects in transvections include testing and diagnostic equipment or software, and sensors. These productivity enhancing resources store the data about the use and the status of products to be able to quickly compare and identify an object's characteristics (Flapper et al., 2005). Toffel (2004) highlights the importance of knowledge involved in recovery options, such as skills and expertise regarding repair, disassembly and product design. These capabilities are important resources in order to perform product recovery activities in networks. In this manner, the tacit dimension of know-how is of great significance in the product recovery arrangements of business networks (ibid.). In many cases, reprocessing firms, including those that have the access to codified OEM specifications, have to reverse engineer the product to understand how to disassemble and reassemble it efficiently (ibid.).

In order to elucidate the existence of links between forward and reverse physical flows, Fleischmann et al. (2001) argue that reverse logistics networks are built on top of existing logistics structures. This interaction between forward and reverse logistics structures has also been demonstrated by Håkansson and Waluszewski (2003) in their analysis of such arrangements. Through application of the Industrial Network Approach on technological development within these networks, they have shown that a waste paper recycling solution had to fit into an activated heterogeneous resource structure adapted to the use of primary paper fibre. As the theoretical foundation of this thesis is the Industrial Network Approach, some of the basic assumptions regarding resources in this theoretical tradition, are depicted in the following part of this chapter.

2.4.2 Central features of resources

The ARA model highlights the significance of adaptations between resources that are considered as heterogeneous within all concepts and models of the Industrial Network Approach (Håkansson et al., 2009). Heterogeneity and adaptations are two of the central features of the Industrial Network Approach, which are the topics presented in the following part of the chapter concerned with resource interaction of the ARA framework.

Resource heterogeneity

Resource heterogeneity is put forward as perhaps the most central assumption in the Industrial Network Approach (Holmen, 2001; Håkansson et al., 2009). During her investigation, aimed at explaining firm growth, Penrose (1959) declared that the value of resources is dependent on the services they can render. Resources do not therefore have a fixed homogeneous utility. The expansion of firms is largely based on opportunities to use their existing productive resources more efficiently than they are currently being used (ibid.). He states that *"It is the* *heterogeneity…of the productive services available or potentially available from its resources that gives each firm its unique character"* (ibid., p. 75, 77).

It is not only through internal usage or combination of resources that firms may gain benefits. The value of a resource is dependent on how it is used, combined or related to other resources in an inter-organisational network setting (Håkansson et al., 2009). An element needs to have a known or potential use in order to be defined as a resource (Håkansson and Snehota, 1995). Hence, resource heterogeneity assumption stresses the importance of knowledge about resources themselves, and about which combinations that might achieve desired outcomes within companies, and between collaborating companies (ibid.). In some contexts used newspapers and packaging products are regarded as waste, while in others, these items might be useful as 'green' material for paper production (Håkansson et al., 2009).

In the ARA model (see Figure 2.3), a company's resources are classified as collections of resources. From a network perspective a single company's resource collection belongs to a resource constellation that is embedded in a business network (Håkansson and Snehota, 1995). Interaction processes between actors, activities and resources affect all these resources by creating and or forming them and their features (Jahre et al., 2006). The pattern of interactions that form the relationship requires resource adaptations over time (Håkansson and Snehota, 1995). Adaptations could involve products, facilities, and equipment. Some of these inter-organisational adaptations take place due to the fact that no company has sufficient assets to satisfy the requirements of any customer (Ford et al., 2003). In resource constellations of business networks, a firm's performance depends on adaptations between skills and technologies of suppliers, distributors, customers and sometimes, even competitors (ibid.). Resource adaptations are discussed in the next section of this chapter.

Resource adaptations

Inter-organisational relationships require resource adaptations across companies (Håkansson and Snehota, 1995). A resource constellation of a business network consists of several resource collections that are controlled by many organisational units. Thus, resource collections of a number of companies are connected to each other. Within business relationships that span multiple company boundaries, the patterns of interactions that form inter-organisational relationships create adaptations over time. As the development of inter-organisational resource adaptations proceeds, the resource constellation of a network emerges (ibid.).

Adaptations are made to increase or decrease the variety of solutions (Håkansson et al., 2009). Standardisations create economic benefits in resource interfaces because they decrease variety. By homogenising working procedures and solutions to problems, companies in inter-organisational contexts can reduce variety. Offerings, reprocessing and production processes are standardised to reduce the need for continuous adjustments. Some resources, such as products, may be related to other resources, such as production equipment, which is crucial for standardisation. Resource adaptations can be carried out in order to increase variety, as well, which is exemplified in specific adjustments made toward certain counterparts. Thus, these resources become a part of a unique resource combination (ibid.). Each resource has a specific interface in its relation to other resources, and these interfaces are embedded into a larger pattern of related interfaces (ibid.).

Resource adaptations create tension in some dimensions, while creating benefits in other aspects of business networks (ibid.). Development patterns of resources may be contradictory in different resource combinations where resources need to fit. A consequence of this resource adaptation is that every resource has features, stemming from previous interactions with other resources. Håkansson et al. state that:*"The more adaptations to the other resources in a specific combination, the more difficult it will be to use the individual resource efficiently in other resource combinations with different characteristics"* (ibid., p. 86) When a resource, tangible or intangible, organisational or physical, interacts with other resources, it is given some specific characteristics, which are referred to as features and imprints (Håkansson and Waluszewski, 2003). As illustrated by the authors in an arrangement where waste paper was collected, classified and distributed to a paper mill, there are combinations of technical and organisational resources that have to be interrelated. At the same time contradictory resource interfaces are created (ibid.). Products in the electronics industry are therefore more adapted in forward logistics networks than in reverse distribution networks (Jahre et al., 2006). Having explored resource adaptations, it is time to turn to analytical tools that are to be employed in the examination of these adaptations, in relation to organising product recovery.

2.4.3 Analytical tools for resources

This part of the chapter presents analytical tools for the exploration of the resource layer in business networks. Resource constellations in this thesis will be analysed by applying a framework, the 4R model (Håkansson and Waluszewski, 2003), in combination with the concept of *object* (Hulthén, 2002), which was used to analyse resources in transvections. These tools for analysis of the resource constellation are described in this section.

The 4R model – the model of four resource entities

The 4R model was developed by Håkansson and Waluszewski (2003), and deals with the technological development of resources. In particular, what is more relevant or suitable for this thesis is the fact that one of their case studies is based on what is essentially an analysis of technological development in a reverse logistics network for collecting, recycling and distribution of waste paper. Moreover, the 4R model has been utilised in a case study of a network involving a logistics set-up for recycling by Jahre et al. (2006). This should make the 4R model appropriate for the study of organising product recovery arrangements here as well.

Håkansson and Waluszewski (2003) developed a tool for analysing resource development by classifying resources in four elements. *Products* and *facilities* are two types of these resources, which are physical in character. The other two kinds of resources in the framework are of an organisational nature, and these are labelled as *organisational relationships* and *organisational units*. Four types of resources could therefore be distinguished in the 4R model as follows (Håkansson et al., 2009):

- *Products*. These offerings are manufactured, distributed, used or reprocessed in the network. They are combinations of tangible or material resources that can be moved around and may relate to several structures.
- *Production facilities.* Facilities are resources that have a more permanent nature than products. They can be materials handling equipment, load carriers, different means of transportation, and tools such as machinery or IT systems utilised in economic and or physical transformation of products. Facilities are vital for other distinctive and succeeding resource combinations.
- *Organisational units.* Knowledge, skills and experience are resources in organisations, individuals or groups and groups of business units that is required to handle particular resource combinations.
- *Organisational relationships.* Organisational relationships are assets that bind together all of the other assets of a company and convert them into something of economic value. Relationships cross company boundaries, routines, procedures, products, and facilities.

When it comes to resource adaptations it may be claimed that adaptations involve both organisational and physical resources and that one type of adaptation impacts on the other (Jahre et al., 2006). The relatedness created between physical resources relies on organisational resources. By applying the 4R model it is possible to study connections between the same and different kinds of assets in resource constellations. These connections between resources are identified as interfaces in the 4R model. Resource interfaces are defined as the *contact points* that specify in a qualitative and quantitative sense how and how much two resources affect each other (Håkansson and Waluszewski, 2003). Interfaces are central in the 4R model as one of the aspects of adaptation is about changing the interfaces between resources (Jahre et al., 2006).

A product such as a used or remanufactured copier has interfaces with its components in terms of resistance, quality features and durability. An additional type of interface is reflected in joint utilisation of resources. The same used copier can share production or distribution facilities, or investments, with other products. Interfaces between product and facilities may refer to interaction between the size of the product and load carriers (facilities), which should be adapted for materials handling and capacity utilisation reasons. Information systems are facilities that can be helpful in selecting suitable means of transport for the product, as well as partly supporting the quest for full loads in terms of grouping the deliveries by common dates and destinations. Relationships with freight forwarders, reprocessing firms and other organisations also have interfaces with products, load carriers and plants.

In order to connect the 4R model to transvections, and the activity layer of the ARA model, the concept of the *object* (Hulthén, 2002) is introduced here instead of products. Hulthén categorised products as objects with form, time, place, and identity features, which are sorted and transformed in transvections (ibid.). Furthermore, she used the concept of the object in order to study resources involved in transvections by relating the object to the resource dimension of the Industrial Network Approach. Therefore, the focal resource in this study is the object. Moreover, this starting point was chosen because this study is about recovering products, and directing them towards multiple resources related to product recovery options. An additional reason for this choice of the product as a focal resource is the fact that in transvections the centre of attention is the product. Hence, in the following three sections objects are regarded as products in the 4R model, while organisational units and relationships are treated as forces that systematically organise facilities and objects through interaction processes. The nature of objects as resources will now be presented.

Objects – products as a resource entity in the 4R model

Products are an essential part of the 4R model as their attributes and their nature largely determine the features of facilities (Jahre et al., 2006). In the 4R model, products are referred to as a type of physical resources that are manufactured, distributed, and used at these facilities. In a product recovery context, products are collected, reprocessed and redistributed to new uses. In this study, objects are utilised to analyse product recovery in accordance with Hulthén's (2002) framework, which connects activity aspects of transvection to the resource layer of the Industrial Network Approach. She held that objects change features when they enter transformations, and that these objects can be used as input in other transformation activities. In addition, this starting point is taken because this study is about recovering products and how they are directed towards different types of reprocessing resources. Objects also represent a more inclusive terminology as products may be regarded as something fixed, whereas in product recovery contexts, substantial changes of object characteristics might occur. For example, end-of-use products could be transported to a secondary user in the same state as they were originally purchased, or become raw materials. The term *object* captures this heterogeneity in a more suitable manner.

In order to initiate any recovery activity, there has to be an organisational relationship that enables this activity by assessing the resources of knowledge, machinery, facilities and relationships of companies involved in product recovery. This means that there is a division of labour and specialisation by inputs and outputs (Alderson, 1957) of activities within and among different facilities belonging to a range of actors. "*Goods are associated at the manufacturing level because they can be made on the same equipment or in the same* *plant…they are associated at the wholesale level because of similarities among trade customers and requirements for shipment and storage"* (Alderson, 1965, p. 33).

Transportation companies, for example, establish different classifications and sorting rules in terms of weight, volume, dimensions, and collection/delivery dates and addresses, without any necessary deeper product knowledge in other form dimensions. These rules are intended to make efficient adaptations to different load carriers, means of transportation, and inventories for many types of goods in order to achieve economies of scale. As explained above, transformations may be combined in different ways with respect to transformations in place, time, form, and identity in order to exploit parallel dependencies. However, time can have a negative impact on appropriate object transformations of products such as electronics. These have short innovation cycles, and might be sent to materials recovery even though they are fully functional, just because some of their characteristics might be outdated.

Hulthén (2002) argues that it is important to create uniformity of objects in time, form, place, and identity, so that they can share same resources of sorting and transformation. Creation and capturing of economies of scale, and activity similarities are enhanced in this manner (ibid.). As previously mentioned, even an exact copy of a product aimed for product recovery can exhibit distinctive characteristics. Changes in desired attributes can suddenly redirect the path of the transvection that could make the object or parts of it, unsuitable for the current facility or resource collection of a single firm.

Facilities – a resource entity in the 4R model

Facilities change objects when these resources interact. A reprocessing plant or a specific machine or software for inspection of a certain kind of product, is regarded as a facility. Hence, interrelated objects and facilities are usually mutually adapted. On the other hand, there are facilities such as pallets or containers, which could be used for different purposes, such as for transportation of various kinds of goods. Facilities can be viewed with varying perspectives and aggregate levels of analysis. A single truck transporting used goods is used the transformation in place, but from a greater perspective, several trucks that deliver a certain type of raw materials to a testing facility are used in collection and logistics.

As regards product recovery structures, all kinds of resources, including collective resources such as infrastructure, can be used to perform sorting and transformation in time, place, identity and form. Machines and human labour are used in form transformations, as recycling, disassembly or remanufacturing. Inventories are used for time transformations of used, refurbished or recycled physical items, while databases are used for time transformations of information. Software is used to vicariously sort the needed information tied to a certain used or remanufactured product according to certain sorting rules, which determine the type of resource that should be utilised in the next sequence.

Testing and classification equipment are facilities that are used for the sorting of products according to predetermined information sorting rules. Diagnostic apparatus, sensors, chips, machines, and telecommunication technology are vicariously sorting or searching either information or goods, on behalf of people. A technical purchaser or an administrative salesperson may only require an article number, which is a type of a sorting rule, to be able to order thousands products of the same type when the automatic reminder information indicates that the inventory level has reached the minimum level. The information system is programmed to search according to sorting rules for time, form, quantity and place when a user wants to locate a desired refurbished object. This is also an example of how resources are used to automate, speed, and rationalise previously manual activities of order quantity calculations.

Alderson and Martin (1965) argue that the situation of adding and subtracting sorts and transformations is dynamic, because of changing technologies in facilities for transportation and sorting. For example, development in mechanical sorting equipment (ibid.) or informational sorting and transformation technology, such as the Internet, vicarious search engines and EDI systems, has enabled sorts to lead to greater efficiency. SpectraCode's Polymer Identification System technology improves disassembly productivity by quickly identifying plastic polymers in both electronics and automotive products (Toffel, 2004). Access to this type of resource is provided by relationships between companies, which, in turn, are regarded as organisational units in the 4R model.

Organisational units – a resource entity in the 4R model

Organisational units are defined as firms, parts or agglomerations of firms (Jahre et al., 2006). These units interact in order to create and maintain activity links, resource ties and actor bonds (ibid.). Competencies and capabilities of employees belonging to companies, and institutions in networks are examples of resources that are associated with organisational units. Organisational units with their resources and experience, work with other business units and their knowledge. Competency for management of physical resources through sorting rules, such as objects, resides within single firms. This also concerns the knowledge of how to handle organisational relationships.

In product recovery settings, several types of capabilities are related to organisational units. These capabilities include knowledge in different firms and departments, ranging from the people involved in marketing and purchasing of used products, those managing reverse logistics, and those transporting refurbished goods. All of these abilities are elements in complex inter-organisational networks. Furthermore, operational management skills are also essential in reprocessing of used products, components and raw materials.

As mentioned earlier, many companies have unique, tacit knowledge about dismantling processes in their businesses, which makes them a vital reservoir of capabilities (Toffel, 2004). From a network perspective, this product-based knowledge is embedded into the resource constellation of a wider inter-organisational landscape, consisting of organisational relationships. Jahre et al. (2006, p. 141) state that: *"It is the business relationship that influences the interfaces and adaptations between the other types of resources through the activities taking place between the companies, i.e. the provision and use of the resource(s)."* Organisational units connect physical and organisational resources in the network through organisational relationships. Due to the importance of organisational relationships, some essential characteristics of those will now be described.

Organisational relationships – a resource entity in the 4R model
Organisational relationships are resources because they are utilised in resource combining and recombining, in resource constellations of business networks. Moreover, these relationships are frequently tied by resource adaptations that can change value of specific resource collections and resource constellations of industrial networks (Håkansson et al., 2009). Organisational relationships are essential in business landscapes as they make it possible to develop and use other resources such as facilities, products, organisational units and other organisational relationships (Jahre et al., 2006).

Organisational relationships play a vital role in connecting resources in a structural and in a process-oriented or functional sense (ibid.). One role of organisational relationships relates to the way relationships function as bridges within the network, providing existing and potential structural access to resources in other parts of the network. An additional function of organisational relationships is their contribution to the changes in the value of resources through their involvement in combining processes.

In order for resources to become combined in an appropriate manner, they must be related to each other through adaptations between companies in technical, administrative and logistical dimensions (Gadde and Håkansson, 2001). Such inter-organisational adaptations tend to bind the companies together and impose interdependence in product recovery settings. By interacting in organisational relationships, organisational units involved in collection, product recovery options and the distribution of objects, develop sorting rules in order to organise resource constellations and inherent resource combinations through interfaces.

2.4.4 Research issues related to organising resources in product recovery

One of the cornerstones of the Industrial Network Approach is the idea of analysing business landscapes through the study of the dynamics of resource combining and recombining. Based on the assumption of resource heterogeneity in networks, the value of a resource is determined by how it is combined with other resources in business networks. Organising actions as in resource combining depend on organisational resources, such as organisational units and relationships. Physical resources are combined with each other which in their turn, are combined with organisational resources.

Organisational relationships between firms involved in collection, remanufacturing, recycling and distribution accommodate resource combining of facilities such as trucks, warehouses, load carriers and information systems. Firms might also share and combine resources between forward and reverse object flows, as explained by Flapper et al. (2005), and Håkansson and Waluszewski (2003). This is crucial from the resource utilisation perspective so that transformations in such physical flows can use same facilities and capabilities as organisational units.

The exploration of product recovery in the resource layer is based on the transvections identified in the activity layer. Sorting and transformation in transvections require resources of various types that are continually combined and recombined. Sorting rules guide the direction of the objects through the facilities involved in product recovery. The interfaces between the specific object and other resources are central for the recovery of the object. The central research issue here is to analyse the interfaces among resources along the transvection, including:

- Interfaces between the object and other products
- Interfaces between the object and facilities
- Interfaces between the object and organisational units
- Interfaces between the object and organisational relationships

Resource combining and activity coordination influence, and are influenced by, the nature of organisational relationships (Gadde, 2004). These relationships are embedded in webs of actors. The effect that interaction has on organising product recovery will be discussed in the next section.

2.5 Organising product recovery in the web of actors

The third layer of the ARA framework is concerned with the actor layer. In this part of the chapter, the reader will be introduced into the actor layer and how this layer relates to the product recovery context. First, there will be a discussion about general aspects of actors in product recovery. These aspects will then be combined with some central features of actors in the Industrial Network Approach. After that, the organising role of actors in product recovery will be described. Finally, as a result of the elaborations with regard to the actor layer of the ARA model and its connections to organising product recovery in the web of actors, research issues are outlined.

2.5.1 Actors in product recovery

Actors both affect, and are affected by, activities and resources in networks (Håkansson et al., 2009). Interaction in a wider web of actors enables activity coordination and resource combining. This section is therefore based on previous elaborations on activities (section 2.3) and resources (section 2.4), associated with product recovery in networks.

There are several categorisations of actors involved in product recovery arrangements in business networks. Most actor classifications are process oriented (e.g. Thierry et al., 1995; Fleischmann et al., 2000; de Brito and Dekker, 2003; White et al., 2003; Krikke et al., 2004; Srivastava, 2007; Guide and van Wassenhove, 2009). This activity orientation defines actors by identifying the activities that they perform in product recovery settings (de Brito and Dekker, 2003). In this regard, actors that are involved in forward physical flows may perform a function or an activity in reverse physical flows. That is to say, firms such as manufacturers or intermediaries can assume the role of collectors or reprocessors in reverse goods flows. Within the Industrial Network Approach research tradition, Jahre et al. (2006) acknowledge interactions between actor roles in resource constellations of forward and reverse physical flows. Logistics service providers usually relate existing activity structures of new products to the activity structures associated with used items (ibid.).

Jahre et al. label actors in accordance with this activity dimension by characterising them as customers, collectors, reprocessing units, and buyers. Customers are stakeholders that need an option to dispose of their waste. Actors involved in collection, storage, transportation, and classification are called collectors. These firms can be existing logistics service providers, waste management companies, municipalities, or retailers. Reprocessors dismantle products into materials and sell these to secondary buyers (ibid.).

In addition, organising the whole logistics network for product recovery can be performed by actors which are deeply involved in forward physical flows, either individually or jointly with other actors (de Brito and Dekker, 2003). OEMs, wholesalers, retailers, or stakeholders in the public sector may participate effectively as coordinators in these structures. Besides those that are involved in coordinating physical activities and combining resources, Flygansvaer (2006) also introduces an additional type of actor, an organiser, which sets up and supports logistics structures for recycling. In her study, this organiser was jointly formed by importers, manufacturers, and distributors of electronics products, who became members of a consortium due to legislative requirements, imposed by what Jahre et al. (2006) call the authorities.

As only a part of the network is more explicitly driven by legislation, this thesis directs only a minor focus on authorities as stakeholders, The actors that are involved in product recovery processes are mainly defined by the activities discussed in section 2.3.1. Following the view of de Brito and Dekker (2003), it is the actor roles determined by processes which are associated with reverse physical flows that are significant. Furthermore, an activity/role perspective is also present in a classification of actors used for the analysis of reverse distribution systems (Jahre et al., 2006), where the analytical tools, related to the resource layer of the Industrial Network Approach have been applied. This terminology should therefore be an appropriate starting point to characterise actor roles in this study.

Therefore, very broadly defined, actors in logistics networks associated with product recovery arrangements may be classified into three groups. There are actors who want or are required to[17] dispose their objects at different stages of the product life. These actors are *disposers*. Disposers are the sources of inputs for product recovery processes in networks. They use their knowledge of object categorisation when they order collection. On the other side, there are those actors who desire these items. These are known as users. Users can utilise objects in combination with their skill and expertise for the production of new materials and products, or for consumption, in which case, they are known as *end-users*. Collectors, reprocessors, and distributors are actors who stand between disposers and the actors who desire the products in question, or their parts and constituent raw materials. Collectors perform activities related to collection, storage, and transportation with their logistical capabilities, which are utilised in combination with warehouses, trucks, cages, and other load carriers. They amass and classify objects. An additional classification can be performed by reprocessors. Reprocessors are involved in product recovery options (e.g. repair, remanufacturing, or recycling), which are connected to the testing, categorising, dismantling, and reassembly of objects. Their specialised capabilities and equipment, such as testing tools and dismantling lines, enable them to arrange their internal activities and to combine their resources. Distributors are concerned with buying, selling, categorising, and modifying objects (e.g. adding new parts), while logistics service providers deal with inventory holding and transport of products. For this purpose they can combine and recombine resources, such as different means of transportation, purchasing/sales competence, warehouse facilities, and information systems for buying and selling, and route/vehicle planning.

From an inter-organisational perspective, these actors organise product recovery structures in networks by combining resources and coordinating activities through business relationships. The importance of inter-organisational issues in logistics systems for recycling has been recognised by Flygansvaer (2006) and Huge-Brodin (2002). Flygansvaer (2006) showed that a change in the organising structure of business relationships enhanced performance in collection and recycling of electronic waste. Nevertheless, several authors (Guide and van Wassenhove, 2009; Srivastava, 2007; Toffel, 2004; Sharma et al., 2010) have identified a need for more research on inter-organisational issues and business relationships within the product recovery context. Behavioural features of business relationships are some of the tools for theoretical description of the actor layer of networks within the Industrial Network Approach. In addition to behavioural features of relationships, other analytical tools

[17] E.g. if the equipment is leased during a certain period of time.

connected to the actor layer of the ARA model are related to product recovery settings in the next section.

2.5.2 Central features of actors

As interaction within inter-firm relationships is one of the essential concepts in the Industrial Network Approach, this section begins with the discussion about interaction in business relationships. This is followed by a description of the concept of actor positioning through interaction.

Interaction

The concept of interaction is one of the elementary pillars of the Industrial Network Approach. Håkansson et al. (2009, p. 33) conceptualise interaction as *"an important economic process through which all of the aspects of business, including physical, financial and human resources, take their form, are changed and are transformed."* The greater the involvement of an actor in a particular interaction, the greater will be the effects on its activities, on its resources and on the company itself. Some interaction processes are long lasting and some are temporary. In this way, interaction in business networks takes a wide variety of forms (Håkansson et al., 2009). Huge-Brodin concluded that frequent interactions or regularity in business relationships can enhance logistics performance in systems for waste collection and recycling (Huge-Brodin, 2002).

Interaction processes involve people from different organisational functions (Gadde et al., 2010). Interactions between firms involved in organising product recovery typically involve complex personal contacts. Contacts between persons in organisations and firms, such as collectors, recyclers and distributors of used/reprocessed items, involve indirect connections and interactions with other companies in forward physical flows (de Brito and Dekker, 2003). This highlights the appropriateness of a network view for the analysis of inter-firm structures involved in organising product recovery. The network concept takes into account interaction dynamics of the wider inter-organisational industrial web. This indicates that companies are not connected in straight lines composed of supply chains and/or marketing channels (Ford et al., 2003). This is analogously valid in the case of reverse supply chains and closed loop supply chains.

The greater complexity of networks induced by extended supply chains and product recovery includes supplementary relationships or a lack of such relationships with inherent interaction processes. Therefore, in several product lines, adaptations between reverse and forward physical flows are not organised in an inter-organisational sense (Ferrer and Whybark, 2000; Flygansvaer, 2006). This is a result of undeveloped interaction and collaboration between OEMs and reprocessing firms on issues such as design for disassembly.

In contrast to this situation, interaction processes contribute to the creation of knowledge required for inter-organisational activity coordination and resource combining. Throughout the network, interaction and business relationships allow firms to develop adaptations and adjustments between resources and activities (Håkansson et al., 2009). These adaptations develop into organisational interdependencies. Håkansson and Johanson (1987, p. 372) state that: *"Through interaction, (firms) influence and adapt to each other's ways of performing activities"*. As interaction between organisations proceeds, positioning of actors evolves.

Positioning of actors

An organisation can be described in terms of its business relationships and interaction patterns within the network. This position illustrates how an actor connects activities and resources that are under control of other actors, both directly and indirectly. From a network perspective an actor's position is also defined by how a firm is connected to the resources and activities of other firms. Hence, an actor's position needs to be regarded in light of how the actor coordinates activities and combines resources through business relationships on its supply and demand side (Gadde et al., 2010). In addition, a single business relationship may be composed of multiple simple relationships, including supplier to customer (and vice versa), competitor to competitor, and partner to partner (Ross and Robertson, 2007).

Actor positions in the network change when companies do business with each other and cope with current issues on a daily basis and over a longer period of time (Håkansson et al., 2009). An example of this positioning involves electronics manufacturers in Japan (Toffel, 2004). Besides participating in the formulation of policies for coordinating the joint network for collection and reprocessing of electronics waste, each manufacturer in Japan maintains one treatment plant in order to accumulate information about reprocessing costs and the effect that design has on these costs. Conversely, disassembly complexities are a result of the lack of interaction and appropriate resource interfaces between manufacturers and recyclers of electronics products in Norway, (Flygansvaer, 2006). Flygansvaer states that the lack of interaction and appropriate resource interfaces between manufacturers and recyclers create dismantling difficulties. Design, production, and use of new products are not adapted to the work of recycling firms.

Flapper et al. (2005) have recognised the fact that firms sometimes share facilities and other resources for jointly coordinated forward and reverse physical flows when activities involved in both of these flows display similarities. Toffel (2004) argues that manufacturers or their partners are more likely to perform product recovery when remanufacturing requires comparable, unique resources and experience to manufacturing or other activities associated with the physical flows of new products.

These positioning and repositioning changes have effects on the whole web of actors in networks. Therefore, positioning and repositioning define the activities and resources in which an actor is involved, by relating them to other actors' positioning moves in the network. In this manner, positioning is a means of specialisation, which, in turn, is dependent on how other actors specialise (Gadde et al., 2010).

The nature of interaction in business relationships influences the positioning of actors in terms of activity adjustments and resource adaptations. Flygansvaer (2006) exemplifies this by stating that customers of waste collection services (i.e. disposers) usually display passive behaviour as suppliers of inputs in reverse distribution systems. She argues that deeper relationships with the business disposers might create more organised product recovery arrangements. Huge-Brodin (2002) concluded that business relationships and the development of interaction between actors in logistics systems for recycling were not characterised by institutionalised maturity.

Håkansson and Waluszewski (2003) have studied positioning behaviour of firms and mutual resource adaptations in the network for the collection and reprocessing of waste paper. Their study revealed that some of the actors that were far from being regarded as crucial to the collaborative development of a more environmentally friendly paper became central ones, thanks to interaction processes.

Power is another type of interactive social behaviour related to positioning of actors in organisational relationships. Gadde et al. (2010) provide a network perspective on power by focusing on the influencing force derived through an actor's network position. Huge-Brodin (2002) has demonstrated that a network position in terms of size[18] and the company's relationship portfolio is one of the power bases in logistics systems for recycling. This position can be used for coercion and/or to exert direct and indirect influence over others through shared values and norms. Inter-organisational coordination of activities and resource combining, which contribute to the definition of actors' positions in a network, are determined by the nature of organisational relationships.

Thus, in addition to cooperative adaptations in business networks there are also other types of social behaviour that involve conflicts between actors. These relationship features and their relevance for organising product recovery are discussed below.

2.5.3 The role of actors in organising product recovery in networks

According to the ARA model webs of actors, resource constellations, and activity patterns are connected. In line with this model actors are responsible for organising activities and resources on firm, relationship, and network level. On a relationship level, it is important for actors to develop activity links and resource ties in order to coordinate activities and combine resources involved in product recovery in an economically efficient manner. Interaction

[18] E.g. total sales of each of the two actors in a relationship.

between actors such as disposers, collectors, reprocessors, distributors, and end-users, enables the organising of product recovery in networks by positioning and repositioning.

Through a repertoire of different kinds of relationship behaviours, firms will position and reposition activities and resources in business networks. Hence, actors have multidimensional identities as their positions and positioning are dependent on the organisational relationships in networks involving reverse and/or forward physical flows. This section deals with the nature of business relationships and the role that information exchange has in activity coordination and resource combining in business relationships.

The nature of business relationships

Organisational relationships contain mixtures of confrontational and collaborative interactions (Håkansson et al., 2009; Ross and Robertson, 2007). Certain interactions are linked to individual purchases while other relate to continuous movement of large volumes of physical goods (Håkansson et al., 2009). A supplier might be able to contribute a specific solution for a particular customer at a particular time. Even some ad hoc and short-term projects can involve intense interaction that might leave significant imprints on the involved companies. Thus, the involvement of actors in relationships has an impact on the outcome of actor positioning and the interaction processes within business relationships. In order to conceptualise interaction, Gadde et al. (2010) divide organisational relationships into two diametrically opposite approaches, *high-involvement* and *low-involvement* relationships.

A *high-involvement business relationship* is associated with large adaptations in the resource and activity dimensions (ibid.). This type of relationship can generate large cost and revenue benefits over a longer period of time because they can provide customised offerings and relationship-specific solutions. Other benefits in high-involvement relationships are related to flexibility, improved service levels and efficient and smooth physical flows as in just-in-time and build-to-order production. However, there are huge costs involved in coordination, adaptation and interaction, which increase relationship handling costs. High-involvement relationships take time to develop because the supplier/seller and the buyer/customer need to know a lot about each other before establishing a high-involvement relationship. It becomes possible for partners to improve skills and capabilities through interaction.

Low-involvement business relationships are handled with limited resource adaptations, activity interdependencies and interaction. Since products and services are usually standardised, this approach leads to minimum resource and activity adjustments and adaptations. Complementarity among activities in transvections is normally not close in low-involvement relationships. Shipment and order processing activities are more standardised than in high-involvement relationships. This implies low relationship handling costs. Low-involvement relationships are frequently connected to the opportunity to play off many business partners, while high-involvement relationships are related to a much smaller number of counterparts.

As argued by Alderson (1965) cooperation is as prevalent as competition in business. This is also true for organisational relationships. Thus, organisational relationships could be characterised by both collaborative and confrontational features (Gadde et al., 2010). In order to describe context dependent but frequent cooperation and competition in marketing channels, Gettell (1950, p. 93) coined the term *"pluralistic competition"*, which he defined as *"the simultaneous cooperation and conflict between and among individuals and business units that characterize the market place"*. An example of simultaneous competition and cooperation in the product recovery setting is provided by Guide and van Wassenhove (2009) who argue that there are risks of having refurbished equipment compete with the sales of new products supplied by OEMs. A manufacturer can thus choose to recycle in order to prevent jobbers from reselling his products at a lower price in the second hand market (de Brito and Dekker, 2003). On the other hand, cooperation between competitors includes joint participation in research projects, the determination of production standards, the enforcement of fair-practice codes, and sometimes, the support of wholesale and retail distributors by extending credit and lending money (Gettell, 1950). An example of collaboration between competitors involved in organising product recovery set-ups, is taking place in Sweden (Huge-Brodin, 2002) and Japan (Toffel, 2004). Competing electronics manufacturers have formed consortia for the collection and reprocessing of their end-of-life products.

With regard to disposers, Flygansvaer (2006) and White et al. (2003) describe that many of disposing organisations supply inputs on a case-by-case basis which creates organising challenges in terms of intermittent flows. Establishment of close relationships with organisational disposers enables increased supply of volumes of homogeneous goods which can make capacity utilisation in collection and dismantling less challenging than in handling of used items from consumer disposers, in which product flows consist of small, high frequent heterogeneous volumes (Flygansvaer, 2006). She indicates that integration of effective information flows in reverse distribution systems is crucial in coordinating effective physical flows.

The role of information exchange

The flow of goods is intertwined with information exchange. Information exchange is, in turn, a precondition for activity coordination and resource combining between firms. Contemporary IT systems are designed to track and trace the position of single items in logistics flows in a much more detailed way which enables more efficient matching of supply and demand (Gadde et al., 2010).

Information content that is registered and identified in IT systems concerns the changing product characteristics and states. This information involves data about the different forms, times, places, identity features, and states of goods. IT systems can alter previously registered data in order to adapt this information to the needs of different actors (Engelseth, 2007). As described above, positioning is a process through which actors specialise in the resource and activity layers of business networks. Therefore, the use of information among actors may vary as different resource features need to be combined with the features of objects through interfaces. In a similar vein, information that is needed for efficient and effective coordination of activities is actor dependent.

Alderson (1965) explains that grading and standardisation (reduction of information complexity by sorting rules or partial homogenisation, in Alderson's terms) makes transactions more efficient. It is these rules that become central in economising on time and effort in searching or informational sorting. In order for these conditions to prevail, the supplier's identification of the object must match the buyer's need specifications (ibid.).

Conversely, information mismatch is one of the identified problems in organising product recovery that is caused by the lack or abundance of information (i.e. uncertainty and complexity). Thus, proper information handling among organisations is central to these milieus, as uncertainties with respect to product returns' features are greater (Ketzenberg et al., 2006). Following the conclusions of Shannon and Weaver (1949) that information provides value by reducing uncertainty, Ketzenberg et al. (2006) argue that efficient coordination of processes in product recovery environments requires accurate information on timing and quality of product returns. This coordination can be achieved through investing in IT systems that track the location and condition of products, and/or through the availability of timely and correct information, which could accommodate balancing returns with demands (Kokkinaki et al., 2004).

The economic process is said to create time, place, and form utility through transformations. Sorting rules and classifications generate uniformities and differences in time, form, place and identity of an object in order to steer the objects to transformation facilities. This means that information about this physical flow must be exchanged through shared classifications about form, time, place and identity to describe the state of the object in order to facilitate inter-organisational activity coordination and resource combining. This general description of information classes is illustrated in Table 2.1. A few collective general apparatuses for registration of change in time, form, and place dimensions, in order to identify uniformities and differences that steer object transformations have been described in Section 2.3.3.

Form	Time	Place	Identity
Product specifications (e.g. a reprocessor needs hardware specifications while a freight forwarder may need information about weight, length, volume).	Collection/delivery date, lead time between actors, current date.	City, address, room number, distance, shelf place, inventory place	User name, exchange coordinator, logistics provider, reprocessor, changing throughout the network

Table 2.1 Information classes and their relation to utilities.

The right combination of assigning and selecting information about objects must be done through shared classification categories with respect to time, form, place and identity in order to synchronise operating ratios of sorting and transformations in machines and load carriers belonging to different companies.

The lack of inter-organisational coordination and integration of reverse physical flows is often caused by information paucity and asymmetry that create confusion and inefficiency (White et al., 2003). For example, reprocessing businesses often deal with facilities staffs that have little data about the composition or modifications of IT equipment that occur during the utilisation (or repair) of the product (ibid.). Furthermore, equipment that needs to be dismantled may be transported unnecessarily to an inspection facility, because there is a lack of information about the state of the product (Blackburn et al., 2004). In most cases the disposer has to pay for logistics services. Greater information availability, either through consortia, regulations, or longer-term contracts, can improve disassembly and production management (White et al., 2003).

Nevertheless, actors in inter-organisational structures can choose not to share information for several reasons. One reason for information withholding in business is that information is considered as a source of power (Mason-Jones et al., 1997). The fear of losing power to another actor is used to explain information distortion and the reluctance to share information in inter-organisational settings. This opportunistic behaviour as regards the withholding and/or distortion of information is nevertheless often coupled with increased transactional costs (Stern and Reve, 1980). Huge-Brodin (2002) has shown that superior information access can be used by a firm to establish itself as a central actor in controlling reverse physical flows. However, this situation was largely influenced by the firm's network position and not as much by a desire to withhold information from other actors (ibid.).

It has been mentioned above that leasing secures timing, volume and quality of product recovery (i.e. reduces the uncertainty or lack of information about time, form, place, and identity). Indeed, Thierry et al. (1995) argue that "*Lease companies usually have more information on the quality and return of used products.*" This is attributed to high-involvement approaches in business relationship in which companies have close interaction regarding maintenance, repair and operations. These connections between information sharing and the nature of organisational relationships are summed up in the research issues associated with the actor layer of the Industrial Network Approach.

2.5.4 Research issues related to the role of actors in organising product recovery

Business relationships may simultaneously exhibit several types of behaviours, including such traits as cooperation and conflict. These features have an impact on the performance of inter-firm organising efforts in activity patterns and resource constellations. The level of involvement in business relationships affects inter-organisational coordination of activities and resource combining of product recovery arrangements. Some business relationships involved in product recovery settings of networks are not characterised by developed inter-organisational coordination.

Resource constellations with corresponding combinations, and activity patterns with related interdependencies, influence the organising structure of business relationships in product recovery arrangements. This refers to interactions of organisations involved in reverse flows of various product recovery options and between forward and reverse physical flows.

Network positions, features of business relationships, and the level of involvement in business relationships have an impact on information exchange, which is vital in linking of activities and resource combinations between firms. Organisation of information exchange with regard to the description of time, place, form, identity, and form characteristics of objects in reverse flows is of great significance to inter-organisational handling of uncertainty, activity interdependencies, and resource combinations. As pointed out above, sorting rules are utilised to classify information about objects in order to steer objects into adequate resource combinations. Resource adaptations enhance performance of resource combinations in product recovery through developed interfaces between interacting objects, organisational units, organisational relationships, and facilities. Interactions between resource constellations for forward and reverse physical flows, and for different product recovery options, may display a variety of tensions, which actors have to manage.

Actors are those that organise activities and resources. Therefore, important dimensions of the organising of the actor layer in product recovery are derived from the previous discussions concerning activities and resources. The first task in the exploration of the actor layer is to identify what actors are involved in the activities in the transvections, and what role they have in the combining of resources. The specific research issues in the actor layer concern:

- The role of business relationships in the interaction and positioning of actors.
- The role of information exchange in these processes.

In summary, these research issues are formulated in order to gain an understanding of the nature of business relationships and how these affect activity coordination and resource combining in product recovery structures. Having discussed research issues associated with the three separate dimensions of the Industrial Network Approach in three corresponding sections, these will now be elaborated upon in a summarised manner in the concluding part of this chapter.

2.6 Summary of research issues

The aim of this study is to explore the organising of product recovery from an inter-organisational perspective, through the development of a framework that permits analysis of business relationships in such structures. Based on this aim, the theoretical frame of reference of the thesis has been described in this chapter. The Industrial Network Approach is used as a main theoretical base in the study. This theoretical approach makes it possible to study product recovery in three separate, but interrelated, fundamental layers based on the three network dimensions of activities, resources and actors. With regard to organising product recovery, this examination can therefore be approached in three ways; organising product recovery in the activity pattern, in the resource constellation, and in the web of actors. After each section that described concepts related to three layers, research issues have been pointed out. These issues are summarised below.

In the activity layer of the Industrial Network Approach, the central research issue is to identify transvections that represent various forms of product recovery options (from reuse to recycling), and activity interdependencies combined with distinctive ways of applying principles of postponement and speculation. The sorting and transformation activities in these transvections are thus analysed with regard to the occurrence of:

- Parallel dependencies and similarities.
- Sequential dependencies and complementarities.
- Postponement versus speculation.
- Uncertainties as to time, place, form, and identity.

The main research issue in the resource dimension is to apply the 4R model in order to analyse resource adaptations and tensions by exploring the interfaces among resources along the transvection, including:

- Interfaces between the object and other products.
- Interfaces between the object and facilities.
- Interfaces between the object and organisational units.
- Interfaces between the object and organisational relationships.

Organising product recovery by coordinating activities and combining resources is performed by actors. Hence, for the actor layer, the key research issue is to identify and explore relationships between organisations in product recovery arrangements and the roles of actors that are involved in activity coordination and resource combining in transvections. The specific research issues in the actor layer concern:

- The role of business relationships in the interaction and positioning of actors.
- The role of information exchange in these processes.

3 METHODOLOGICAL CONSIDERATIONS

In the first part of this chapter, the actual research process is described as it relates to the iterative and emergent development of the case studies and the analytical framework. The research method applied is presented in the second part of this chapter. Here, the choices regarding the research approach, case selection, and the methods for collection of data are dealt with. Finally, the quality of the study will be evaluated.

3.1 Research process

In 2009, I took up my position as a PhD student and became part of the Division of Industrial Marketing at the Department of Technology Management and Economics, which is one of the departments at Chalmers University of Technology. At the same time as I commenced my employment, I became involved in a research project, called Sustainable Logistics. The project, Sustainable Logistics, which is briefly described below, involves other organisations besides those coming from the academic world. These actors are the Swedish Governmental Agency for Innovation Systems, Logistics Transport cluster (LTS), Volvo Logistics, Schenker, Stora Enso, Västra Götalands Region, and City of Gothenburg Traffic Division.

3.1.1 Project Sustainable Logistics

The project is performed in collaboration by six PhD students and the same number of senior researchers from the Division of Industrial Marketing and the Division of Logistics and Transportation at Chalmers University of Technology, and logistics researchers at the School of Business, Economics and Law at the University of Gothenburg. Sustainable Logistics has a general focus on operational efficiency and environmental sustainability within the field of transport-related logistics.

Taking into consideration the assumption that there are opportunities for transport buyers, transport providers, and transport operators, and society at large, to move in the direction of efficient and sustainable logistics solutions, the project covers six areas of research. These areas include operational transport efficiency, effective transport and logistics solutions from a third party logistics provider’s perspective, requirements set on the transport by the buyer, business opportunities related to sustainability issues, analysing current measures aiming at sustainable transportation of goods from a system perspective, and sustainability in making and distributing domestic biofuel. My research area deals with how companies through collaboration, take advantages of business opportunities related to sustainability issues in logistics. The development of the case studies and the analytical framework that were used to explore this research area are discussed in the next section.

3.1.2 Development of the case studies and the frame of reference

As the research area that I planned to investigate dealt with inter-firm cooperation, even at the beginning of the project, there was a match between the theoretical foundations of the

Division of Industrial Marketing and my research topic. The theoretical base that unites this division is the Industrial Network Approach (e.g. Håkansson and Snehota, 1995; Håkansson et al., 2009). One of the pillars of the Industrial Network Approach is the assumption that firms and organisations, in general, are embedded in networks of relationships. It is the interdependencies between suppliers, manufacturers, logistics service providers, intermediaries, and customers that constitute the structure of the network.

Given this theoretical base and the empirical areas of interest, researchers at the Division have used analytical tools and concepts derived from the Industrial Network Approach in order to analyse technological development, purchasing, and distribution. These theoretical and empirical interests had a major influence on the research process of this thesis from the very first day, as this study is about inter-organisational coordination of activities and resources.

Early in my association with the Division of Industrial Marketing, I was introduced into the theoretical foundations of the Industrial Network Approach by reading three books (Ford et al., 2003; Jahre et al., 2006; Ford et al., 2007). Regarding empirical enquiry, an article (Sharma et al., 2010), which was handed to me prior to its publication, was the most significant guide in my initial search for appropriate industrial structures to explore my research area. These references were very influential in the selection of the empirical area of interest and the analytical framework of the study.

Since the textbooks covered all three layers of the Industrial Network Approach, activities, resources, and actors, I had all of these three lenses in mind during the collection of data. In particular, the ARA model, which integrates all of the dimensions into a systemic whole coloured my perception of the business world.

The Sharma et al. (2010) reference wakened my interest in reverse logistics of PCs, as it empirically covered product recovery arrangements in this business sector. I was briefly introduced to the research field of reverse supply chain management at the courses that I took on the master's level. Since I considered this research subject to be very closely connected to sustainability and logistics, and a suitable point of departure for this thesis, I decided to contact companies involved in collection, distribution, and recycling of electronics, including a collector/recycler, Renova, PC manufacturer, Dell, and their third party logistics provider, Schenker.

Thanks to a doctoral colleague from the Division of Logistics and Transportation, who was a manager at Schenker, I was able to contact the person responsible for logistics solutions offered to Dell in the Nordic region. This interview dealt with general and broad areas of business that connected environmental aspects with logistics. One of the topics concerned reverse logistics, which I wanted to explore further in the empirical world. I therefore decided to contact Renova as I thought that this firm could give me more elaborate answers on the processes that were more closely related to the recycling of electronic waste.

The interview at Renova provided me with a general overview of the recycling industry for electronic and electrical products, in terms of the largest actors and processes involved in these structures. I noticed that products themselves were adapted with regard to forward physical flows, as many operations were manual and the dismantling of products required a lot of time. In addition, I observed the changing features of products at Renova's facility. Renova got paid per kilo of categorised goods depending on the properties of the raw materials that went into the manufacturing of the products.

These circumstances enabled me to see the connection between the empirical world and the analytical tools related to the resource dimension of the Industrial Network Approach. Because this interview was conducted concurrently with my attending a course based on a book about resource combining in logistics (Jahre et al., 2006), I decided to include the 4R model and the notions of resource adaptations and tensions in the frame of reference of the thesis. The four resource entities of the 4R model: products, facilities, organisational units, and organisational relationships, were discernable at Renova's facility as well as in collaborations between companies that were dealing with other product recovery options.

After the interview with Renova, my search for appropriate research companies, based on the article (Sharma et al., 2010), led me to Dell. My first interview with the company was supposed to take place at the local sales office of Dell in the spring of 2009. During that spring, I came across a doctoral dissertation (Hulthén, 2002), which turned out to be a major source of inspiration for the analytical framework of this thesis, besides the analytical tools stemming from the literature on the Industrial Network Approach.

As I was skimming through the dissertation, the concept of object, sorting and transvections caught my immediate attention. I had already performed a minor literature review on reverse logistics, which familiarised me with the definitions of activities in this particular research field. In several frameworks for the analysis of this kind of logistics systems, the activity of sorting and classification was explicitly stated as a crucial operation for routing of products, parts, and raw materials inside the companies, as well in of inter-organisational physical flows. At that moment, it seemed that the theoretical representation of transvections and sorting provided by Hulthén (2002) could be applied to the study of product recovery milieus.

When the interview with Dell in Stockholm was finished, I learned more about transvections from the original sources (Alderson, 1965; Alderson and Martin, 1965). In this manner, the interview with Dell proved to be a significant moment with regard to the analytical framework and the empirical inquiry of the thesis.

The interview with the market manager at Dell in Stockholm and other contact persons at the company served as “door openers” to actors that were involved in taking care of the used PCs from Västra Götalands Region (hereafter, “VGR”). When I introduced the project that I was part of and the actors that were involved in it, including VGR, the sales manager concluded that it would be appropriate for me to study the product recovery arrangement for the collection and reprocessing of their PCs, which were regularly replaced by Dell on a three years basis. Dell helped me by providing access to the firms that were involved in this kind of networks on their behalf. In 2010 I made some observations of the operations of two companies, IT Logistics, and Igus Data. Besides conducting observations, I interviewed companies that were planning logistics and selling refurbished PCs.

At the time of the initial interviews with Dell, and other actors described in the first case study, which is not presented in this thesis, I attended a doctoral course entitled Dissertation Analysis. The aim of the course was to introduce PhD students to techniques for the examination of scientific work with a focus on doctoral dissertations. One of the course seminars dealt with a dissertation that covered the topic of inter-organisational coordination of activities. The framework of the dissertation (Dubois, 1994) and further developments (e.g. Håkansson et al., 2009) gave me supplementary tools for the examination of activity interdependencies, in terms of balancing differentiation and customisation with economies of scale (i.e. activity complementarities and activity similarities). I viewed these concepts as very suitable for the theoretical framing of the direction of activities towards actors that perform distinctive product recovery options.

Thus, analytical tools associated with the activity layer of the Industrial Network Approach shaped my understanding of the product recovery processes between 2009 and 2011, as I made several interviews and observations with firms that were involved in collection, logistics, reprocessing, and distribution of PCs that Dell leased to VGR. The active role of VGR in the disposition and collection processes associated with used PCs made them a focal actor in this network and case after discussions with my main supervisor in the autumn of 2011. From a theoretical perspective, this delimitation or bounding of the case seemed appropriate in terms of theoretical contributions of the thesis as research in reverse logistics usually does not take the perspective of the disposer. Furthermore, in the literature on reverse logistics and Closed Loop Supply Chain Management, disposers are often described as passive actors and are largely considered as external parties in reverse logistics systems.

To further investigate reprocessing, I interviewed the company that refurbished the used PCs coming from VGR, Igus Data, and took notice of the varying level of involvement and differentiated features of business relationships they handled. As a result of this observation, I undertook literature studies, after consultation with my supervisors, decided to include behavioural dimensions of relationships in the frame of reference of this thesis. In the spring and autumn of 2010, I undertook literature studies concerning the actor layer of the Industrial

Network Approach, to acquire analytical tools for the examination of inter-firm relationship behaviour.

As the literature studies of the actor layer of the Industrial Network Approach continued, I continuously searched the Internet for industry-related articles on Swedish companies involved in product recovery settings, I came across a refurbisher named Once Again. At an interview conducted in 2009 with the Managing Director of Once Again, I learned that the largest distributor of IT related products, Atea Logistics, whose managers my supervisors were acquainted with, was also involved in refurbishing PCs. I decided to contact Atea Logistics, the company that eventually became the focal actor of the second case study of this thesis. The firm and its network contributed to the understanding of the phenomenon of organising product recovery, as they offered differentiated logistics services to disposers, and were themselves involved in refurbishing products. The case study about Atea Logistics and its partners introduced another kind of variety into the thesis, as that company, in cooperation with Schenker, Eurovironment, and Jemacon Logistics, offered a set of standardised solutions with regard to collection processes.

All in all, I ended up with having two case studies based on different perspectives of the archetypical roles of actors in product recovery arrangements, which broadened my research process by adding different perspectives. In other words, VGR as the focal actor highlighted the role of the disposer in the first case study, which is not described in this licentiate thesis as, stated above, whereas the second case study assumed the perspective of a reprocessor, Atea Logistics. Moreover, Atea Logistics acted as an organiser of the activities involved in this context as they developed solutions that directed the path of the collected articles toward alternative product recovery options, in contrast to the first case description and the actors involved in the case study, which concentrated on one product recovery option, remanufacturing and refurbishing.

Towards the end of 2010, joint efforts related to the handling of used PCs from VGR, and logistics and reprocessing companies were discontinued. This temporal demarcation made it easier to observe the case boundaries and to detect a distinction between the case studies. So, most of the interviews from that moment on were conducted with Atea Logistics and the actors that were closely connected to the logistics services provided by this firm. I therefore concentrated my data collection efforts on the second case study, which was about Atea Logistics, a company that was initially interviewed in the spring of 2010. A year later, I conducted additional interviews with Atea Logistics as well as with its partners, Eurovironment and Inrego.

Data collection was finalised in the autumn of 2011 as the last follow-up interviews with Schenker and Atea Logistics were finished. Since the concepts and tools for the analysis of activities and resources were developed towards the end of 2011, I turned my attention to the models associated with the actor layer of the Industrial Network Approach. In that regard, after consultation with my supervisors, I decided to conduct a literature study on the level of involvement in business relationships and the positioning of actors in the network.

As Huge-Brodin (2002) analysed network positions in the logistics systems for recycling, this dissertation was included in the literature study concerned with the actor dimension of the Industrial Network Approach in the spring of 2012. I had previously read the dissertation in 2010, but now that my frame of reference was in its final phase of development I could use the findings of this dissertation more appropriately, as relating to the positioning of actors in this thesis. This last literature study meant that all three network dimensions could now be fitted into the frame of reference for the analysis of how actors organise activities and resources in product recovery structures embedded in networks.

3.2 The research method

As outlined in the section on the actual research process, this thesis has developed through a constant and continuous alternation between the analytical framework and the empirical world. This procedure for conducting research has been defined as systematic combining, and is discussed in section 3.2.2. First of all, I will turn to the question of the appropriateness of using the case study approach as a research strategy.

3.2.1 Case study approach

A rationale for the choice of a qualitative case study design in this thesis is grounded in the literature on research methodology (e.g. Yin, 2003). Yin classifies commonly used research strategies and methods in social sciences as surveys, case studies, longitudinal and ethnographic studies, action research, 'true' experiments, and historic and archive analysis. According to the author, three conditions determine the choice of a research strategy: the type of research question posed, the extent of control an investigator has over actual behavioural events, and the degree of focus on contemporary, as opposed to, historical events. In agreement with the guidelines of that author, the following conclusions with respect to the choice of the research method have been drawn. As this research deals with the identification, description and explanation of how business relationships function in a product recovery context of networks, there is no control of behavioural events, and that there is a clear focus on contemporary events, the case study approach was suitable for this study. In line with this reasoning, Correa (1992) argues that case research, is the most appropriate research design when there is a need to build theory and answer the 'how' question, as compared to experiments, surveys and action research.

Since I focused from the outset of the study on how companies, through cooperation, could take advantages of business opportunities related to sustainability issues, I believed that qualitative case study design would be an appropriate research strategy in an empirical and theoretical sense. From the empirical perspective, the main reason for the choice of this method is my conviction that business relationships and inter-organisational interaction are phenomena that cannot be described or measured quantitatively, due to their inherent complexity. On the theoretical side, the qualitative analytical foundations of this thesis, the Industrial Network Approach which has a rich set of concepts for the analysis of business relationships, contributed to the selection of the qualitative case study research method for data analysis and data collection.

Dubois and Gadde (2002) acknowledge that qualitative case studies provide unique means of developing theory by utilising in-depth insights of empirical phenomena and their context. To achieve an understanding of business relationships in networks, it is crucial to study interplay between three elements for qualitative analysis and collection of data in the Industrial Network Approach. Hence, as one of the aims of the thesis is to make a contribution to the Industrial Network Approach in light of the observed results of how the activity, resource, and actor layers interact within the context of product recovery settings in networks, the case study research methodology was chosen for this thesis. More precisely, the research questions are heavily connected to this analytical framework and deal with issues of how actors coordinate activities and combine resources in product recovery arrangements.

Dubois and Araujo (2007) state that case studies fit well with interactions, relationships and dependencies, which are the basic units of analysis of the Industrial Network Approach. The complexity of industrial networks requires a methodology and data collection process that parallels the connectedness and dynamics of these milieus. This can be explained by the embededdness of business relationships in networks, which causes events to spread in a chain of consequences in such a dynamic manner that it is impossible to delimit the case boundaries in time or scope, in advance. This process of case study bounding and case selection with regard to this thesis is discussed below.

Selecting cases

The selection of cases in this thesis has gradually evolved through interaction between collected data and the analytical framework. According to Dubois and Gadde (2002), the way boundaries in the empirical world are expanded is of major importance because this determines what will be found. In the network context it is common or natural to study interaction between several supply chains and distribution channels of a certain industry. In this thesis, two case studies of networks surrounding two focal actors have gradually emerged as the theoretical frame of reference and their collected data interacted. Both case studies provide empirical descriptions of how product recovery can be organised by disposing/supplying, collecting, sorting, reprocessing and redistributing firms.

First and foremost, two case studies have been empirically identified, owing both to the different periods when data collection took place, and the intention to highlight variety from the disposer’s and the reprocessor’s perspective. The case study description from the disposer's (VGR's) perspective was finished towards the end of 2010, while the case study description from the reprocessor's perspective was finalised in the autumn of 2011.

As stated above, the first case study is about the disposal and handling of used PCs from organisational units of Region Västra Götaland (VGR) in Sweden. It describes how VGR has organised the handling of its obsolete IT-equipment with its partners. The second case study demonstrates how a distributor of new IT-products, Atea Logistics, works together with its customers, suppliers and other parties in product recovery, with a focus on handling used PCs.

In accordance with the discussion of Handfield and Melnyk (1998), I employed a few focused multi-site case studies in order to develop theory by identifying and describing key variables or concepts and linkages between these. Thus, organising of product recovery is elaborated upon and scrutinised in the activity pattern, resource constellation, and the web of actors. Moreover, from the theoretical viewpoint, the selection of case studies was based on the concept of transvection and its focus on the object. In other words, the object, the PC, was the focus of the analysis of empirical findings through the application of all three layers of the Industrial Network Approach in this thesis. The PC industry was selected at the beginning of the study, as the decision to contact actors involved in this business was influenced by the article about business-to-business marketing and sustainability (Sharma et al., 2010).

Although, Denscombe (1998) and Eisenhardt (1989) state that multiple case studies strengthen the chain of evidence and increase the generalisability of conclusions drawn, the aim of the two conducted case studies was not so much in drawing general cross case conclusions, as to also illustrate variety in the organising structures associated with product recovery arrangements. Variations in transvections or the activity structures of both case studies related to principles of postponement/speculation, activity interdependencies, alternative product recovery options, and the involvement of different types of actors. As regards the resource dimension of the ARA model and the 4R model, two different objects were analysed: a desktop in the case study from a disposer's perspective and a laptop in the case study in which the reprocessor was a focal actor. In the actor layer, the centre of attention was to a minor extent on a particular product, compared to other two layers. This meant that analysis focused on how behavioural factors such as the level of involvement, positioning of actors, cooperation, and competition influenced the overall efficiency and effectiveness of activity coordination and resource combining and recombining.

To summarise, both empirical observations and the analytical framework gradually influenced the bounding and selection of case studies. This interplay between the case and the framework, called systematic combining, is discussed in the next section.

3.2.2 Systematic combining – an abductive approach to case research

As to general research approach, there are two methods which are each other's counterpoints: the inductive and the hypothesis deductive method (Wallén, 1996). The choice of research method concerns the interplay between theory and empirical findings. Induction means making general and theoretical conclusions on the basis of the material gathered. In contrast, the hypothesis deductive method is an approach that creates theoretical hypotheses and tests them against the empirical findings to see whether they can be verified.

In this study, a combination and iteration of the inductive and the hypothesis deductive approach, abduction is used. Abduction means alternating back and forward between theory and the empirical findings (Alvesson and Sköldberg, 1994). The authors cited also argue that abduction reflects the true nature of the research process in comparison to induction and deduction.

Systematic combining (Dubois and Gadde, 2002) is an abductive approach to case study research process where empirical findings inspire successive changes of the view of the theory concepts and vice versa. This results in a continuous reorientation of the analytical framework and research issues. Systematic combining emphasises two main processes that affect the research process through continuous interaction between the case study, the analytical framework, the empirical world, and the theory. These two processes, depicted in Figure 3.1, are *matching* and *direction and redirection*.

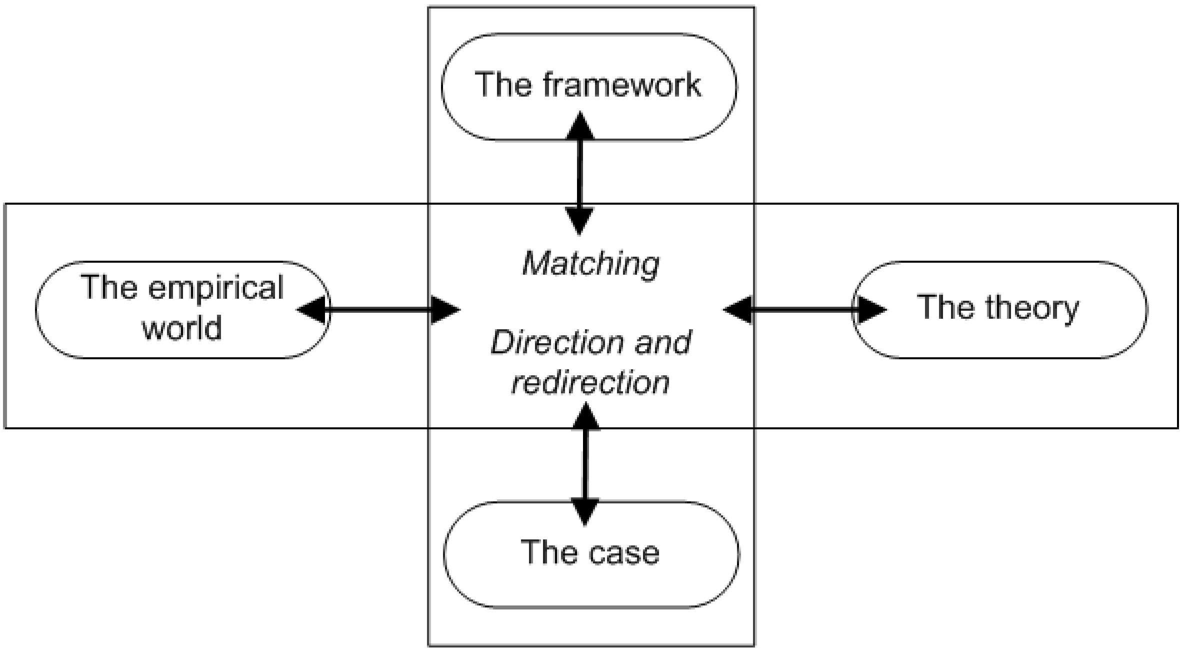

Figure 3.1 Systematic combining (Dubois and Gadde, 2002).

Matching between the development of the case and the framework is dependent on the matching between the empirical world and the theory. This process of matching is connected to the direction of the study or in other words the development of the course or focus of the study. Direction/redirection refers to continuous changes in a researcher's view of reality that can elucidate new research issues. This process is, in turn, facilitated through the matching process (ibid.).

As outlined in the section on the actual research process, I read the current literature about sustainability and business relationships, reverse logistics, and the Industrial Network Approach before conducting the initial interviews. More precisely, the work of this project started with an initial exploratory literature review of the Industrial Network Approach, in order to establish a platform that would enable me to identify the structures and patterns related to organising product recovery in the field. At the beginning of the research process, I conducted literature studies on the Industrial Network Approach, which was the theoretical base of the study in accordance with suggestions of Dubois and Gadde who argue that theoretical underpinnings or the analytical framework of the study is one of the cornerstones of systematic combining (ibid.).

Then, after the first literature review on reverse logistics and Closed Supply Chain Management, I decided to integrate the concept of transvections and the concept of the object into the frame of reference. The reason for this addition of analytical tools in the framework was the fact that the concept of transvection grouped all activities into two fundamental processes - sorting and transformations. This made me aware of the importance of sorting during the initial interviews, and as my literature studies on reverse logistics continued. These first interviews also contributed to the application of concepts and analytical tools, such as the 4R model, and resource tensions and adaptations as they were recognised to be relevant in the empirical world. An example of the tensions was displayed in the troublesome dismantling operations. As mentioned earlier, during the development of case studies, I noticed that the features of relationships influenced activity coordination and resource combing, which led to studies of the behavioural dimensions of the actor layer of the Industrial Network Approach, in general, and with regard to product recovery, in particular.

In summary, the theoretical framework and the case studies of this thesis have emerged through interaction between reality and the theoretical assumptions. The acquisition of theoretical knowledge and analytical tools occurred simultaneously as the empirical observations of reality took place through interviews, observations, study visits, and documents. Just how these empirical observations were collected is described in the following section.

3.2.3 Collection of data – primary and secondary data

Creswell (1994) describes a qualitative case study as an inquiry process, conducted in a natural setting with the intention of understanding a social or human problem, through building a complex, holistic picture, formed with words, and reports of detailed views of informants. Arguing for a combination of the Industrial Network Approach and case study research approach, Easton (1998) recognises that studies of complex intertwined layers of actors, resources and activity links across organisational boundaries require the collection of multiple forms of data that cannot be easily standardised or aggregated as in quantitative research design. In addition, various combinations of quantitative and qualitative data collected from interviews, databases, archives, and observations represent one of the strengths of the case study approach (Eisenhardt, 1989). Thus, in this thesis, both quantitative and qualitative data have been collected and analysed.

Besides grouping the data in a qualitative and quantitative form, information that has been collected during a research project can be classified as either *primary or secondary data* (Arbnor and Bjerke, 1994). *Primary data* are the data collected for a certain purpose, for example, information from interviews which will be used for a certain study. Methods of primary data collection are observations, interviews and experiments (ibid.). *Secondary data* is information that is often produced for a reason other than the purpose of the current study. Examples of secondary data include information from literature, earlier research, and official statistics. According to Yin (2003), there are two types of secondary data, namely documentation (e.g. memoranda, agendas, minutes of meetings, administrative reports, formal studies, newspaper articles) and archival records (e.g. organisational charts and budgets, maps, personal records, survey data).

The possibility of using several data collection methods and sources during a study is one of the greatest advantages of the case study research strategy (Denscombe, 1998). Therefore, several sources of data, both primary and secondary, have been utilised in this investigation. A case study can include data from public and private archives, as well as from direct observations and systematic interviewing (Leonard-Barton, 1990). A similar classification is made by Bryman and Bell (2007) who state that qualitative collection of data is conducted by interviewing individuals or groups, observation and collection of texts and documents.

To achieve the purpose of the study, product recovery arrangements in networks disposers, collection and transportation companies, reprocessors (e.g. recyclers or remanufacturers) and intermediaries, have been examined. As illustrated in Table 3.1, information regarding the resources and activities that these actors handle has been collected via interviews, participative observations, and through the study of documents or secondary evidence.

3.2.4 Secondary data

Yin (2003) explains that different data collection methods and the use of primary and secondary data in case studies is one of the strengths of case studies. These data can be gathered from documentation, interviews, physical artefacts, archival records, and direct observation. Documents are most often accessible as texts (in printed form), but they can also be in the form of an electronic file (Flick, 2009).

In this thesis, the main source of qualitative and quantitative data in terms of secondary data have been administrative reports, formal studies, newspaper articles and archival records such as organisational charts, process maps and administrative lists. It has been interesting to note how these charts and procedures only mirror general description of processes, whereas reality exhibits a large number of modifications in the resource and activity structures that are done on a daily basis. Another disadvantage of secondary data is that these documents are produced for other purposes than to research a particular issue (Yin, 2003).

3.2.5 Observations

Direct observation usually means live observations of current events (Flick, 2009). Less formal, direct observations can be made during interviews or field trips. Non-participant observation enables the observer to find out how something factually works or occurs (ibid.). The observer can obtain a clear picture of social behaviour without a large amount of interacting with people. Participant observation is a type of data collection where the researcher is not a passive observer, but assumes a role in the studied sequence of events. The observation periods might be a problem for the observer since he/she has to select or be invited to the places where the process of interest can be observed, on the dates when this can occur (ibid.).

During my research I have studied different processes such as reprocessing, delivery of new and collection of old products. For a number of hours on several occasions I studied the delivery of the new products and collection of the used products. I even performed some minor setting up of the products (i.e. PCs) on site in addition to conducting observations of a more passive type in storing, transporting, and reprocessing products. Regarding the rest of the actors such as managers, which I interviewed, it can be said that they usually had a span of time from one to three hours of time available to do interviews, which explains why the participant observation was not a possible type of observation to a larger extent on every occasion. Most of observations have been confirmed by additional data via personal contact, e-mail, and telephone.

3.2.6 Interviews

Interviews can be structured, unstructured, or semi-structured (Bryman and Bell, 2007; Yin, 2003). As the research process of this thesis progressed, the interview questions became increasingly structured. Although this has not been a completely linear process, interview guides became more focused as the work with the case studies and the theoretical frame of reference proceeded. In other words, the topics that were discussed became more focused, deeper and narrower, as I got a better grip of my interest and the issues that were relevant in the field. However, I still tried to be open-minded in order to perceive facts that I had not been focusing on. I therefore tended to eschew questions with a small number of answer alternatives, and instead formulated my questions so as to be able to take notice of new and previously unnoticed data (Wallén, 1996). Instead, I tried to ask people to describe situations and processes with regard to information and goods handling. This also gave me an opportunity to adapt the sub-questions to each individual interviewee, who would thus be answering more nuanced questions (Bryman and Bell, 2007). These more open, semi-structured, but focused questions gave me a better position to ask deeper questions on the same subject.

During this research project I discovered that I had to create more structured interviews. As I was neither employed by a company nor involved in collaborative action research, on most occasions, I was given a relatively short time to interview my subjects. This was especially the case with the firms that were not the focal actors of the case studies. Therefore, in this study, I tried to read secondary evidence prior to the visit, ask semi-structured, focused but open questions during the interview, and collect as much of the secondary evidence as possible. In addition, my intention was to collect the data from several organisations in the network surrounding the focal actors in both case studies in a fashion that could be called a snowballing interview strategy. This strategy involved framing interview questions and discussion topics in a process that leads to observations which may generate new questions and dimensions to the subject on which further interviews could be based (Dubois and Gadde, 2002).

Distributed among two cases, Table 3.1 illustrates the categories of interviewed organisations, positions of the interviewees, the type of data collected about the firm and its network, and how data collection was conducted. In total, I conducted 30 interviews with 17 organisations in 2009 to 2011. Of these 30 interviews, 25 interviews with 13 organisations and 33 persons were included in the chapters that deal with empirical findings as I decided to focus on the PC industry during the research process. Each interview lasted approximately 1-2 hours, with the shortest interview lasting thirty minutes and the longest, three hours.

	Organisation category	Organisation	Position(s) of interviewee(s)	Data collection		
				Interview	*Secondary data*	*Observation*
The case study from a disposer's perspective	PC manufacturer	Dell	Sales Manager, Environmental Manager	Personal, telephone	Yes	No
	LSP[19]	Schenker	Sales Manager	Personal	Yes	No
	Recycler	Renova	Managing Director, Operations Manager	Personal	No	Yes
	Distributor	Infocare	Service Manager, Repair Service Manager, Sales Manager, Technician	Personal	Yes	Yes
	LSP	IT Logistics	Managing Director, Logistics Manager, 2 Drivers	Personal	Yes	Yes
	Refurbisher	Igus Data	Managing Director	Personal	Yes	Yes
	Distributor	ReuseIT	Sales Manager	Personal	Yes	No
	Disposer	Västra Götalands Region	Exchange Coordinator/IT Strategist, IT responsible employee, IT Technician	Personal	Yes	Yes
	Collector	SITA	Sales Manager, Transport Manager	Personal	Yes	Yes
The case study from a reprocessor's perspective	Distributor, Refurbisher	Atea Logistics	Logistics Coordinator, Operations Manager, Recycling and Logistics Manager, Implementation Manager, Configuration Manager, Sales Manager, Service Manager, Managing Director	Personal	Yes	Yes
	LSP	Schenker	Service Manager, Logistics Coordinator	Personal	Yes	Yes
	Collector	Eurovironment	Managing Director	Personal	Yes	Yes
	Broker, Refurbisher	Inrego	Quality Manager	Personal	Yes	Yes
	Broker,	Once Again	Managing Director	Personal	Yes	No

Table 3.1 Overview of data sources.

In most cases I booked interviews by phone so that interviewees would be familiar with the issues I intended to cover, before the interview took place. The interviews usually began with the presentation of the project and my research area. During the interviews, the informants were asked to describe processes and physical and information flows with regard to their partners on the supply and demand sides. Issues discussed also concerned cooperation between logistics service providers and consignors and consignees. I took notes during half of

[19] Logistics service provider

the interviews, and taped the other half. As soon as the interviews were transcribed, I sent the transcripts to the interviewees and corrected the material in line with their comments.

3.3 Evaluation of the research quality

In order to evaluate the quality of research influenced by qualitative methodology, Lincoln and Guba (1985) propose the concept of trustworthiness. The main issue in evaluating the trustworthiness of a study is how the researcher can convince *"his or her own audiences (including self) that the findings of an inquiry are worth paying attention to, worth taking account of"* (p. 290).

Several researchers in the Industrial Network Approach tradition have assessed the quality of their work by applying the concept of trustworthiness (e.g. Holmen, 2001; Hulthén, 2002; von Corswant, 2003; Skarp, 2006; Lind, 2006). These studies have used four criteria proposed by Lincoln and Guba (1985) in order to evaluate the trustworthiness of research: credibility, transferability, dependability, and confirmability. All four of these criteria are described in greater detail below, as they relate to this thesis. Credibility will be discussed first as it is considered to be the most significant criterion for the trustworthiness of the study.

3.3.1 Credibility

There are seven processes that can *"make it more likely that credible findings and interpretations will be produced"* (Lincoln and Guba, 1985, p. 301). These activities include prolonged engagement, persistent observation, triangulation, peer debriefing, negative case analysis, referential adequacy, and member checks. Negative case analysis, which is associated with the testing of hypotheses, is not elaborated upon here, as the aim and the abductive nature of this research has not been to revise or propose hypotheses. Therefore all of these sub-criteria, except for negative case analysis are discussed in relation to the research process of this thesis.

Prolonged engagement addresses the sufficiency of time spent in the empirical inquiry so that a broad understanding of the phenomenon in focus can be achieved (Lincoln and Guba, 1985). As I had a network perspective on the phenomenon as a focus of this study, I did not consider it to be a primary goal to spend a lot of time in studying single companies, (i.e. the focal actors of both case studies). Instead, I tried to understand how various other firms around the focal actors cooperate to coordinate activities and combine resources. This meant that a connection to a given actor was not the objective. Although data collection for both of the case studies was separated, it was more or less continuous from the perspective of the phenomenon in focus. In addition, the analysis of data and the development of the framework were carried on continuously.

Persistent observation refers to gaining a sufficient depth of the context investigated through the identification of the most relevant aspects of the phenomenon studied. I identified the concepts of transvection and sorting as central in the early phase of the research process as they could continuously be observed directly from empirical findings, during the entire data collection process. This was also the case with the 4R model and resource adaptations or tensions, which could be spotted in the field. This was done in both case studies. With regard to the actor layer of the Industrial Network Approach, I had to frame the empirical findings through theoretical concepts that I acquired towards the final stage of the research process. Thus, it is important to note that the analytical tools had an impact on how I viewed the empirical world with regard to transvections and the 4R model.

Triangulation is usually suggested as a technique for cross-checking data in order to enhance the credibility of a study. For, example trustworthiness of empirical findings may be secured by combining quantitative and qualitative methods (McKercher, 2000). Even though I cross-checked some information given to me by various actors in the network for the sake of logical coherence (Meredith, 1998), the primary aim of data collection from multiple sources in this study was to gain a broader and deeper understanding of the phenomenon, in agreement with the abductive approach (Dubois and Gadde, 2002) adopted in this study. Thus, in order to compensate for lack of primary data from some firms, I used data from the interviews with their partners, articles, websites, and other kinds of secondary data.

Peer debriefing is defined by Lincoln and Guba (1985, p. 308) as a *"process of exposing oneself to a disinterested peer in a manner paralleling an analytical session and for the purpose of exploring aspects of the inquiry that might otherwise remain only implicit within the inquirer's mind"*. There was no formally appointed peer during the course of this study. Nevertheless, parts of the analytical framework and empirical findings have been presented at seminars, workshops and conferences in order to provide an external control for the inquiry process. This process also inspired the development of the case studies and the frame of reference.

Referential adequacy refers to keeping collected data as 'raw' as possible so that the readers can draw their own conclusions. The empirical enquiry of this thesis can be interpreted and analysed in alternative ways since I tried to avoid using theoretical concepts and analytical tools associated with different layers of the Industrial Network Approach, for example, in my case descriptions. On the other hand, as all data collection is influenced by the theoretical background of the researcher, I cannot claim that information presented in chapters on empirical findings could be regarded as the absolute and objective truth. In addition, I selected and analysed the data several times before completing the final version of my case description (Dubois and Gadde, 2002).

Member checks, is an activity contributing to the establishment of credibility. It usually means that the collected empirical material is validated by the respondents (e.g. interviewees). Case descriptions have been sent to informants. Some have chosen to make comments on the written material, while others did not. In accordance with the guidelines provided by the interviewees, I made revisions of the material. To ensure that the perspective of the informants is accurate, follow-up interviews, telephone conservations, secondary data and written correspondence were used.

3.3.2 Transferability, dependability and confirmability

Transferability signifies the scope to which actors can apply the empirical findings and concepts in contexts other than those for which they were originally developed (Lincoln and Guba, 1985). This concept parallels theoretic generalisability or what Yin (2003) terms as "analytical generalisation", which is the ability and potential to applying theory based on a certain case study to other contexts. In order to establish transferability of the thesis, I believe I have provided a 'thick description' which enables *"someone interested in making a transfer to reach a conclusion about whether transfer can be contemplated as a possibility"* (Lincoln and Guba, 1985, p. 316). Although this thesis is under a major influence of the PC industry, I do not consider conclusions in this thesis to be only limited to the context of product recovery arrangement in the network. With respect to the theoretical framework, one of the theoretical contributions of this thesis refers to connecting the concept of transvection to the product recovery structures. Another theoretical contribution relates to the analytical framework, which integrates all three layers of the Industrial Network Approach. From an analytical perspective, I believe that this framework can be used to analyse other types of business networks, as well.

Dependability, which relates to *"examining the process of inquiry"* (ibid., p. 318), has hopefully been attained, as I have tried to describe theoretical and empirical development of the research process. The reader has been provided with an illustration of issues that arose and the ways they were handled, on a fairly detailed level. I outlined as fully as I could the progression of work with this thesis and how the approach of systematic combining inspired continuous interplay between the theoretical framework and the empirical world.

Confirmability concerns the evaluation of the extent of consistency of the used concepts, findings and data (Lincoln and Guba, 1985). My belief is that this thesis displays coherence between different parts and chapters as the empirical findings and analytical tools and concepts have been matched. Indeed, I believe that there is a consistency in the study, as I tried to select concepts and data for this purpose in line with the spirit of systematic combining (Dubois and Gadde, 2002). To conclude, I hope that that the combination of the collected data, data collection methods, analytical frameworks and conclusions in this study are found to be inter-subjectively reasonable to other people in academia and practice.

4 EMPIRICAL FINDINGS

This case description illustrates how a large provider of IT equipment, Atea, takes an active role in handling the challenge of the disposed goods for firms and other types of organisations. The company's internal logistics coordinator, Atea Logistics, is described with a focus on the product recovery services that it offers to disposers. Atea Logistics's partners in logistics operations, product classification and distribution of obsolete items and refurbished products are described in this part of the chapter as well.

4.1 Atea Group

The Atea Group is one of the largest providers of IT-related products and services in the Nordic and Baltic region. With its local presence in 80 cities in Norway, Sweden, Denmark, Finland, Lithuania, Latvia and Estonia, Atea Group is a major player in the distribution and sales of new IT-products. In 2010 Atea Group had revenues of approximately NOK 17 billion. The whole group has approximately 5,400 employees.

Atea Group delivers IT products from leading vendors, and assists end-users with specialist competencies associated with IT infrastructure. IT infrastructure offerings include a range of product and service arrangements. In cooperation with its suppliers, and its internal distributor, Atea Group manages logistics processes related to PCs, servers, mobile phones, printers, monitors, and other similar goods within the electronics industry.

4.2 Atea Logistics

Atea Group's internal distributor, Atea Logistics, is a firm responsible for coordinating physical distribution with other external logistics and transportation companies. An example of logistics services provided is the inventory of products and spare parts it maintains. For this purpose Atea Logistics has control of strategically placed warehouses on a national and local level in Sweden and other Nordic countries. One function of the local inventories is to enable short-notice deliveries of spare parts and products.

Atea Logistics's agreements, close dialogue and well established relationships with suppliers, internal sales companies, and logistics service providers, promote efficiency in its distribution activities. In addition, close partnerships with the sales companies facilitate effective provision of demanded product assortments. The sales companies also market Atea Logistics's distribution services, which include materials handling and transportation of electronic waste and used IT equipment. Thus, Atea Logistics works more closely with the sales companies than with the disposers themselves.

Atea Group's sales companies have their own management and a high degree of autonomy within the group. Sales consultants, for example, are allowed to buy various products and services from firms in addition to Atea Logistics. This policy, called "country is king", implies that a sales company can choose any other available supplier (either manufacturer or a distributor/logistics provider) with similar capabilities outside of the Atea sphere.

According to the managers at Atea Logistics, there are advantages and disadvantages of such an arrangement. By putting pressure on each firm, this policy leads to an overall cost reduction, keeping Atea Logistics alert to improvements and new kinds of services provided by other companies in the industry. On the other hand, competitors are aware of the fact that they cannot charge Atea Group's sales companies much more than Atea Logistics does. Atea Logistics is still the main logistics service provider of Atea Group's Swedish sales company. Furthermore, Atea Logistics is also a business partner of many competitors of Atea Group that procure distribution services from the company. In this manner, competing and cooperating actors can be involved in combined solutions for forward and reverse physical flows. Representatives from PC manufacturers and Atea Group, for instance, may work out solutions for the handling of electronic waste, jointly with end-users.

A recent development in the relationships between PC manufacturers, Atea Logistics and end-users is the establishment of direct connections between these entities. In other words, hardware is nowadays sold directly to the end-users, while product-related distribution services are procured separately from Atea Logistics. These relationship constellations have led to diminishing profits for Atea Group which no longer makes a profit from the sales of the physical products. These trends and developments have turned Atea Logistics into a more service oriented company.

4.2.1 Atea Logistics's involvement in product recovery

Atea Logistics decided to go into the recycling and product recovery business in 1998, as a result of legislation that required the establishment of logistics systems for recycling of electric and electronic waste. Currently, Atea Logistics works closely with various actors who are responsible for handling of used electronic equipment. Thus, besides providing new equipment to end-users, Atea Logistics also offers different kinds of product recovery services, such as the marketing of used units, refurbishing, and recycling. Figure 4.1 portrays actors and various physical flows from disposers to new end-users or recyclers, which are described in depth in this chapter.

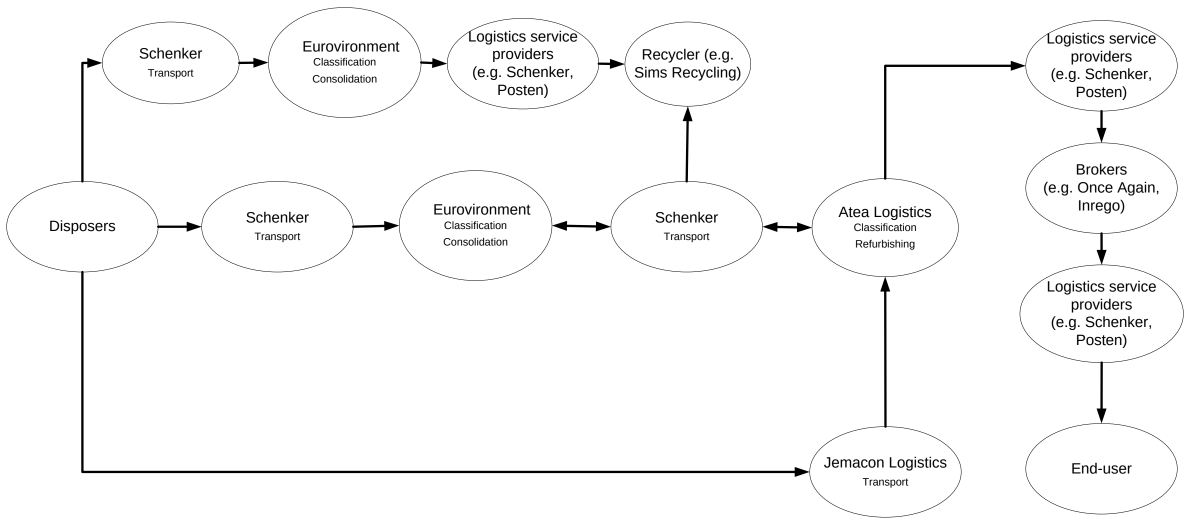

Figure 4.1 Schematic overview of actors dealing with the physical flows of used products.

Most of organisational disposers face the challenge of getting rid of obsolete IT equipment in an efficient way. In addition, a purchasing or IT department invests most of its resources in procuring new equipment. Consequently, they do not have as much time and resources to carefully administer the administration of logistics services related to the handling of used and obsolete products.

In order to make disposers' administration of used products as efficient as possible, Atea Logistics has developed a uniform pricing policy for Swedish disposers. This means that a logistics service package for handling the used equipment has a fixed price, regardless of where in Sweden it is ordered. Prior to this arrangement, Atea Logistics bought all used products and then sent the information about costs that were incurred in the logistics and renovation processes, thus creating unnecessary accounting troubles for the disposers. At present, when the logistics and refurbishing/recycling costs have been accounted for, a disposer can receive a partial refund depending on the current demand for their used products. To facilitate payment to disposers, Atea Logistics has a list of prices associated with the product specifications, which is updated once a month by the sales manager.

A number of large companies and public organisations have made significant progress in the efficient administration of orders for combined delivery and collection of products. This is reflected in efficiencies from the geographical proximity of several departments within the same organisation, and the homogenisation of hardware and software requirements to 2-6 standards, for the whole organisation. As an example of efficient purchasing of collection services for used products, and the handling of orders for new units, some disposers have only two standards with regard to hardware. Furthermore, organisations are beginning to have a clearer picture about the exact placement and the age of their IT-related products. This enhances the opportunities for Atea Logistics to achieve economies of scale in administration, order handling, sorting, storing and transporting goods during collection and logistics of used products and delivery of new units.

As many PC assemblers have a warranty and/or leasing period of three years, some of the disposing organisations have realised the benefits of organising regular replacement programs on these three or four year cycles. Complete integration of the logistics management for new and used/obsolete equipment is not possible yet, because many organisations cooperate with different companies regarding the delivery of new equipment and the collection of used products. When PC manufacturers sell new products on their own, they instruct the disposers to contact their partners in product recovery for logistics management of the used units. This diminishes the opportunities of Atea Logistics to increase market shares in services related to the handling of these used products.

4.2.2 Handling of used equipment at the disposer’s site

Disposers have a range of options for the collection of used products. In principle, there are two alternatives that can be clearly distinguished. Some disposers order the collection of used goods separately from placing the orders for delivery of new units. Others have predetermined cycles of product replacement, during which synchronised collection of the used products and the delivery of the new products occurs.

When disposers order collection of obsolete equipment and delivery of new products separately, the logistics service provider employed by Atea Logistics delivers the load carriers to the disposer’s site. Here, load carriers are filled with obsolete items. Disposers are allowed to retain the load carrier from Atea Logistics for a maximum of two weeks as Atea Logistics has a limited number of load carriers (1,000 cages/boxes) which need to be returned for other collection projects. In order to secure the regular return of load carriers, Atea Logistics has a system that sends automatically generated messages to the disposers, reminding them to order collection within 2-3 days. Otherwise, if they are not finished with the filling of the carriers, disposers are required to pay a fee for retaining the carrier for a longer time than stipulated for the service package purchased. This situation is normally caused by misunderstandings about the state of the products in the disposers’ possession.

In contrast, close collaboration and extensive information sharing among actors involved in forward and reverse flows, for example, enables Atea Logistics to send a checklist in the load carrier, which can serve as a means of instructing disposers to fill the cages correctly. These data were first stored in Atea Logistics’ information systems when the products were delivered as new. This kind of system is still underdeveloped, and Atea Logistics are putting effort in designing improvements in the system, which would further enhance the convenience of disposers in handling of their electronic waste. An organisation that does not have organised information enabling the localisation and tracking of the IT equipment would particularly be assisted by this type of information technology.

Atea's sales companies are continuously trying to communicate to the disposers how to use different product recovery services, in order to eliminate problems in the inspection and categorisation of products at Eurovironment[20]'s hubs or Atea Logistics' reconditioning facilities. There are even written manuals on how to handle the products to be disposed:

- The heaviest components, such as, desktops should be placed at the bottom of the cage or a load carrier, whereas monitors and accessories should be placed on top of the desktops for maximal stability.
- Disposers and collectors are advised to use packing, wrapping and/or cardboard to immobilise the equipment during transport, in order to avoid damage. The screen surface of TFT-monitors, for instance, is pressure sensitive, and it is recommended to pack these units in foam plastic or bubble wrap.
- Accessories such as mice, adaptors, and keyboards should be placed in separate smaller packages in the cage to prevent the equipment from becoming tangled in cables and cords.
- Load carriers could preferably be placed close to a wide exit that does not have raised thresholds. Furthermore, a manual pallet truck should be made available to make it easier for the driver to collect the goods.

Atea Logistics tries to remind and inform the disposers about the classification rules when they order the services for taking care of obsolete or unwanted products. These instructions are provided to prevent disposers from placing obsolete equipment in load carriers intended to carry goods destined for refurbishing and sales. This is one of the reasons why approximately 30-50 percent of goods coming to Atea Logistics' facilities are inappropriate for refurbishing. These items are therefore transported to refurbishing facilities and then to recycling facilities, instead of being sent for recycling from the start. In order to decrease unnecessary transportation of products that should be sent to recycling facilities from the start, Eurovironment[21] and Atea Logistics are planning to develop a more thorough process of preregistration and testing at Eurovironment's facility in Enköping.

4.2.3 Atea Logistics's product recovery services

Atea Logistics has an assortment of four basic standardised sets of logistics processes, which are designed to handle disposed electronic equipment. These standardised arrangements are called LOOP services, and are more or less adaptable to the varied needs of disposers.[22] For an overview of the content in different LOOP services, see Table 4.1.

[20] A logistics firm dealing with the physical flows of used products. See section 4.6 for a detailed description of the company.
[21] An actor specialising in coordination of logistics regarding obsolete products.
[22] There are actually two or three LOOP services in addition to the mostly standardised four ones.

The kind of LOOP service appropriate for a given disposer depends on a number of factors, such as the status of the product that is to be recovered, and security issues regarding the protection of sensitive information. LOOP1, LOOP2, and LOOP3 do not normally involve any delivery of the new products, while LOOP4 is an arrangement for integrated delivery of new products and pickup of used units. This is done with load carriers on wheels, which are used in both directions in order to increase vehicle fill rates during the backhaul. In LOOP1, LOOP2, and LOOP3, load carriers are transported to the disposers, by Schenker, before the load carriers are filled with the used and/or obsolete products.

LOOP services and processes	LOOP1	LOOP2	LOOP3	LOOP4
Pickup Pickup and transport of equipment from your location.	Yes	Yes	Yes	Yes
Environmental handling Optimised environmental handling of equipment – recycling of 99.7 % and correct disposal of 0.3 %.	Yes	Yes		Yes
Quality control Quality control according to ISO14001 and ISO9001 standards.	Yes	Yes		Yes
Sorting and classification Sorting equipment - separating scrap from functional units.		Yes		Yes
Asset information/reporting Asset reporting on all equipment, i.e. volume and weight for scrap and serial no's, inventory no's etc.		Yes		Yes
Information security/data erase Erasing all digital information in equipment using Blancco certified software or degaussing using Ibas (erases media using an extremely powerful electromagnet). The unit cannot be operated after being degaussed; the data is totally beyond salvage.		Yes		Yes
Reconditioning Removal of all corporate identification and labels not related to the equipment itself. Customised production processes are used to remove visible information, depending on the type of equipment.		Yes		Yes
Steel cage transport Transport in special steel cages. Maximum weight: 500 kg.	Yes	Yes		
Steel box/container for secure transport Equipment is transported in specially designed steel boxes for secure delivery. The boxes are locked for the entire journey so the contents cannot be identified.			Yes	Yes
Handling in a high-security warehouse The recycling centre offers high-security warehouse facilities.		Yes	Yes	Yes
Handling by authorized employees Equipment is handled by authorized personnel only.		Yes	Yes	Yes
Purchase of operating units/reimbursements Administrating and purchasing functional units that still have a market value. The customer receives reimbursement when the equipment has been resold.		Yes	Yes	Yes
Synchronised delivery and return Returning used IT equipment in the same carrier that delivered the hardware including unwrapping of all new hardware.				Yes

Table 4.1 Overview of the content in different LOOP services.

LOOP services are a result of the corporate policy for the standardisation of processes. These standardised services are continuously developed in cooperation between disposers, Atea Logistics and its partners. The purpose of the standardisation policy is to avoid drawing similar process maps and corresponding checklists, each time a disposer orders a comparable service package. Current procedures may be rearranged so that tasks can be added to or removed from the existing process maps. In this manner, every standardised solution gets an article number with an accompanying checklist and a process map, which are stored in the information system.

LOOP1 is mainly utilised for obsolete products that do not contain any sensitive information. Often firms regard the handling costs, such as classification and disposal, as higher than the actual storage costs. LOOP2 is used when the disposer has IT equipment that is no longer used, but is still functional. It can also be that the disposer is uncertain about what is to be regarded as scrap and what can be reused. LOOP3 is used when a higher level of security is needed, such as during the handling of PCs containing personal or organisational data, which is the reason for substituting the steel cage used in LOOP1 and LOOP2 with a locked steel box. This box can fit 50 laptops or 25 PC desktop units. The disposer keeps the steel box for ten days instead of five. In LOOP4, a specially designed steel cabinet is used. The steel cabinet fits 30 laptops or 16 PC desktop units, which are delivered to the disposer with unwrapped new equipment. Then, the disposers themselves or a logistics service provider, Jemacon Logistics[23], unpack the steel box and fill it up with obsolete equipment. This method of organising the collection means that the box is filled both when delivered and returned from the disposer, something that leads to less transportation as a whole.

Each of the LOOP services involves specialised types of load carriers, adapted to such features as the state of the product, information security and the number of units disposed. The purpose of these specialised load carriers is to make materials handling ergonomic and efficient, minimise transport damage, and guarantee the safety of the information stored in the IT equipment. Table 4.2 illustrates characteristics of load carriers and their association to LOOP arrangements.

Load carrier's feature	LOOP1	LOOP2	LOOP3	LOOP4
Size (width x depth x height – in cm)	80 x 120 x 180	80 x 120 x 180	120 x 80 x 180	120 x 60 x 195
Maximum capacity (in kilos)	500	500	400	350
Capacity – PC SFF (in units)	55	55	50	30
Capacity – PC Desktop (in units)	40	40	25	16
Capacity – Server, PC Tower (in units)	35	35	22	8
Capacity – TFT Monitor (in units)	12	12	24	20
Capacity – Laptop (in units)	60	60	60	60

Table 4.2 Capacities of load carriers in terms of dimensions appropriate for various LOOP services.

The features of load carriers are closely connected to the characteristics of LOOP services. Besides being adapted to the features of the equipment that is placed inside of the carriers, steel boxes/cages are adapted to the standard sizes of trucks and pallets. Moreover, the load

[23] Jemacon Logistics is a specialist in planning and performing synchronised delivery of the new products and collection of the used goods.

carriers with wheels, used in LOOP4 are adapted to Swedish construction standards as the cabinets have to be rolled inside of the buildings and rooms. As LOOP3 and LOOP4 are designed to protect the information stored in the equipment, load carriers associated with these logistics arrangements are closed and locked. This results in a reduced carrying capacity in terms of the number of units that are transported in the cages. Figure 4.2 provides a comparison of load carriers related to different LOOPs from LOOP1 to LOOP4. The first load carrier from the left is utilised in both LOOP1 and LOOP2.

Figure 4.2 Different load carriers adapted to different LOOPs.

Atea Logistics marks every load carrier with an article/order number and a disposer name, to ensure proper identification of information about delivery/collection dates and locations, during transportation and inventory holding. Information stored in order and article numbers enables actors to be updated on the status of the product in the logistics network. Thus, each time an article number is scanned, Atea Logistics receives information about the status of the particular load carrier. This makes it possible to plan the capacity of the refurbishing facility prior to load carriers' arrival.

4.3 Organisation of Atea Logistics's physical flows in LOOPs

The key aspect of the organising at Atea Logistics is about distributing new products to the end-users and delivering the used articles back for refurbishing and/or recycling in accordance with agreed prices. The acquisition of the products can be accomplished in two principal ways. First, and most often, the disposer contacts Atea's sales companies when it has some obsolete equipment they wants to get rid of. Second, in some cases the acquisition and collection of obsolete equipment is coordinated with deliveries of new products.

Depending on how a disposer perceives the status of the products in terms of functionality and information security, one of four LOOPs is selected for the collection of goods. The price for the services is a fixed cost plus a cost per kilo. LOOP1 is least expensive and LOOP 4, most expensive. When a LOOP is ordered, a booking order is sent to Atea Logistics, and an order is sent to Eurovironment and Schenker or to Jemacon Logistics[24], who contacts the disposer for pickup. As mentioned earlier in this chapter Atea's sales companies are the main contact interface with the disposer. Hence, it is the sales companies that administer the orders from the disposers. and forward these to other partners for logistics coordination and production planning of the recycling and refurbishing processes.

The Operations Department at Atea Logistics is responsible for implementing orders from sales companies and providing communication on the content of LOOP services to sales staff. Personnel of the Operations Department forward the order information, translated into standardised procedures, to the technicians. However, different disposer requirements lead to continuous modifications of LOOPs in terms of project administration and logistics coordination. The Transportation Department of Atea Logistics is responsible for logistics solutions together with Schenker, Posten and Jemacon Logistics.

4.3.1 Order handling

A disposer may communicate the order to a sales company by phone or through an IT system. The salesperson then sends the order to Atea Logistics. The order number carries a form that a disposer cannot bypass during the order placement. For example, when a disposer sends an order (s)he must fill in contact information (e.g. address, organisation name) which is needed for logistics planning, and later on for reporting the processes performed on each unit. Otherwise it is impossible to arrange transportation and to bring the products into Atea Logistics's facilities for testing and remanufacturing.

Processes for handling of used products are therefore activated by unique disposer orders, at least with regard to address and date. As a result, operations are generally guided by the orders that are composed of article numbers. Each article number, in turn contains a checklist with the activity description of a particular LOOP service. In addition, article numbers include the data needed for the collection of used goods and distribution of the new equipment. Thus, when technicians at Atea Logistics' facility in Växjö scan article numbers, displayed checklists provide process instructions.

4.3.2 Collection of the used products from the disposers

There is a range of service arrangements related to LOOP services. These are illustrated in Figure 4.3. Four standardised set-ups (LOOPs) are discussed in this section in a detailed manner. These arrangements are organised in cooperation between disposers, third party logistics providers, and reprocessing firms. The reason for illustrating LOOP2 and LOOP3 jointly is the commonalities of the physical flows of these services. Collection of used products in LOOP1, 2, and 3, is managed by Atea Logistics's partners, Eurovironment and

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[24] A specialist in logistics operations involved in synchronized delivery of new products and collection of used goods.

Schenker. Schenker's responsibility is to pick up the box or cage by truck at the disposer's facility, and transport it to Eurovironment's hub in Enköping.

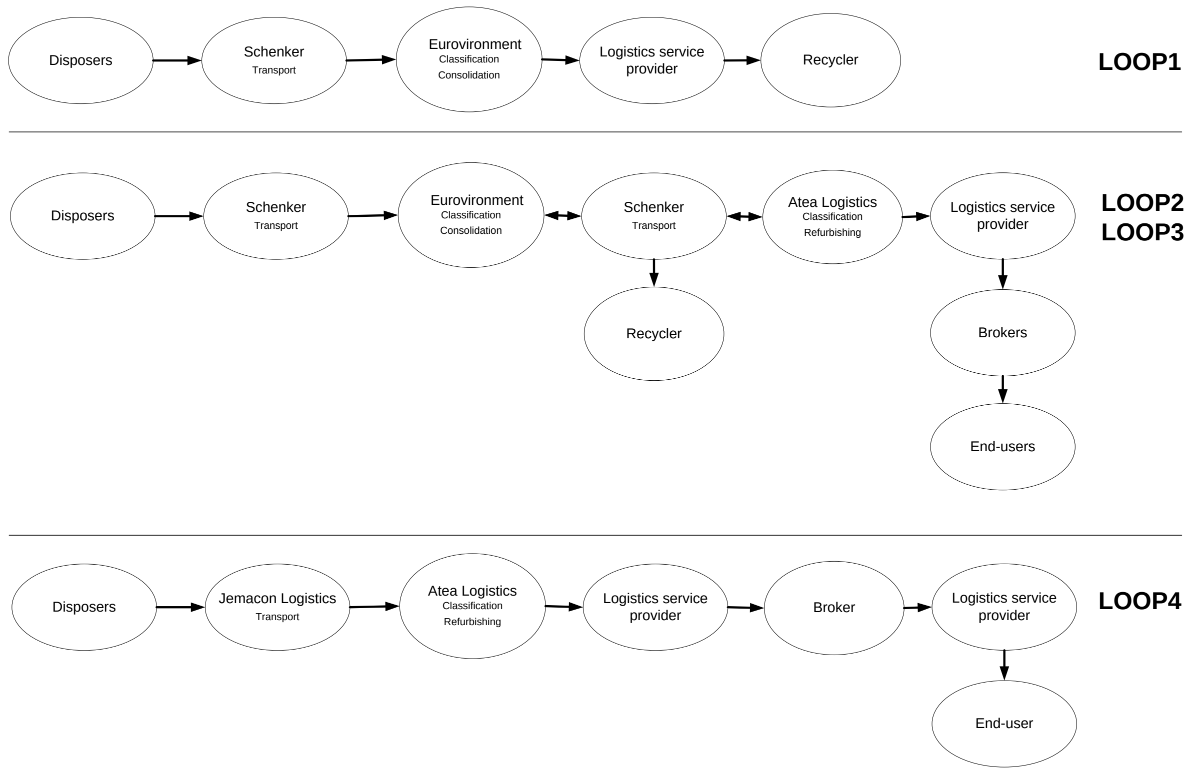

Figure 4.3 Diagram of actors involved in physical flows related to Atea Logistics' four standardised services (LOOPs) aimed at handling of used products.

In LOOP1, Eurovironment contacts the disposer for coordination of the delivery of a steel cage fixed on a EUR pallet. The cage can be filled with a maximum of 500 kilograms, and can fit 60 laptops or 40 PC desktop units. When the cage is delivered to the disposer, it is kept for five working days. The disposer fills it up, and the cage is transported by Schenker to Eurovironment's facilities, where the products are categorised into fractions adapted to the needs of Sims Recycling[25]. Thus, products in LOOP1 never reach Atea Logistics in Växjö as they are completely obsolete and do not contain any information that needs to be deleted. Still, the products are classified into different fractions adapted for the purposes of recycling.

LOOP2 has a lot in common with LOOP1. The most significant difference between these LOOPs concerns the uncertainty about the state of the products (whether the product should be recycled or resold) and the need of the disposer to have information in the products deleted. A disposer orders the collection service via Atea Logistics, Eurovironment, and Schenker. Schenker delivers cages and picks up the goods on the spot, which are transferred to Enköping where Eurovironment makes the first classification of products with regard to

[25] A company which performs recycling, categorisation, and defragmentation of raw materials inside of the used products.

reprocessing alternatives. Those products that are regarded as obsolete and without any information stored inside of them are categorised into 12 groups which are adapted to recycling standards. Regardless of the technological obsolescence of products, all units with stored information must be transported to Atea Logistics' facilities in Växjö for safe data erasure. In Växjö, a more thorough classification procedure is done, resulting in shipments to recycling facilities via Eurovironment or distribution through brokers, depending on the results of inspection.

In LOOP3, Schenker transports locked cages to disposers who fill them up, and then pick up the cages five days later. Eurovironment receives the cages, selects equipment from the cages that are directly passed on to recycling and categorises these items in accordance with appropriate product groups. The products that do not contain any information but are perceived as having sales potential for a secondary end-user are transported to Atea Logistics' facility in Växjö where they are thoroughly tested and possibly sold. If the results of testing show that products cannot be repaired, these items are sent to recycling. All of the products that could contain some kind of disposer created information must be shipped to Atea Logistics in Växjö for secure data erasure. This even concerns products that do not have any expected value for a secondary end-user in a refurbished form. These units are then sent to recycling facilities.

The role of Eurovironment is to consolidate and classify used functional products in LOOP2 and LOOP3 for further transport either to a recycling or a refurbishing facility of Atea Logistics. However, goods that have been classified as refurbishable by Eurovironment and thus arrive at Atea Logistics could still be shipped to recycling depending on the results of inspection performed by Atea Logistics. Almost all LOOPs besides LOOP4 are transported to Eurovironment's hub in Enköping, where the equipment is classified and stored until a full truck shipment to Atea Logistics's facility in Växjö is filled. The turnaround in the logistics network is approximately 14 days, which means that the equipment is stored 14 days prior to its delivery to the testing and refurbishing facility. The trend is toward a decreased turnaround period, since the volume of equipment is increasing, so that the trucks bound for Växjö can be filled up faster.

Synchronised delivery of the new equipment and collection of the used products is part of LOOP4, which is aimed at renovating and redistributing products that can be sold in the same state as they were bought by the first end-user. This service offering involves two alternative arrangements, which are dependent on the number of units. LOOP4 is usually combined with a very large order (e.g. 3,000-10,000 or more units over a longer period of time, such as a year) from a large organisation. The second alternative concerns orders such as for a single day's replacement, which is carried out on short notice.[26]

[26] This service may also be offered to new offices that did not posses any IT equipment previously.

In LOOP4, Atea Logistics unwraps new products from suppliers, installs software, and places the PCs in specialised cabinets on wheels. These load carriers are collected and delivered to individual end-users by Jemacon Logistics. Jemacon Logistics has hubs close to many larger towns in Sweden where products can be stored, distributed and picked up from disposers. An example of a logistics solution for collection of used products involves transportation by small trucks to local inventories and by larger ones to reconditioning facilities of Atea Logistics or other refurbishing firms. LOOP4 service arrangement makes transportation more efficient because there is no need to distribute excessive packaging. Furthermore, this arrangement decreases the amount of unpacking and installing products that disposers would otherwise need to perform at their respective locations.. This way of organising collection means that the box is filled both when it is delivered and returned from the disposer, something that leads to less transportation as a whole.

4.3.3 Operations at Atea Logistics's facility in Växjö

Atea Logistics' facility has a capacity to refurbish 200,000 units of various kinds of IT equipment. Of these 200,000 units, 100,000 are desktops, laptops and PC accessories. Results of several classifications as goods move through the facility of Atea Logistics are crucial for the choice of product recovery option. Due to data protection issues, the equipment in LOOP3 and LOOP4 are handled by authorised personnel in a certain 'security area', separated from the rest of the warehouse.

Order and article numbers that are related to LOOPs are registered by scanning, and stored into the information system. Article numbers are part of an order number which, in turn, can be divided into different pallet position codes. This system makes each product searchable, enabling localisation of products and associated pallet positions in the inventories. An additional function of this inventory system is to place refurbished products headed for the same customer close to each other. This is done in order to minimise the movements of trucks in the warehouse.

As soon as the goods come to Atea Logistics, they are tested and reconditioned or forwarded to recycling. This depends on whether the products are in working order or if they match the requirements of potential end-users. After their arrival to Växjö, products are first sorted by appearance and type into different groups such as monitors, desktops, printers, laptops and desktops. Mice, keyboards, cables, and coffee machines are normally not registered in the Atea Logistics' internal information system in a detailed manner because they do not contain any disposer-created information. Hence, these units are for the most part sent to recycling via Schenker and Eurovironment once a critical mass for economic transportation in standardised load carrier has been reached.

More expensive units (e.g. a desktop or a laptop) have to pass the first test of product categorisation by identifying their processor speed in order to move on further through other stages of renovation. A very slow processor in relation to current end-user requirements is an indication that the product should be put in a load carrier for recycling and sent to a material defragmentation facility. Still, the disposer created data might need to be deleted by the electromagnet Degausser. As this sub-process of data removal by electromagnet is completed, products are placed in the box which is shipped to a recycling facility.

Data in the information-bearing units is deleted through the application of specialised software from Blancco or Ibas, certified by Swedish Armed Forces. As a result of the inability of the software to perform data erasure operations satisfactory, the electromagnet is used to delete all of the disposer created information. Data erasure by the electromagnet makes it impossible to retrieve any kind of information from the product.

If the information in the product has been erased by the software, it identifies the original serial number, defective properties (and parts), and product specifications by comparing them to a test protocol with various technical properties, such as broadband capacity and processor speed.[27] The information about the deletion processes is then sent to the disposer. Product-specific features are made available to the sales staff and brokers through the information system.

Identification of product characteristics serves as a basis for pricing and grading of each unit, regardless of whether it is a printer or a PC. Every unit becomes connected to a grade which is also part of the article number. An industry wide grading system is an aid in decision-making as it outlines four basic letter grades connected to reprocessing options:

- Grade A: Goods that are practically new.
- Grade B: Equipment that is fully functional but missing some components or having very minor flaws.
- Grade C: Products not working, and able to be repaired, or have components replaced.
- Grade D: Units destined for recycling, as they are either not saleable and/or in such a bad condition that refurbishment or repair are not profitable.

Insofar as grades A and B are concerned, most of the companies in the reconditioning business keep themselves updated on the technical specifications associated with these grades. Grades C and D, on the other hand, are not as fixed as A and B, requiring extensive communication between Atea Logistics and its partners in order to settle upon these grades.

When the software for the identification of product attributes has determined the state and functionality of the product, the product is given an internal serial number, which is used for

[27] Both the software and the protocols are regularly updated in phase with launching of new product models.

storage of information about product specifications and their grade. Then, prices, which are provided by the sales manager, are inserted into the article number. More precisely, the refurbishing staffs compare prices and other specifications on the list in order to input the price of the product into the information system, enabling a complete identification of the product for the purpose of selling it to the brokers. Products that can be resold are registered in a protocol form in a database used for the sales of products, deletion and de-identification reports for the disposers. The equipment is then made anonymous by removing stickers with organisational identities, company logos and security marks. This is mainly done by blasting dry ice on the label attached to the product.

The deletion and identification procedures by Blancco, take approximately 30 minutes, which is one of the reasons why Atea Logistics has decided to process several units simultaneously. The test provides Atea Logistics with information on further steps in the processes. As regards equipment that is not reusable, disposers often require that these items be destroyed in a way that makes it impossible to use the unit or extract any data from it. Atea Logistics makes asset reports about all units that arrive at its facility, and Eurovironment provides the information about the weight and volume of recycled materials. Goods passed on to be recycled after several classification points are handled by one of Atea Logistics's partners for recycling, such as Sims Recycling. In 2007, LOOP services reused about 50 percent of incoming units. Out of the other half, 99.7 percent was recycled and only 0.3 percent was sent to a landfill. All products that contain hazardous substances are taken away for special treatment. A part of the material goes to the partner's shredder plants where the equipment is dismantled in order to be able to identify pure metal or plastic parts for further refinement.

If the test results show that the product can be sold to a secondary end-user, some components might need to be exchanged or upgraded. Consequently, Atea Logistics keeps a small inventory of used but working components taken from malfunctioning IT equipment. Moreover, new components coming from other distributors can be installed into PCs. When the units are refurbished they are ready to be sold and distributed. In this context, Atea Logistics tries to match production batches with various sizes of trucks in order to maximise the fill rates.

4.3.4 Atea Logistics' sales of refurbished products

Thanks to well established relationships with brokers, the sales manager of Atea Logistics is able to collect the information for pricing of refurbished products. Atea Logistics's experience has demonstrated that disposers appreciate the opportunity to solve disposal problems, while receiving fixed prices for these units. In contrast to Atea Logistics, many other companies may offer high purchase prices for the collected products and later deduct the costs for testing, reconditioning, and scrap handling, which creates generally undesirable uncertainties for disposing organisations.

In order to differentiate itself, Atea Logistics gives the disposer additional security in the form of more fixed prices of their used goods and LOOP services. Because of the expertise and knowledge of the sales manager, it is possible to guarantee prices of used products to disposers one to three months ahead of the collection. It is Atea Group's sales companies that forward information about prices from the sales manager of Atea Logistics.

Nevertheless, the sales manager at Atea Logistics takes risks when he guarantees the price to the disposer one month before the unit is sold, as prices may fall in the meantime. A decision by a large German firm to replace its large stock of equipment of a few standardised models can cause a dramatic drop in price of these particular products on the European market. Indeed, the whole refurbished equipment market is characterised by a large number of small firms, and dynamic periods of large price fluctuations that can result in bankruptcies. Atea Logistics therefore tries to manage potential losses by spreading these risks within the Atea Group.

According to the sales manager, the ideal situation for Atea Logistics would be to have a serial number of a LOOP service attached to a unit at the time it is delivered as new. This serial number would contain the information about the product required for effective coordination and planning, including the data on collection (disposal) date, address and the name of organisation. All of these data would then be stored in the information system of Atea Logistics. This system would send a reminder for order placement of a LOOP service to the responsible local sales company, six months before the replacement of the products has taken place. In this way, practically all disposed equipment could be resold before entering Atea Logistics's inspection and refurbishing facility in Växjö.

Thus, even when there is no synchronised delivery of the new units and collection of used products, a disposer could communicate to Atea Logistics that (s)he has a hundred of PCs of a certain model, six months before the products are disposed. The sales manager, in that case, would make certain estimates about prices of particular models through contacts with brokers. In 2010, only 10 percent of the equipment was presold to the brokers prior to its entry into the reconditioning facility.

Atea Logistics uses an indirect form of distribution for sales of refurbished goods for several reasons. First, Atea Logistics does not want to offer warranties on refurbished products, as intermediaries handle this. Second, Atea Logistics does not want to compete with their collaborators (e.g. manufacturers and Atea's sales companies) involved in distribution of new equipment. A potential conflict between the partners would arise, if an organisation would decide to buy refurbished products in order to complete its current assortment[28] instead of procuring new products from the manufacturers.

[28] Replace a fraction of the erroneous equipment.

In addition to these policies related to indirect distribution, Atea Logistics works only with brokers who follow strict environmental and social guidelines in order to prevent products ending up in the landfills of the developing countries. There are five brokers who distribute 80 percent of the refurbished units, and Atea Logistics works more closely with two of these brokers. The rest is handled by several small companies.

Brokers buy pallets from Atea Logistics which they split up and/or combine with other equipment. The equipment can then be sold either to other brokers or end-users via web shops, for example. Since the equipment refurbished by Atea Logistics comes without mice, keyboards and software installations, it is the job of brokers to add these accessories to the products. On the other hand, many of the brokers in Sweden have relationships with disposers, either directly or via manufacturers, which puts them in a competitive position in relation to Atea Logistics. In this manner, brokers of refurbished products both compete and cooperate with Atea Logistics.

The lack of integration between disposers and the brokers of Atea Logistics causes unpredictability in the refurbishing business. This is mirrored in the fact that neither quantities nor qualities of products can be assured. According to Atea Logistics, this situation could improve if the disposers would organise information about their inventory of IT equipment in order to share it with other actors in the network a certain period of time before they place an order for collection. Firms in the reconditioning business are trying to solve this kind of problems by having many contacts among suppliers and customers. Hence, they buy and sell to each other and from each other for the sake of balancing supply and demand. From Atea Logistics's perspective, it is often the seller's market as Atea Logistics become involved in situations where many brokers desire to buy the products in same quantities and of similar specifications. This normally occurs when potential end-users, in their search for a specific product model, contact a number of brokers, who, in turn, contact Atea Logistics.

The instability of the trade involving used products is especially noticeable internationally as credit is rarely, if ever, extended to buyers. Atea Logistics lost a significant part of its sales when one of its brokers in Sweden, Once Again, went bankrupt without paying for delivered refurbished units. This broker will be described in section 4.5. But first, this thesis presents a Swedish broker who is a current partner of Atea Logistics.

4.4 Distribution of refurbished products through Inrego

Inrego is a refurbisher and a broker/distributor of used IT equipment in the Nordic region and Europe. Inrego is specialised in providing secure, optimised and environmentally friendly IT products and logistics services. In terms of sales, Inrego is one of the largest European actors, and is working to become the leading European company handling used IT units. The company was started by two students in 1995, and currently employs over 50 persons.

Inrego's facilities process around 15,000 computers, servers, laptops and monitors per month. Collaboration with several logistics service providers, such as Schenker, Posten, IT Logistics, and Jemacon Logistics enables effective collection and transfer of used products to Inrego's facilities in Enköping where the information in the equipment is erased, and the units are resold to new customers.

An increasingly important arrangement for Inrego is combined collection of used equipment and delivery of new items. This service accounts for approximately 50 percent of sales. Disposers of the products are paid for their old and still working equipment, which can be sold to end-users. As a service to the disposers of used products, Inrego guarantees prices one month in advance. Non-functional components must be considered when disposers get paid for their used products. Most of the disposed products are three years old, in line with disposers' replacement policies.

Over the past five years, sales have tripled, and Inrego has been playing an important role in developing the logistical infrastructure for cost efficient and sustainable handling of the used IT equipment on the European continent. Efficient logistics planning gives the company the opportunity to reduce carbon emissions and distribution costs. Moreover, Inrego tries to stop distribution of electronic waste to developing countries by requiring its brokers and recycling partners to monitor trade across international borders. Over time the company has established a large network of hundreds of buying and selling relationships in 60 countries, both in Europe and in the United States.

4.4.1 Suppliers of Inrego

Inrego has two main supplier groups of used or refurbished products - disposers and brokers/refurbishers (e.g. Atea Logistics). Most of Inrego's disposers are located in the Nordic region, and at the offices of Nordic companies across Europe. Inrego views disposers both as suppliers and customers of its services. The most elementary requirements imposed by Inrego on its disposers, is that they have to be registered companies with a minimum quantity of 20 disposable units.

Orders coming from disposers trigger organising at Inrego. As a rule, disposers receive an empty cabinet via logistics providers, which they fill with the used equipment. Taking into consideration the fact that many organisations are not accustomed to manage used units, Inrego makes it as simple as possible for them to take care of these issues. Therefore, as disposers normally do not have packaging or materials handling equipment Inrego can step in and arrange processes and resources related to collection, packing, and materials handling.

Inrego would prefer to have an increased share of clients ordering synchronised collection of the used products and delivery of the new units. That is to say, the whole process would be more efficient thanks to specialisation and resources provided by Inrego. Integrated collection of used products and delivery of the new units would create logistical and environmental benefits in terms of full vehicle capacity in both directions. As Inrego and its logistics partners use load carriers on wheels to roll the products inside of buildings, collection procedures become more streamlined.

However, most disposing organisations are ordinarily not aware of the possible advantages of having the same partner involved in the collection of used equipment and the delivery of new products. This tends to indicate that most of the disposers separate service agreements associated with forward and reverse physical flows.

Not all of the supplies come from disposers as Inrego procures used and renovated equipment from brokers and refurbishers, as well. The existence of extensive information sharing between brokers and refurbishers on the European level facilitates efficient marketing and purchasing. The most important issue in this regard is the need to have as many contacts as possible in order to meet the demand for a given type of a used product. The actors in these relationships can therefore be both each other's suppliers and customers which is one of the features of the business relationship between Inrego and Atea Logistics. In its commercial relationship with Atea Logistics, Inrego is most frequently the buyer of the refurbished equipment, although it is not uncommon that partners take the opposite roles. As the PCs coming from Atea Logistics only posses a guarantee of processor speed, they have to be tested by Inrego. The next section describes processes performed at its refurbishing facility, where the products become identified and separated into flows related to internal refurbishing or recycling at a partner of Inrego.

4.4.2 Processes at Inrego's refurbishing facility

Regardless of its source, every product has to follow a process of testing and identification so that each unit gets a test result through the internal unit number. This internal number, which defines the product by describing its price, type, model name, and other characteristics, serves a range of purposes. First, all product-specific numbers (e.g. serial numbers, asset numbers etc.) are tied to the internal serial number so that asset reports to the end-user can be created. Second, the internal serial number which can be integrated into a unique pallet place number, thus allowing for simplified identification and inventory localisation of products within Inrego, as PCs are covered with various kinds of stickers (and therefore the same amount of numbers). Thus, whenever Inrego's serial number is scanned, it is possible to distinguish product characteristics. Third, the internal serial number stores information about identified product characteristics which are acquired during the testing. Fourth, all processes, including the various recovery options performed on the products, can be connected to the internal number for the purposes of environmental reports to the authorities and disposers.

There are two main alternatives regarding processes inside of the refurbishing facility, which are dependent on the source of the used products, i.e. disposers or other refurbishers/brokers.

In case the products are being supplied by the brokers, they are associated with an internal article number immediately, upon arrival at the refurbishing facility. This number ties the product to an inventory place or a buyer depending on whether an order has been placed. In other words, most of the products delivered from brokers and refurbishers have been pretested and/or renovated at a previous stage. The other source of the used products concerns items coming from disposers. These must be thoroughly tested and classified. Thus, as soon as the goods are inside the facility, they are categorised into several groups such as printers, monitors, mice, keyboards, and PCs. Mice and keyboards are almost immediately placed into boxes designated for electronic waste. The boxes are then transported to a recycling facility as the number of the load carriers becomes sufficient for full truckloads.

The equipment that could have some disposer-created information inside (e.g. hard drives and thin clients) must go through a process of complete product identification. For this purpose, the IT system provides the personnel with instructions on the allocation of products to the processing equipment in the facility, based on successive inspection results. That is to say, the testing system compares the processed unit with technical specifications associated with the most similar model. This results in the assignment of technical features and internal serial numbers to individual units. The information in the products that continue towards refurbishing is deleted by means of the same information system. The price inserted into the protocol of each product is provided by the sales personnel who, in turn, obtain this information through their business relationships with other companies. Products are graded according to the previously described grading scale, and the grade itself is stored in the internal serial number. Inrego tries to sell A-graded products directly to end-users while B-graded units are usually distributed to the brokers. Once the products are about to be delivered to the end-user, they are tightly wrapped with plastic film.

If it is impossible to erase information stored in the product by means of the software, an electromagnet is used to perform this operation. As the process of data erasure by the electromagnet is being completed, each item that went through the deletion procedure is split into pieces. In order to prevent any further exposure to the risk of information leakage, Inrego's technicians follow the transportation of these products to the materials shredding facility of the company's recycling partner. This actor in turn distributes these materials for the production of new raw materials.

4.4.3 Buyers of refurbished equipment

Inrego has two main groups of customers - brokers/refurbishers and end-users. End-users in the Nordic region are regarded as the preferred buyer group since their geographical proximity to Inrego's premises facilitates the most economical and environmentally friendly delivery alternative. In order to accommodate effective marketing of refurbished products to these end-users, Inrego has developed a Swedish and a Norwegian web shop. These web shops enable buyers to create their own offering by combining new and used products. Thus, new accessories such as mice and keyboards, purchased from other distributors, can be added to the PCs in accordance with the demand from the end-users. However, owing to the fact that the majority of Nordic end-users are following the latest technological developments in the PC industry, most of Inrego's refurbished products are distributed to end-users in Eastern Europe through intermediaries. These end-users do not purchase PC models in the early stages of their sales life cycle. Hence, refurbished products normally fit well with the product characteristics demanded by the end-users in Eastern Europe.

Inrego is not able to sell all of the equipment to the end-users, which is one of the reasons why the sales of the used equipment to other brokers exceed 50 percent. In addition to their sales competence and capabilities related to country-specific requirements, the brokers provide Inrego with access to their business relationships. Hence, brokers have usually an already established contact with potential clients when they get in touch with Inrego. In a similar vein, brokers are given access to Inrego's relationships on the supply side. This enables Inrego (and thus, the brokers) to look for the requested products throughout the supply network. Therefore, in order to increase its possibilities of finding requested products, Inrego tries to establish as many relationships as possible with suppliers.

The application of integrated collection of used products and delivery of new units reduces the need for search activities on the supply side. As the accurate information about the state of the products at the disposer's site is available for Inrego's marketing personnel, products can be sold before they are refurbished. This arrangement facilitates remanufacturing to order because units that are processed in this manner do not have to be placed in an inventory for unsold articles. That is not to say that all disposed products are remanufactured to order; indeed some products have to be stored before they are ordered, as the customers have to be guaranteed assured quantities, qualities, and delivery times.

4.4.4 Logistics operations

Inrego sources logistics and transportation services from specialised providers. Nowadays, even the previously integrated activity of collection of used products in the Stockholm area is procured from transportation companies.

Inrego has a differentiated approach towards its suppliers of logistics services due to distinctions in the logistics solutions which these firms offer. Thus, Inrego collaborates with Jemacon Logistics and IT Logistics in arrangements that cover synchronised collection of the used products and delivery of new units, in load carriers on wheels. As these load carriers are not adapted to the standardised operations and load carrier measurements of the largest transportation companies, Jemacon Logistics and IT Logistics can take the role as providers of distribution services of a more exclusive nature.

Therefore, when the distribution set-up does not require rolling load carriers, Inrego normally cooperates with Schenker or Posten which transport tightly wrapped pallets to the end-users. When the delivery requirements involve speedy logistics solutions, the actors specialising in these offerings, such as DHL or UPS, are used.

Internationally, when there is a need to coordinate collection from several countries and with a number of logistics service providers, the main collaborator of Inrego is a transportation intermediary and a freight broker. This intermediary, for example, was involved in arranging and coordinating a transportation solution for the collection of used products from 32 countries.

4.5 Distribution of refurbished products through Once Again

Once Again was an intermediary involved in refurbishing, purchasing, and marketing of used IT equipment between 1999 and 2010. The business model was to offer refurbished products and surplus stock from manufacturers and distributors, as an environmentally friendly and economical complement and alternative to new products. The warehouse and refurbishing facilities of Once Again in Ronneby processed around 30,000 IT-related products annually. When the company went into bankruptcy in 2010 it had a turnover of 100 million SEK per year and a staff of 24 employees.

Handling of returned end-of-lease products from large organisations was the core business area of Once Again. In these arrangements that company was working closely with Jemacon Logistics and IT Logistics[29], logistics providers specialised in integrated delivery of new products and the collection of the used units. Once Again collaborated with Schenker and Posten in logistics coordination during collection processes, when the collection of used goods was detached from the distribution of new products.

Organisations in the public sector were the most important customer group of Once Again. Unused returns were usually offered to administrative departments of municipalities or regional governments. Schools were the other subgroup of customers in the public sector to which refurbished products were delivered. Once Again had a special agreement with the actors in the public sector, which allowed them to provide the products on a short notice without any tender-like purchasing procedures.

The business relationship between Once Again and Atea Logistics displayed several types of behaviours, such as cooperation and competition. They competed in public auctions related to purchasing of collection, disposal, and refurbishing services. The companies cooperated as Once Again procured refurbished products from Atea Logistics. Furthermore, both Once Again and Atea Logistics were HP “Preferred Partners” and a part of HP’s European

[29] A company specialised in transportation and inventory holding of used products.

programme for handling and reselling of returns. This included demonstration and trial equipment, lease and rental returns, discontinued products, excessive inventories from factory, customer returns, and returns from trade-in and trade-up programs.

When the products arrived at the refurbishing facility, they were tested and all disposer-created data were deleted. Since Atea Logistics removed all information from the products but only provided guarantees for the functionality of the processor, all products coming from Atea Logistics had to be tested. Based on the test results, PCs were either recycled or refurbished. Thus, products that were regarded as obsolete were transported to actors specialised in recycling of various materials such as Ragn Sells, Stena Technoworld, and HA Industri. In case technicians at Once Again considered products to have a potential value for the secondary end-user, the products were cleaned and their anti-theft marking was removed. Once Again would then normally install software in accordance with customer requirements. As some components inside of PCs were technologically obsolete or malfunctioning, new replacement parts were assembled into refurbished PCs. The components which were installed in the reconditioned PCs were bought from the distributors of IT equipment (Ingram Micro, Dustin, Tech Data).

4.6 Distribution of obsolete items through Eurovironment

Classification is crucial for directing products into various reprocessing alternatives, such as refurbishing or recycling. Eurovironment provides this service on behalf of Atea Logistics in various LOOPs and at a number of decision points. This section aims at describing Eurovironment, in general, and its role in LOOPs in particular.

Eurovironment is a company which is primarily oriented towards three types of actors in product recovery arrangements. These organisations include disposers, buyers of used/refurbished products, and firms who have producer responsibility for electronic waste. Eurovironment has a turnover of SEK 10 million. The company is certified in accordance with both Quality and Environmental Management Systems.

Eurovironment’s most important functions in relation to other actors are renovation and classification of electronic and electric products. In collaboration with its partners Eurovironment may arrange collection of used products, synchronised replacement of used units with new products, and distribution of obsolete items and refurbished products. Refurbished units are sold to intermediaries (e.g. brokers) or secondary end-users. The products that are classified as electronic waste are divided into recyclable fractions depending on their raw materials features and transferred to recycling specialists.

In future, Eurovironment and its partners have plans to establish a regional transportation network in the Nordic countries because waste is not allowed to move freely across borders. As a result of this policy, national sub-optimisations are created, which, in turn, generate negative effects in both economic and environmental terms. Eurovironment wants to influence regulators in Nordic countries to allow, but still control, these flows. A change of policy in this direction would probably increase Eurovironment’s turnover. Nevertheless, the demand for its services has been increasing over the past few years and the company has been enlarging its capacity for inventory holding. In addition, Eurovironment has been continuously developing an information system for tracking and tracing products. This system is connected to the IT system for order handling at Atea Logistics.

Order handling

Every morning Atea Logistics sends accumulated orders for collection of used products to Eurovironment. Each collection project is considered to be a unique disposer-specific project, tied to a unique order number, which, in turn, enables continuous tracing of the load carriers. The information in such an order or order number is classified into data regarding particular LOOP services, location, and delivery/pick-up dates. The Excel-file with this information is then transmitted to Eurovironment's own IT system. Upon delivery of an order to Eurovironment, the company contacts Schenker and the disposer for order confirmation.

Ever since the beginning of collaboration between Atea Logistics and Eurovironment, Eurovironment has been experiencing a recurring communication problem. The Managing Director at Eurovironment noticed that some disposers had been expecting their phone call, and consequently collected used units for a longer period of time than expected. According to him, this is a result of too many steps involved in order handling, and the lack of information sharing between actors. That is to say, there is no direct contact between disposers, Atea Group’s sales companies, and Eurovironment, as Eurovironment always receives the orders through the sales companies, and Atea Logistics. The Managing Director of Eurovironment speculated that this lack of information sharing between firms could be a result of the policy that enables Atea Group’s sales companies to procure similar services from other companies besides Atea Logistics, which also includes Eurovironment.

An additional communication problem concerned inaccuracy of data in order information coming from Atea Logistics. This caused disturbances in coordination and performance of logistics operations in the early stages of the business relationship between Atea Logistics and Eurovironment. The Managing Director of Eurovironment provided an example of an assignment regarding the disposal of used electronics from a large company during which Schenker experienced troubles in locating filled cages. As the central goods department of the company received empty cages, they were delivered to 10 different buildings without Schenker or Eurovironment having been informed.

In order to prevent this kind of situations, Eurovironment developed a questionnaire which is used for the collection of data about each disposer. Thus, all new disposers have to provide answers to the questions posed in the questionnaire, before any service will be provided.

These answers are then stored in Eurovironment's information system for reuse in other collection projects involving the same disposers. This information concerns the persons who are responsible for returns, their telephone numbers, delivery and pick-up locations, the height and width of facilities, and disposers' working hours. Generally speaking, by creating a structured way for data collection and categorisation, Eurovironment has obtained access to more detailed and accurate information than Atea Logistics or the sales companies of Atea Group have. All these data enable Eurovironment and Schenker to jointly coordinate the collection processes, even though Atea Logistics, on occasion, sends incomplete and inaccurate information.

Eurovironment plays therefore an important role as an information link between disposers and Atea Logistics, and especially with regard to the physical flows between the parties. Integrated information systems between these two actors facilitate tracking of the physical flow of load carriers from disposers to the facilities of Atea Logistics. Hence, each time load carriers are scanned Atea Logistics receives status notifications on when the load carriers have been delivered to Eurovironment's facility, and when they are expected to be transported to its own facility in Växjö. Moreover, as the information about the location of the disposer becomes available, Eurovironment and Atea Logistics can reroute transportation of products in LOOP3, if disposers' premises are geographically closer to Växjö than to Enköping.

Eurovironment's involvement in LOOPs

Eurovironment is involved in LOOP 1, 2 and 3. Its participation in LOOPs refers to logistics coordination, and classification of products for recycling or refurbishing. In the collection phase of the three LOOPs, Eurovironment is a forwarder of information. This enables Schenker to deliver empty load carriers to the disposer and to distribute the filled load carriers to Eurovironment's facilities. Both Eurovironment and Schenker try to consolidate other consignments besides those related to LOOP services.

Upon the arrival of products from disposers, Eurovironment separates products into flows aimed for recycling and refurbishing. For this purpose, Atea Logistics and Eurovironment have established definitions, which serve as a guide for classification. There are general manuals on how to classify products. Nevertheless, there are constant small changes in classifications that create the need for continuous standardisation. A new employee has to learn from colleagues by following their advice and their classification procedures.

For instance, technologically obsolete products, units that do not contain any disposer-created information, and electronic waste, are sent to the recycling specialist instead of being transported to Atea Logistics for refurbishing. Items that Eurovironment considers to be functional and valuable for a secondary end-user are transported by Schenker to Atea Logistics' facilities for data erasure, and refurbishing. Furthermore, regardless of their functionality, products that contain disposers created information must be transferred to Atea

Logistics for data erasure. All equipment that is classified as appropriate to send to Atea Logistics is not shipped directly to its facilities, as Eurovironment waits until a large truck can be filled.

As regards classification for recycling, there are two sources of this type of product, as these items can come either from the disposers in LOOP1 or from Atea Logistics and all four standardised LOOPs. Hence, after detailed testing by Atea Logistics, all products out of which information has been removed, and products that do not have any value for an end-user are transported to Eurovironment. Eurovironment performs sorting into 12 fractions and 12 corresponding boxes adapted to requirements of recycling companies. The boxes are then moved to larger containers for economies in transport.

Firms like Stena or Sims Recycling test a product's physical properties in order to pick as pure raw materials fractions as possible out of consignments sent by Eurovironment. The aim of the achievement of purity in raw materials is to enable other actors to produce new raw materials. Recycling firms inspect the density, magnetic properties of products, and the composition of materials inside of the products. After each test, these materials can be transported to firms specialised in treatment of particular types of materials. One of the firms that distribute products, parts, and materials in these arrangements is Schenker. Their role in product recovery arrangements is presented in the following section.

4.7 Schenker – a logistics service provider in the handling of used items

DB Schenker develops and produces logistics services on a worldwide basis. The company was started for more than hundred years ago in Vienna, Austria. The business model was to consolidate product flows from various consignors, and this is still one of the company's transportation services. Furthermore, Schenker offers logistics and warehousing solutions, as well as consultancy services related to planning of logistics arrangements, which include all modes of transportation. Schenker is certified in accordance with environmental and quality management systems, ISO 14001 and ISO 9001.

Schenker's customer base in Sweden consists of approximately 42,000 regular customers, for which Schenker distributes 17.4 shipments annually. The Swedish branch has a turnover of SEK 14.7 billion per year and a staff of 10,000 employees. This includes personnel of Schenker's haulage contractors and the staff directly employed by Schenker. Schenker acts as a coordinator in their relationships with haulage contractors with whom they offer locally customised services.

While routines do not exhibit a large variation on a national level, regional offices of Schenker have the advantage of in-depth knowledge of freight services from local customers.

For instance, in Växjö, a number of consignors and consignees have had contact with the same people from Schenker's local office for ten or twenty years.

4.7.1 Order handling

While consignors and consignees may agree upon who will pay the transportation costs, one or both must supply Schenker with information about the details of the shipment. Every order has to include information about volume, weight, pick-up/delivery locations and dates so that transportation managers can plan the routes and coordinate transport solutions together with the haulage contractors. In addition, materials handling and other instructions are provided through the orders in order to minimise transport damage. Each order received by a local branch of Schenker is transmitted to smaller trucking companies that perform collection and/or delivery processes in the region. Haulage contractors then allocate trucks of variable sizes to different routes in order to maximise fill rates.

The pattern of how orders are placed differs among those that book their consignments. For instance, customers of transportation services with large variations in size, weight, delivery and pick-up dates usually place orders in accordance with their current needs. Thus, some consignors or consignees book transportation on a less regular basis while others have a pre-booked amount of pallet places on trucks that are collected or delivered on predetermined dates.

Normally, the customers with regular physical flows have integrated information systems with Schenker. It is important that this inter-firm linkage is performed accurately because certain types of information may not be transmitted to Schenker. This can cause disturbances in the provision of logistics services. All settings of interlinked information systems are therefore adjusted by a central IT department in Gothenburg so that crucial parameters such as length, height, breadth or weight are always included in the order. Volume and weight are the most essential product properties in this regard as they affect pricing, the type of truck and whether the goods should go through a terminal or not.

For Schenker the crucial information from Atea Logistics concerns how much space they needs to dedicate to Atea Logistics, as the actual content of load carriers and pallets is not that significant. This is a common way of pricing in the transportation industry, and means that a transport buyer is charged for a fully occupied volume of the pallet place even when a consignment is not of this size. The pallet place has a weight of 780 kilograms and a height equivalent to the height of a truck. However, Schenker and its haulage contractors are not merely focusing on transporting full truck loads of palletised products. A supplementary focus refers to car loads that contain mixtures of shipments of various sizes as these consignments are generating higher profits.

As a fixed number of pallet places get collected from Atea Logistics on a day-to-day basis, the company is perceived as a regular customer by Schenker. Hence, Schenker and Atea Logistics have integrated their information systems via Electronic Data Interchange. The responsibility of Atea Logistics in this collaborative set-up is to create unique freight documents and article numbers, attached to individual shipments or load carriers related to LOOP services. These numbers make it possible to get status reports each time a particular consignment is registered by scanning the barcodes. That is to say, each time a consignment's order number gets scanned upon pick-up, delivery or in a hub, Atea Logistics can register the changes of the shipment's location through the information system.

Physical flows to Denmark are coordinated by a special arrangement regarding information exchange between Atea Logistics and its logistics service providers. Schenker receives only information on the level of load carriers when they are transported between Atea Logistics' facilities and a hub of another logistics service provider in Denmark. Since Schenker's personnel do not have to handle administration of each product in the load carrier, this organisation of information flows reduces the amount of the overall paper work. Detailed information about each unit in the load carrier is given to a logistics service provider who distributes the goods from the hub to their final destination.

4.7.2 Physical flows

Schenker's geographical districts are divided according to aspects related to volumes and duration or distance of collection/delivery assignment in relation to its regional hub. In order to maximise fill rates of trucks, collection and delivery volumes are matched with corresponding frequencies. Thus, collection and delivery are performed less frequently in cities or villages which do not receive or send large volumes. Furthermore, if the shipment between the original consignor and the final consignee is large enough there is no need to co-load or break the bulk between their facilities. Finally, depending on the weight, the collected load goes either through the regional terminal[30] and then to the consignee, or to a regional hub close to the consignee's premises where the shipment is split up into smaller consignments headed for their final destination.

At Schenker's Växjö hub collected packages are unloaded, weighed and measured on a conveyor belt. The next step is to place the packages into a box which has the measurements of the standardised pallet. This box is then co-loaded with other boxes headed for another regional terminal or the final destination, depending on the size of the co-loaded consignment.

Schenker distributes 1½ trailer to Denmark and 7-9 meter of length extended across the truck, and up to the top, to Norway per day on behalf of Atea Logistics. Atea Logistics' reverse flows on modularised and standardised pallets from both of these countries are also

[30] For example, the regional hub in Växjö handles all collected consignments which weigh less than 1,000 kilograms.

Schenker's responsibility. When it comes to Sweden, Posten is the only supplier of logistics services to Atea Logistics in this geographical area.

4.8 Summary

This case description focuses on Atea Logistics and its collaborators, who are performing and coordinating different logistics and product recovery options with respect to disposers' different needs. Some disposers have pre-planned shipments of their used goods. Others deal with the issue of product recovery on a case-by-case basis. Information needed for planning is organised around the properties of products as regards their state, specifications, age, geographical location, and delivery/collection dates.

For the companies that have a fully integrated collection of the used products and the delivery of the new ones, it is much simpler to plan and send the information about incoming used goods to brokers. This arrangement makes it possible to create delivery plans that optimise inventory levels, purchasing administration and transportation of the used equipment. Industry wide grading system of refurbished PCs provides a means for efficient inter-organisational communication and uncertainty reduction. In order to balance volatile supply and demand of refurbished products at the right price, brokers and refurbishers have established relationships with a large number of partners. These partners can act as both suppliers and buyers.

Logistics service providers offer standardised and specialised solutions in the handling of used products. Jemacon Logistics is a more specialised logistics company with regard to the collection of used IT equipment from individual working places. Posten and Schenker do not make any major distinction between new and used products with regard to their operations. Schenker and Eurovironment coordinate the collection of the used goods, which are transported to the recycling partner. Eurovironment classifies obsolete parts and products for refurbishing and recycling.

5 ANALYSIS

This analysis combines the analytical framework of this thesis and the empirical findings of the case study of Atea Logistics and its handling of used products. The case analysis is structured in accordance with three interconnected layers of the ARA model – activities, resources and actors. The activity layer is analysed by applying the concepts of transvections, activity similarities and activity complementarities, together with the principles of postponement and speculation. In the section where the resource layer is analysed, the 4R model is used to elaborate resource interfaces and resource combining. Finally, the actor layer is scrutinised by discussing features of business relationships, actor positioning, and information sharing in the network.

5.1 Analysis of organising product recovery in the activity pattern

The case analysis of product recovery in the activity pattern is based in the concept of transvection, presented in the theoretical frame of reference. In total, five transvections that start at a disposer and finish at an end-user or a recycler, are described and discussed in order to illuminate different reprocessing options, organising principles, and inter-organisational structures (see Table 5.1).

	Product recovery/reprocessing option	**Principle of postponement/ speculation**	**End destination**	**Actors involved in addition to the disposers**
Transvection 1	Recycling	Speculation	Recycler	Schenker, Eurovironment, Recycler
Transvection 2	Recycling	Speculation	Recycler	Schenker, Eurovironment, Atea Logistics, Recycler
Transvection 3	Refurbishing/ remanufacturing	Speculation	End-user	Schenker, Eurovironment, Atea Logistics, Once Again, Posten
Transvection 4	Refurbishing/ remanufacturing	Speculation	End-user	Jemacon Logistics, Atea Logistics, Schenker, Danish third party logistics provider, Broker
Transvection 5	Refurbishing/ remanufacturing	Postponement	End-user	Jemacon Logistics, Atea Logistics, Posten, Inrego

Table 5.1 Outline of analysed transvections in terms of their reprocessing option, organising principles, ending point, and involved actors.

In Transvections 1 and 2, objects coming from disposers are recycled while objects in Transvections 3, 4, and 5 are refurbished and resold to an end-user. As objects coming from disposers in Transvection 1 are considered to be electronic waste, it are all directed and transferred to recycling facilities via Eurovironment. Transvection 2 illustrates the importance of coordination with regard to object classification, since the object in this transvection takes a detour via additional categorisation and transportation to recycling. Another distinction among transvections concerns the principles of postponement and speculation. In Transvection 3 and 4 the object is refurbished speculatively, while Transvection 5 operates according to the principle of postponement. The main difference between Transvection 3 and 4 relates to the involvement of diverse actors and information sharing procedures between these actors.

5.1.1 Transvection 1 – LOOP1

As depicted by Figure 5.1, a used laptop in this transvection goes from the disposer via logistics service providers, Schenker and Eurovironment, to a recycling facility. To be more precise, this transvection, which is typical for LOOP1, is focused on a laptop that does not contain any information that disposer regards as sensitive. Another requirement for the assignment of a laptop to the particular facilities of this transvection is the evaluation by disposers and Atea that these objects are obsolescent. Thus, interaction between Atea's sales staff and disposers enables the disposer to make proper assignments of objects to appropriate facilities, although there is no single organisational unit belonging to Atea Group (including Atea Logistics) that handles the objects physically in this transvection.

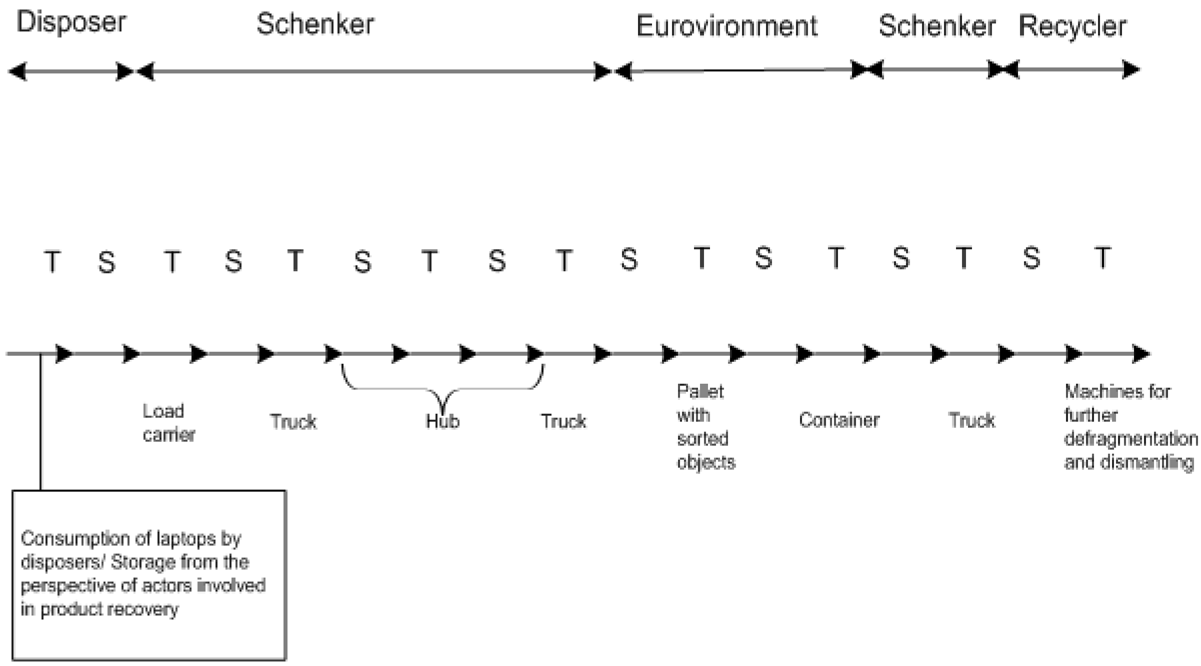

Figure 5.1 Illustration of Transvection 1.

A disposer's order for reverse logistics services contains data on when laptops need to be collected, their location, and the type of objects. This order is normally sent from disposers to Atea's sales companies, via Atea Logistics, and further on to Eurovironment. Eurovironment transfers this information to Schenker for arrangement of the collection of the object from the premises of the disposer.

The disposer assigns the used laptop to a load carrier. which is picked up by Schenker.[31] Then, Schenker assigns the laptop inside the load carrier to a truck, which transports the object to a hub, as the quantity is not sufficient for direct delivery to Eurovironment's facility. At the hub, the object gets jointly assigned with other objects to Eurovironment's facility. When the object arrives at Eurovironment's facility, it is assigned to a box with other objects of comparable characteristics from the viewpoint of the recycling company. At this point, the laptop in the box becomes assigned to a container for storage, to be transferred to the recycling facility where it is separated into material fractions.

Activities in this transvection are sequentially coordinated, all the way from the disposer of the laptop, via Schenker, and further down the transvection to Eurovironment and the recycling firms. The identity features of used laptops are changing in a predetermined fashion in this transvection, as objects are pre-assigned and preselected by the actors in the transvection. Differentiation in form, on the other hand, is postponed until the load carrier associated with LOOP1 arrives at Eurovironment's facility. Here the used laptops are assigned to a specific box depending on the material content of the object.

Uncertainty in form, time, place, and quantity, combined with short lead times prior to the assignment of used laptops by disposers, create the need to stock the objects in hubs. Used laptops are collected with a small truck from disposers in order to utilise economies of scale in transportation related to shorter hauls. At the hub, the objects are jointly assigned to a larger truck so that time and place discrepancies are bridged at a lower cost per unit of weight or volume over a longer distance. Sorting according to the time and place dimension at Schenker's hubs and at Eurovironment's facility is crucial to economies of scale in transportation. For this reason, parallel dependencies are generated at several instances, such as pallets, boxes, trucks and other types of load carriers.

Different parts of this transvection require different kinds of uniformities. Between disposers and Eurovironment, the creation of parallel dependencies in time and place is more significant than the creation of activity similarities in form features of objects. This is attributed to the fact that all objects in this transvection are regarded as electronic waste. The recycling firm that receives this type of object has another point of view, and Eurovironment sorts objects on their behalf having a more detailed differentiation of form in mind. In order to achieve parallel dependence in transportation from Eurovironment to the recycler, sorted objects in the form dimension share the same vehicle. Further along the transvection, the recycler categorises objects physically according to even stricter and more detailed form features.

[31] Depending on the quantity of objects, laptops are either assigned to Eurovironment's facility for physical object categorisation and breaking bulk, or to Schenker's a hub for consolidation.

5.1.2 Transvection 2 - LOOP2

Transvection 2, illustrated in Figure 5.2, is concerned with the path of a used laptop from disposers via Eurovironment, Atea Logistics, back to Eurovironment, and finally to the recycler. Hence, the object is handled by the same actors as in Transvection 1 until it reaches the facility of Eurovironment. At Atea Logistics the object is sorted for material defragmentation at the recycling company via Eurovironment, implying that it has to be transported for an additional sorting at Eurovironment. Eurovironment, in turn, ships the used laptop to the recycling company. There is a sufficient volume for direct transportation of a trailer to from the disposer to Eurovironment.

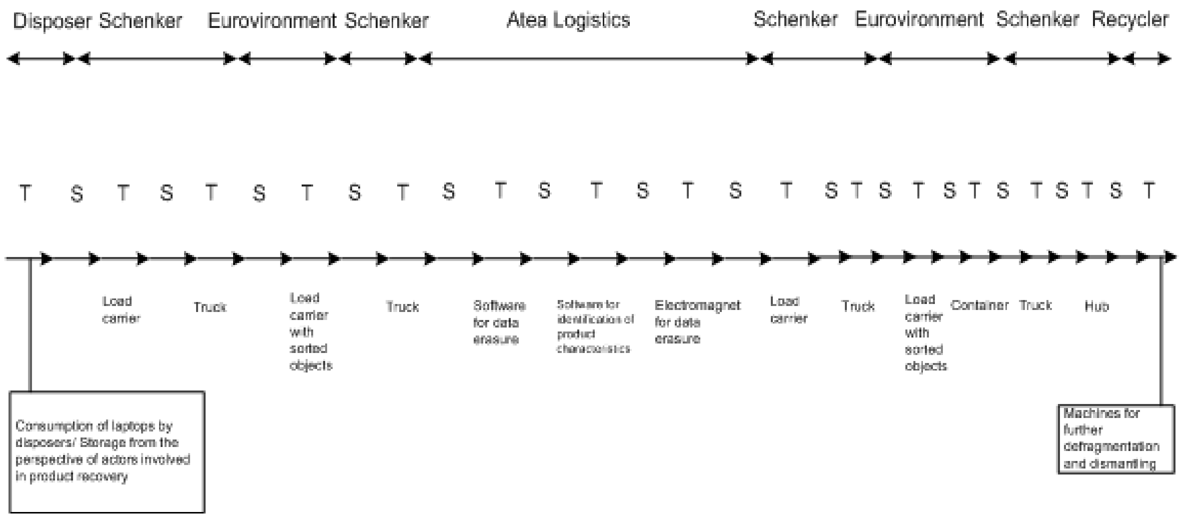

Figure 5.2 Illustration of Transvection 2.

The starting point of this transvection is a disposer who assigns the laptop to the load carrier, which is loaded on a truck and delivered to Eurovironment. At Eurovironment the object is unloaded and assigned either to boxes adapted to the requirements of the recycling company or to the requirements of Atea Logistics. According to rules established between Eurovironment and Atea Logistics, the object in this transvection belongs to those that could at this moment be assigned to the identity of Atea Logistics (more precisely, according to the properties of this used laptop match the requirements of Atea Logistics and thus of a new end-user). The used laptop is then assigned to inventory where other objects headed for Atea Logistics are stored. When sufficient volumes are achieved for economical transportation, the object in the load carrier is assigned to a truck and transferred to Atea Logistics by Schenker.

After arrival at Atea Logistics' facility, the laptop is assigned to a resource which removes disposer-created data and identifies properties of the object in the form dimension. In this transvection, objects with properties that do not match the desired ones may result in the product turning out to be non-functional, and the object is therefore assigned to data erasure by an electromagnet. Then, the used laptop is jointly assigned to a pallet with other objects aimed for recycling via Eurovironment. The object is kept at Atea Logistics' premises until it gets assigned to a truck that transports this object back to Eurovironment in Enköping. In accordance with Transvection 1, the object is unloaded at Eurovironment and assigned jointly to a specific box with other objects which have similar material characteristics. These boxes are, in turn, assigned to a larger container for economies of scale in transportation between Eurovironment and the recycling facilities.

The main difference between Transvection 1 and Transvection 2 is the greater uncertainty in Transvection 1 as regards form features of the object, which goes through two inspection processes. Transvection 2 is associated with greater uncertainty in the form dimension than Transvection 1 since all objects coming from the disposers are not regarded as electronic waste. Activities are hence sequentially interdependent from the disposer to Eurovironment where differentiation in time, form, place, and identity occurs. Consequently, objects become either assigned to Atea Logistics' or Eurovironment's resources for transformation. Consequently, the form features of objects determine assignments and subsequent changes in identity. In other words, actors in the network control resources for sorting and transformation which are adapted to object specifications.

A helpful tool in Eurovironment's assignment of objects to refurbishing or recycling facilities is an agreement between Atea Logistics and Eurovironment which roughly regulates form features of objects that are exchanged between these firms. This agreement states sorting rules in qualitative dimensions of objects. As laptops and IT-related products are subject to short innovation life cycles, adjustments of these sorting rules are made continuously in interaction processes. In other words, these rules are continuously being adapted to characteristics demanded by end-users.

Physical categorisation of objects at Eurovironment partially reduces uncertainty in the form dimension to the benefit of recycling companies and Atea Logistics. Recyclers and Atea Logistics can therefore be surer that it is getting objects according to its predetermined selections. That is to say, complementarity with regard to either Atea Logistics or recycler becomes confirmed at Eurovironment. To continue with the transvection, when the object comes to Atea Logistics' facility it is sorted according to form features. At this point in time, activity complementarity towards Eurovironment and the recycling company via Schenker gets established. Uncertainty in the form dimension thus creates a necessity to store objects at each stage in the transvection with the intention of obtaining activity similarities in various load carriers used in transportation.

5.1.3 Transvection 3 – LOOP3

This transvection, which is presented in Figure 5.3, takes its starting point in the disposer that orders collection of the used laptop. The actors involved in the transvection are the disposer, Schenker, Eurovironment, Atea Logistics, Once Again, Posten, and an end-user. Transvection 3 ends with the end-user, who purchases the refurbished laptop through Once Again.

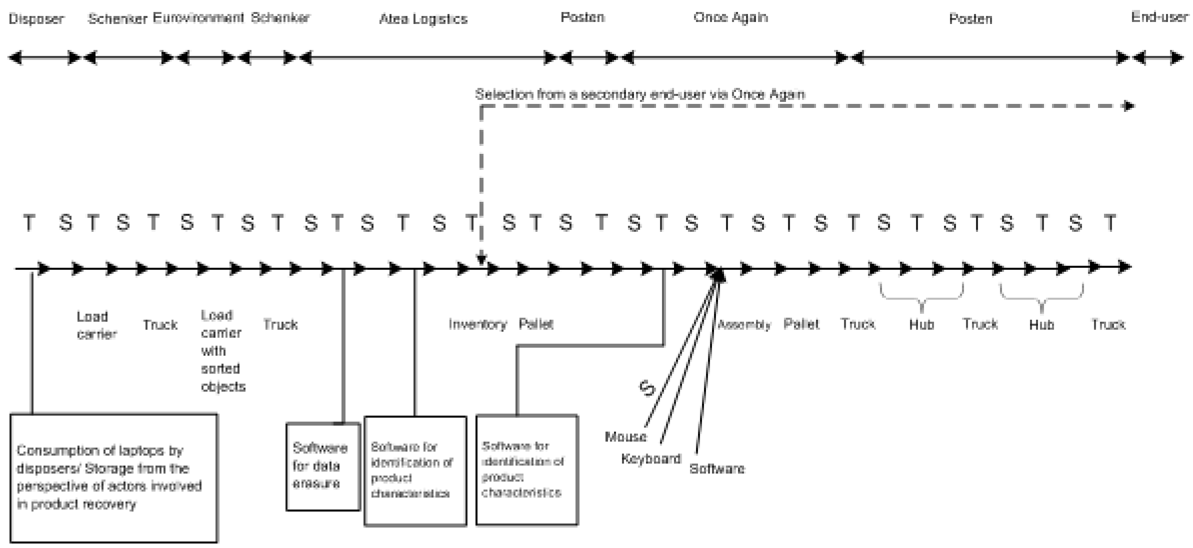

Figure 5.3 Illustration of Transvection 3.

Regarding the object handled by the actors in this transvection, the disposer assigns a used laptop with information perceived as sensitive to a LOOP specific load carrier with a padlock. Conditions surrounding the uncertainty of the object are the same as in the previous transvection. Another condition concerns the quantity of the objects that are disposed. Thus, in this transvection, it is assumed that the disposer possesses a sufficient volume of objects to facilitate direct transportation to Eurovironment, where the laptop is jointly transformed in load carriers involved in LOOP2 and LOOP3. According to the previously described transvection, Eurovironment assigns the object to Atea Logistics' facility, as the used laptop belongs to a group of objects that have been preselected by Atea Logistics. Consequently, the used laptop is assigned to a truck that transports this object to Atea Logistics' facility.

Together with other laptops, the object is assigned to a resource for form transformation, which deletes disposer-created information and identifies the attributes of the object such as memory, screen brightness and price. This identification of object characteristics, in turn, facilitates assignment to an inventory. After a period of time in the inventory at Atea Logistics, Once Again selects the refurbished laptop. The object is then assigned to Once Again's identity as soon as it is picked from the inventory. From the loading area of Atea Logistics' premises, the refurbished laptop gets assigned to a truck that transports objects on pallets to Once Again's facility.

When the object is unloaded at Once Again's premises, it is assigned to an additional identification of characteristics by software, as Atea Logistics guarantees the functionality of the processor, alone. Here, the object is assigned to other operations including the addition and assignment of new monitors, mice, keyboards, and software to the refurbished laptop. Physical delivery to the end-user is handled by Posten. Consequently, the refurbished laptop is assigned to a truck that transfers this object to a hub. Here, the laptop is assigned to a larger truck designed for long hauls to another hub. From this local hub the object is assigned to a smaller truck, which carries the laptop to its final destination.

Transvection 3 follows the same route and same sorting decisions as in Transvection 2 until the object reaches Atea Logistics. Eurovironment acts as a coordinator when it comes to quantities of objects that are shipped. Depending on a rule that takes distance and volume/weight into consideration, Schenker is able to send the object, either directly or through hubs, to Eurovironment's and Atea Logistics' facilities.

The direction of transvection towards Atea Logistics is confirmed at Eurovironment according to the sorting rules in the form dimension, which are continuously being developed by both of the companies in the relationship. Thus, differentiation in time, form, place, and identity dimensions is postponed at Eurovironment due to uncertainty in the form features of objects. As the form dimension of an object is uncertain until it arrives at Eurovironment, Eurovironment must capture similarities among activities which are related to uniformities in time and place dimensions of shipments to Atea Logistics. The used laptop in this transvection is therefore co-loaded with other objects in the LOOP2 set-up. In this way, Atea Logistics, Schenker, and Eurovironment try to capture uniformities in time, place, and form features of objects with the purpose of minimising transportation and inventory costs (i.e. overcoming time and space discrepancies).

Information from Eurovironment and Schenker concerning objects' features in the time and quantity dimensions is vital for Atea Logistics, so that sorting and transformation of incoming objects are carried out as efficiently as possible along the transvection. Planning of resource utilisation, such as labour and machinery, must be performed prior to objects' arrival at Atea Logistics. Atea Logistics reduces the uncertainty of Once Again, as the laptop's time, place, and form features become definite through identification of the object's features. Atea Logistics' facility accommodates activity similarities as the same resources for transformation might be utilised in order to identify form attributes of many objects.

Concerning the storing of the object at Atea Logistics' facility, inventory holding provides a time utility for Once Again, which can make selection consistent with the end-user's requirements. Differentiation towards end-users is postponed by Once Again as it can assign monitors, software, mice, keyboards and other accessories to refurbished laptops in line with the needs of end-users. In this manner, customisation is combined with risk minimisation. Logistics services on the supply and demand side of Once Again are performed by Posten. Hence, Posten and Once Again coordinate distribution operations before the objects' arrival, and after their departure from Once Again. By doing this, it is possible to balance the stock level so that deliveries can be secured.

To summarise, this transvection is coordinated intermittently between facilities as interruptions are caused by uncertainties in the form features of objects, and short lead-times between the order placement for disposal and inspection of objects. This intermittent coordination is caused by insufficient and unorganised information sharing between disposers, reprocessors, and distributors.

5.1.4 Transvection 4 – LOOP4

Transvections 4 begins at the disposer's facility with a used laptop. The object in this transvection belongs to a group of objects that require data erasure. Facilities involved in Transvection 4 belong to disposers, Jemacon Logistics, Atea Logistics, Schenker, a Danish logistics service provider, an international broker, and a logistics service provider. Furthermore, the used laptop is selected by an end-user when it is placed in the inventory of Atea Logistics.

At the disposer's site, the used laptop and the product-specific accessories such as monitors, keyboards, mice, and cables are all assigned to a rolling load carrier by Jemacon Logistics immediately after the delivery of the new laptop. The used laptop in the load carrier is then assigned to a small pick-up truck that transports the object for a short haul to a hub. At this point, the object in the load carrier is assigned, together with other objects in other load carriers, to a truck for a long haul to Atea Logistics' facility in Växjö.[32]

In Atea Logistics' facility, the used laptop is assigned to software, which modifies the form attributes of the object by deleting information and identifying its features, as portrayed in Figure 5.4. Sorting rules for comparison of object characteristics with those in demand facilitate assignment to subsequent resources for transformation. The used laptop in Transvection 4 is assigned to a pallet, which is placed in inventory. The Danish broker selects the object from the inventory through sorting objects by their form features. Then, Atea Logistics assigns the object to a pallet, which is transported via Schenker and the Danish logistics service provider to the broker. This is done together with other objects headed for Denmark.

[32] As the objects are unloaded, mice, keyboards, and cables are stored on a pallet until they become assigned to Schenker's truck that transfers the pallet to Eurovironment's facility. These objects follow the path of Transvection 2.

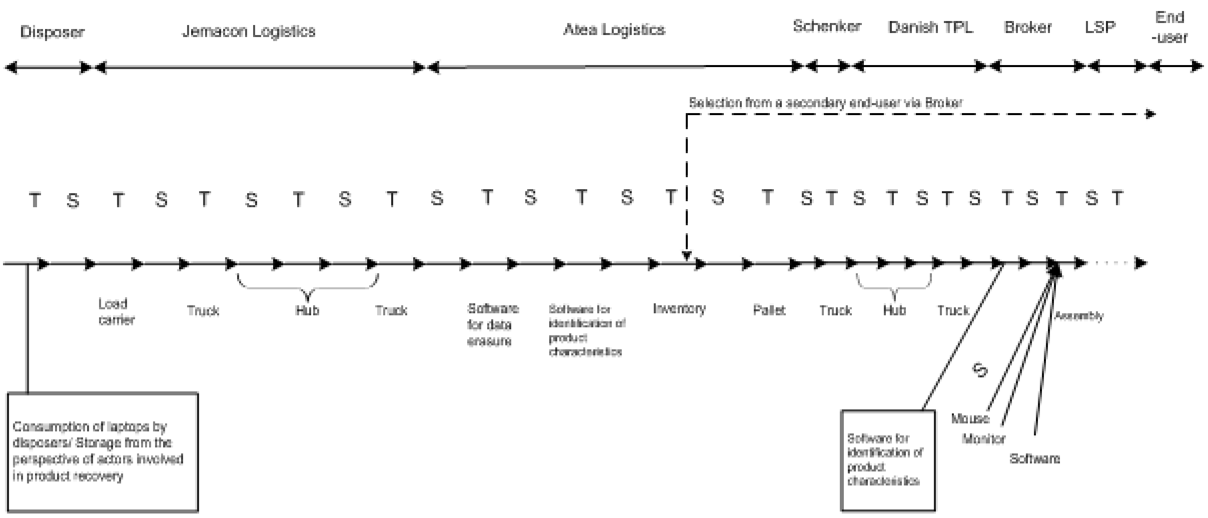

Figure 5.4 Illustration of Transvection 4.

There is a sorting rule for Schenker in Växjö that guides the assignment of objects to facilities. This rule states that if an order contains more than 1,000 kilograms, it does not have to be sorted in Schenker's local hub. As Schenker only transports the object to the regional hub in Denmark, the company is not aware of the final destination of the object. Nevertheless, Schenker is informed about time and place dimension of the object and, to a certain extent, about the form features of objects (e.g. weight, volume, length, breadth).

From the regional hub, the object is assigned to other smaller short haul trucks by another logistics service provider, who has received information on the broker's address and the object's delivery date from Atea Logistics. The broker then assigns other components and accessories, such as mice, keyboards, and software, to the refurbished laptop with the aim of differentiating the product in accordance with customer requirements.

Early provision of accurate information between the actors in the network creates opportunities for joint handling of parallel and sequential activity interdependencies. Transvection 4 is sequentially coordinated by disposers, Jemacon Logistics, and Atea Logistics until the object is tested and sorted in the form dimension after the transformation related to identification of form features. At this point in time, the object is not assigned any identity and hence placed in inventory at Atea Logistics. Here, marketing, purchasing, and inventory holding of objects display parallel dependence among activities.

Since Transvection 4 is characterised by the principle of speculation, the risk of unsold goods and consequent recycling is borne by Atea Logistics. This firm keeps the inventory of undifferentiated objects in time, place, and form features until an order for the object gets placed. Then, sorting and transformation in time and place dimensions are performed by Schenker and logistics service providers while certain form transformations are done by the broker. This firm is able to make adaptations towards end-users through the replacement and/or upgrading of some parts which could be delivered with new mice, keyboards, software, monitors, and other accessories. The object is then transported to the end-user by a logistics service provider.

Owing to the fact that Atea Logistics is deeply involved in coordination of Transvection 4, that company acts as the provider of information to brokers and other actors in the network. Thus, in Transvection 4 Atea Logistics and Schenker share only information about the object's pick-up and delivery hours and address between their own facility and the facility of the Danish logistics firm. The Danish logistics service provider is, in turn, given information about the object's delivery date and final destination. As logistics service providers are not given any unnecessary information, the information is adapted to each actor's needs in order to guide the object through the activity pattern.

5.1.5 Transvection 5 – LOOP4

In Transvection 5, a used laptop follows the same path as in Transvection 4, from the disposer to Atea Logistics. From Atea Logistics' facility and further down the network, the object is handled by Posten, Inrego and a logistics service provider. Inrego and Inrego's customer select the laptop before it arrives at Atea Logistics in Transvection 5 because information about the object's time, place, form, and identity dimensions are certain. Thus, sorts and transformations in this transvection, depicted in Figure 5.5, follow the same pattern as in Transvection 4 but the objects are not assigned to an inventory at Atea Logistics. Instead, they are assigned to a truck almost immediately after sorting and transformation at the testing and inspection facility of Atea Logistics.

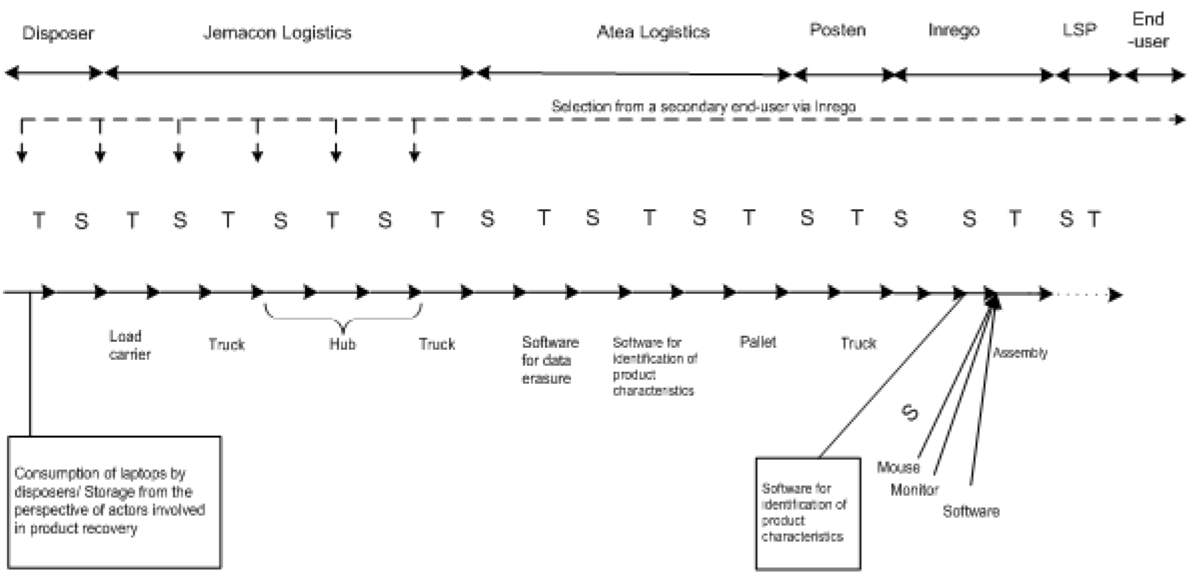

Figure 5.5 Illustration of Transvection 5.

The laptop is assigned to a resource for transformation that erases the data inside. If this transformation is successful, the object is assigned to a resource which alters or discovers (confirms) the object's characteristics in the form dimension. The used laptop acquires an article number which is used as a resource for sorting since it contains information about the object. These data are then shared with brokers.

As transformations at Atea Logistics' facility become finalised, the object is assigned to a pallet which is transported on Posten's vehicles of various sizes through a range of transportation set-ups, depending on factors including the size and the weight of the shipment. In Transvection 5 the size of the shipment is sufficient for a direct delivery by a single truck from Atea Logistics to Inrego. Inrego, in turn, can assign mice, keyboards, and software to the object, which is then transformed during assembly.

Transvection 5 is postponed by differentiation in time and place, and to a minor extent, form, at Atea Logistics and brokers. Many features in the form dimension of objects remain the same as when they were disposed. Nevertheless, Transvection 5 is closely complementary, as the object is assigned an end-user identity prior to its arrival at Atea Logistics' facility. Therefore, one of the key distinction between Transvection 4 and 5 is that the identity of the object in Transvection 5 can be end-user specific as soon as it is dispatched by the disposer.

Uniformity in time, place, form, and identity, and the reduction of supply uncertainty are achieved thanks to regular replacement of a number of objects with alike attributes in the form dimension, located close to each other at the disposers' sites. This uniformity creates opportunities to distribute the risks over several objects, and to provide the information about the future availability of objects to brokers and secondary end-users. However, it is not exactly certain which object gets selected by an end-user with regard to a unique article number.

Regarding parallel dependency, activities performed in the physical flows of objects and interaction processes involved in purchasing and marketing of objects are executed simultaneously. Brokers like Inrego, and, in extension, end-users, are able to place orders even when the objects are still at the disposer's premises.

Thus, disposers in Transvection 5 provide exact information about objects to Atea Logistics a longer period of time before the collection gets ordered. Therefore, Atea Logistics becomes able to effectively coordinate activities and share information about the objects with other actors. For logistics companies, information on form features, such as weight and volume, and including the breadth, height and length of objects, are more essential than detailed description of attributes such as the size of the memory or the speed of processor. As Atea Logistics' transportation partner for Swedish deliveries, Posten, manages the entire logistics arrangement from Atea Logistics to Inrego's facility in Stockholm, Posten is given complete information about object's entire path from a consignor to a consignee.

In summary, from the viewpoint of companies that are involved in product recovery, disposers maintain inventory in each of the transvections that were analysed. There is one major difference between the Transvections 1, 2, and 3, which were analysed in the first part of this section, and Transvections 4 and 5. In the latter transvections, there is a lower level of supply uncertainty with regard to the time, place, form and identity features of an object, owing to the fact that disposers provide accurate information about the laptop to Atea Logistics before it enters its facilities. This enables Atea Logistics to engage in long-term planning of its resources in terms of its capacity utilisation. In the next section of this chapter the resource layer of the scrutinised transvections is analysed.

5.2 Analysis of organising product recovery in the resource constellation

The resource constellation in this section is scrutinised with the 4R model. As portrayed in Figure 5.6, a used laptop is the object, which is regarded as the focal resource in this analysis. Supported by the framework of the 4R model, the object's interfaces with other products, facilities, organisational units, and organisational relationships, are discussed in this section.

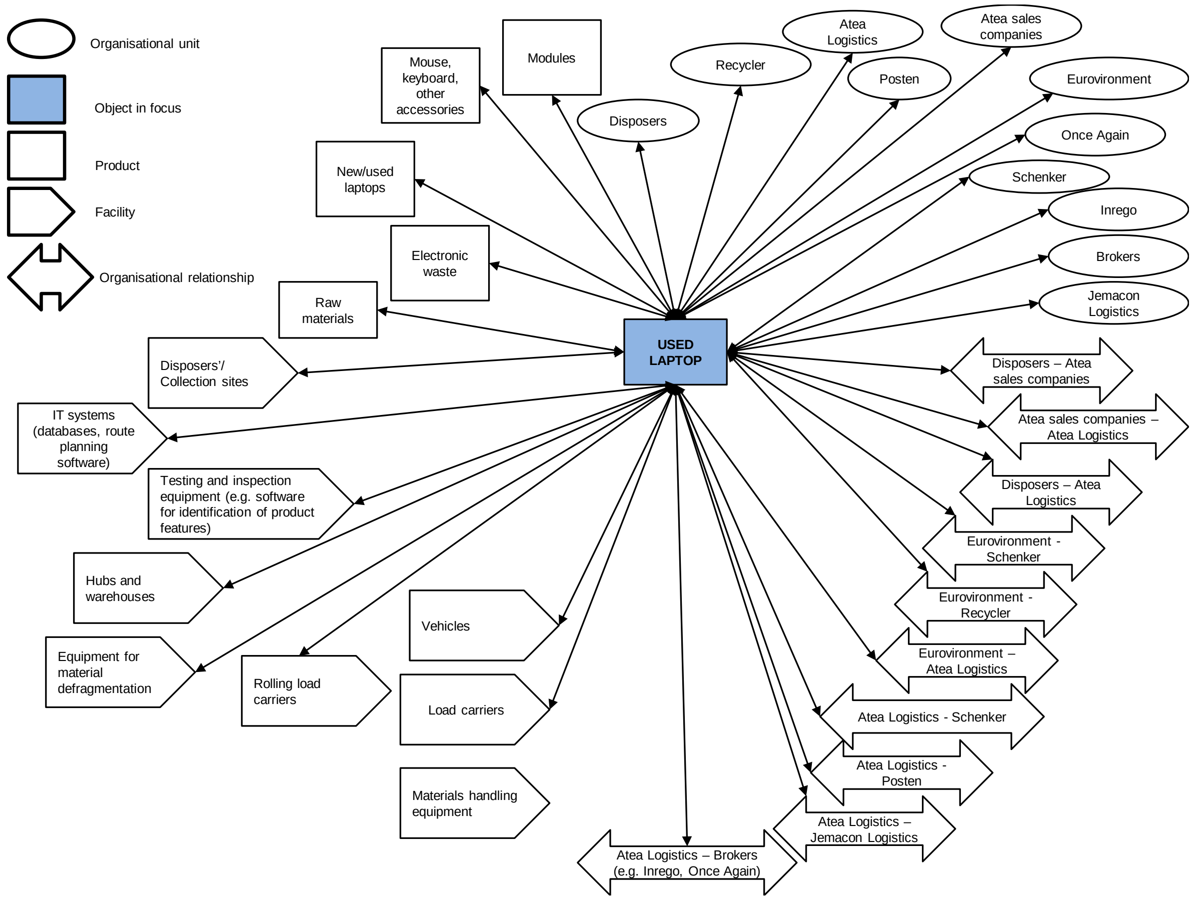

Figure 5.6 Overview of resources and their interfaces.

Figure 5.6 can guide the reader through the analysis since it accounts for an overview of the resources involved in LOOPs and related transvections. The object's interfaces with other resources are investigated in the associated subsections, and the first part of the analysis relates to the object's interfaces with other products.

5.2.1 The object's interfaces with other products

Objects like laptops are more or less well adjusted in resource combinations involving multiple product recovery options, such as recycling, repair and refurbishing. The greatest tension appears in reverse physical flows for recycling in Transvections 1 and 2. As recycling requires extensive reprocessing and manual categorisation, tensions in resource combinations for recycling run higher than in resource combinations that involve other reprocessing alternatives. This is a consequence of the tight raw materials combination in laptop modules that was designed to support efficient assembly for the sake of postponing product differentiation and customisation. On the other hand, the modular design that has been adapted for production-distribution networks of new laptops makes reprocessing options such as repair and refurbishing less laborious and time consuming, in comparison to recycling. After all, it is less complicated to replace parts and modules than to manufacture new raw materials out of electronic waste.

In Transvections 1 and 2, used laptops and other electronic waste have features of raw materials that were used in their original manufacturing. However, these objects that might display a large variety in use can complement each other during collection, classification, reprocessing and transportation. Thus, in Transvections 1and 2, objects classed as electronic waste are jointly distributed from disposers, via logistics service providers, to recycling firms. By utilising common features of electronic waste in terms of similar pick—up/delivery destinations and dates, it is possible to maximise the fill rates of trucks.

However, operations associated with collection, classification, reprocessing, and transportation of electronic waste do not proceed without tension and conflicts. For example, uncertainty as to quantity and form of objects results in the need for inventories in order to obtain economies of scale in transportation to a facility for categorisation of products. Inter-organisational coordination is essential as objects with equivalent material characteristics have to be forwarded to various resource collections for reprocessing and distribution.

As Eurovironment steers objects into appropriate reprocessing resource collections in Transvections 1, 2, and 3, common features of electronic waste from the disposer's perspective, enable spreading of fixed costs, investment and capacity. In other words, the focal object and other products share resources such as the knowledge of personnel and facilities on behalf of other actors in the network. In a similar vein, Atea Logistics and Jemacon Logistics use interfaces that associate laptops, keyboards, monitors and mice together in load carriers with the aim of coordinating forward and reverse physical flows in Transvections 4 and 5. One of the benefits of this arrangement is that it increases capacity utilisation as old equipment is collected simultaneously with the delivery of new equipment.

In addition to handling interfaces between the objects and other products, Atea Logistics manages interfaces between objects and their parts. The same labour force may perform the disassembly and reassembly of parts and modules. Moreover, software that identifies the features of laptop modules and deletes information inside of them can be used for parts and modules inside of other IT equipment, such as used printers. According to the same logic of exploiting comparable features of products in time, form, and, place dimensions, logistics companies such as Schenker and Posten, can transport various types of both new and used objects.

During the distribution of low-priced (refurbished or new) objects and products over longer distances, it is crucial to use the space in vehicles as economically as possible. Hence, these objects are placed tightly together in wooden boxes with the intention of utilising capacity as efficiently as possible. In addition, joint utilisation of inventory and various means of transportation by new and refurbished objects can reduce the costs of distribution.

Interfaces that involve competition between new and refurbished laptops are discernible at the level of Atea Logistics and brokers, as used laptops are offered together with new laptops and desktops. This competitive tension especially applies in the case of Atea Logistics, which has a more direct connection with manufacturers of new products. Conversely, other types of new products such as mice, keyboards, customised software, and parts/modules are complementary with used laptops. With regard to interfaces in recycling combinations, the focal object and other products can complement or compete with raw materials that do not originate from a recycling process.

5.2.2 The object's interfaces with facilities

Objects and facilities are mutually adapted in many types of situations during the execution of LOOP services. Facilities, such as load carriers, are adapted to the quantities and features of laptops. Therefore, when a disposer orders collection, the appropriate size, type, and quantity of the load carriers must be transferred from Atea Logistics. Thus, information about the object's features is of great importance for Eurovironment, which jointly with Schenker coordinates collection from the disposer's location to reprocessing firms and/or brokers.

Electronic waste and used laptops usually have very low monetary value per unit of weight or volume, which are two attributes with great impact on vehicle utilisation (i.e. transportation costs). This transport sensitivity of electronic waste implies that loading rates of vehicles are normally maximised while unnecessary mileage and associated costs are avoided in Transvection 1. However, the uncertainty in the form dimension of objects in Transvection 1 creates a need for inventory maintenance and categorisation of objects at Eurovironment to maximise the fill rates of trucks, headed for recycling companies. Nonetheless, from the recyclers' perspective, there may be difficulties in obtaining sufficient continuous volumes for the defragmentation equipment, as accurate quantities and qualities of products are not completely known until after their arrival.

Comparable difficulties may also appear at different facilities in Transvections 2, and 3 as a result of uncertainties related to the object's form features. In addition, uncertainty about object features may create excessive transportation between disposers, Eurovironment, Atea Logistics, and recyclers and unnecessary inventory handling in Transvections 2 and 3. On the other hand, inventories at Eurovironment, Atea Logistics and other actors are essential as a means of adapting classified laptops and other objects to input requirements of recycling and refurbishing equipment via transportation of full truckloads or other load carrying units, such as pallets and containers. These resource combinations are therefore developed with the intention of economising on vehicle space and minimising the number of loading and reloading operations.

Regarding load carriers that are used in collection, reprocessing, and distribution activities, laptops may share standardised load carriers, which are adapted vis-à-vis resource combinations related to transportation. During the collection phase, load carriers need to be adapted to the features of disposers' site, and vice versa. Thus, load carriers in all transvections are adapted in their physical features to the size of doors, elevators and other construction standards of disposers' facilities. This is done in order to reduce damage to objects and to make loading and reloading operations as easy as possible. For these reasons, disposers are provided with instructions and rules on how to combine objects in load carriers associated with Transvection 3, so that the job of collection proceeds as efficiently as possible. In Transvections 4 and 5, it is Jemacon Logistics, which, during collection, combines used laptops and other accessories in the rolling load carriers at disposers' premises. The wheels that are attached to these load carriers enhance materials handling inside of disposers' sites as the load carriers themselves can be rolled in and out of the buildings. Moreover, these specialised load carriers create opportunities for leaner processes at hubs and refurbishing facilities.

Since features of objects in Transvection 1 do not have any monetary value in their present state, load carriers in this transvection are primarily designed for optimal utilisation of volume in vehicles and inventories. Therefore, transport damage to objects does not have to be taken into account when the goods are collected from disposers and distributed to recyclers. In this way, load carriers used in Transvection 1 and 2 are the ones that are most adapted to existing logistics resource constellations out of all LOOPs. More precisely, the cages that are applied in arrangements involved in Transvection 1 and Transvection 2 are primarily adapted to the size of EUR-pallet, which is adjusted to Schenker's transportation network, designed for efficient materials handling at hubs, and distribution centres. Moreover, Schenker's transportation network is adapted to this type of load carriers on several levels, such as containers and trucks. This standardised resource combination and large volumes make Schenker a scale-efficient partner for Atea Logistics and Eurovironment.

A similar situation concerns distribution between Atea Logistics and Once Again or Inrego and further down to the end-user of the refurbished laptop. These objects, including used laptops, are adapted to Posten's logistics network with standardised pallets, utilised for many other kinds of products. Conversely, rolling load carriers in Transvections 4and 5 are more influenced by laptops, as these load carriers are especially designed to carry IT equipment without any undue cardboard packaging.

As features of products in the resource combination concerning Transvections 3 and 4 could be more valuable with respect to information content and price, load carriers must be adapted to this type of used laptops in order to prevent the risk of theft. This adaptation with regard to altered product features is done by closing load carriers and equipping them with padlocks, which, in turn, usually means a decrease in the size of the shipment. As a smaller amount of weight, units, and volume of objects is transported and handled in Transvections 3, 4, and 5, the space in vehicles is less efficiently utilized than in Transvection 1 or 2. Nevertheless, load carriers, in Transvection 2 and 3 are compatible with each other in order for them to use the same transportation and materials handling resources.

All in all, quality and quantity aspects of objects are used to develop and formulate rules that guide the objects in the network toward appropriate facilities, such as testing machines, and software for form identification, which are all adapted for inspection of laptops, desktops, and printers. These facilities are either adapted to the features of objects as they were initially bought, or to features of modules and raw materials inside of objects. In this manner, certain form features of objects will guide the objects to facilities belonging to various organisational units.

5.2.3 The object's interfaces with organisational units

Disposers' skills in the purchasing of reverse logistics services, and its related knowledge in organising information about objects in form (e.g. age and technical specifications), time (delivery/collection date) and place (geographical location) dimensions affect resource combining and recombining. Organisations that have more precise data about these object features provide opportunities for Jemacon Logistics and Atea Logistics to achieve integrated coordination of forward and reverse physical object flows in Transvection 4 and 5. Jemacon Logistics is, in turn, affected by used laptops because its logistics planning and execution expertise revolve around this product. In addition, Jemacon Logistics' capabilities with regard to organising goods handling equipment, warehouses, and IT software, are built around laptops and other IT equipment.

Other logistics service providers involved in LOOP services, such as Schenker and Posten have the knowledge required to minimise overall logistics costs. Thus, logistics companies are concerned with how their facilities are managed, and how objects coming from various geographical locations headed for a range of sites could be coordinated jointly. This organising is supported by their competence in managing facilities related to their physical and informational infrastructure, such as warehouses, IT systems and materials handling equipment. In particular, logistics service providers have expertise in the efficient physical handling of objects in standardised load carriers at their facilities. Thus, the objects that are distributed in the same state as when they were bought, or as raw materials, do not have a considerable impact on operations performed by logistics service providers.

Eurovironment is affected by used electronic goods because its personnel are familiar with sorting rules and testing machines. Furthermore, Eurovironment has skills in collecting and organising data about disposers and features of their facilities. This information is are stored in a database, and includes pick-up and delivery locations of load carriers, which are continuously updated so that Schenker's used object collection processes may proceed as smoothly as possible.

Used objects influence Atea Logistics in terms of its expertise in operating software, testing machines, and material handling equipment, which are utilised in reprocessing and storing objects before these are sent to brokers. Nevertheless, used objects have a minor influence on Atea Logistics since the company is primarily concerned with distribution of new IT equipment. As Atea Logistics is dealing with used objects in almost the same form as those that are delivered as new, the company does not experience same difficulties as recycling firms who process raw materials inside of used objects.

Brokers, in turn, are influenced by the used objects to a great extent. In Transvection 3, for example, Once Again had expertise in physically categorises these types of objects. Once Again's skills relating to using inspection, reprocessing, and material handling equipment are significant for the efficiency of the internal processes. In addition, expertise in promoting used objects and provision of information to Atea Logistics about the desired object features affects the direction of objects into distinctive resource collections of the network.

Manufacturers of new products indirectly influence objects and other actors involved in reprocessing and distribution activities via their pricing principles. Furthermore, their product design methodology which includes the choice of materials for ease of assembly, and thus, disassembly, has a great influence on reprocessing operations. Public actors affect this kind of network in a more indirect sense as authorities that regulate international physical flows. For instance, these regulations have an impact on Eurovironment's resource utilisation and expansion, as electronic waste is not allowed to cross borders freely. As a consequence of these rules, Atea Logistics' customers of new products in northern Norway have to ship their disposed objects for inspection to Oslo instead of sending them products to Eurovironment where the objects could jointly use Eurovironment's facilities for the same purpose.

5.2.4 The object's interfaces with organisational relationships

Organisational relationships are often a prerequisite for organising forward and reverse object flows. The organisational relationship between Atea's sales companies and disposers is an enabler of coordination between collection, reprocessing, and distribution, as disposers order reverse logistics services through the sales companies. Used laptops affect the relationship between the sales companies and disposers only marginally since sales companies focus on the distribution of new objects.

In contrast, the relationship between Atea Logistics and Jemacon Logistics in Transvections 4 and 5 is significantly influenced by used laptops and other IT equipment. Atea Logistics and Jemacon Logistics are specialised in logistics and work together to plan the routing of used IT products from disposers to Atea Logistics' refurbishing facility in Växjö. Thus, used objects have an impact on the relationship between disposers and logistics service providers, Atea Logistics and Jemacon Logistics, since these relationships facilitate information exchange about object features related to forward and reverse physical flows in Transvections 4 and 5.

As regards physical flows in Transvections 1, 2, and 3, the orders containing information about objects are transferred from the disposers to Atea's sales companies via Atea Logistics, and then on to Eurovironment. As a result, used laptops influence business relationships between Atea's sales companies and Atea Logistics, and Atea Logistics and Eurovironment. However, the used laptops are only physically handled in the business relationship between Atea Logistics and Eurovironment, which means that these objects have a larger impact on jointly planned activities of these two actors than on collaboration on order handling between Atea Logistics and Atea's sales companies.

Organisational relationships between Eurovironment and disposers affect the collection of used laptops. Eurovironment has more detailed and updated data about the characteristics of objects at disposers' sites than Atea Logistics does. Information flow of orders (i.e. the fact that Eurovironment receives orders from disposers via Atea's sales companies and Atea Logistics) could be examined. At present, Eurovironment has a minor influence on the content of LOOPs and the choice of LOOP services. Nevertheless, Eurovironment's relationships with disposers have so far contributed to enhanced detailed knowledge about disposers, which streamlines coordination of the collection process.

When Atea Logistics receives an order, it is transferred to Schenker so that Eurovironment and Schenker can arrange for the collection of the used laptops. Thus, object features influence the relationship between Schenker and Eurovironment, as these actors organise loading and reloading sequences during the collection and transportation of used objects to

Eurovironment’s facilities. Further down the network, the organisational relationships between recyclers and Eurovironment, and between Eurovironment and Atea Logistics, have encouraged the development of sorting rules that direct the objects from Eurovironment to Atea Logistics or the recycler. In addition, haulage to Eurovironment’s and recyclers’ facilities must be coordinated so that the costs of logistics operations are kept at a minimum.

Used laptops have an influence on the business relationship between Atea Logistics and Eurovironment as these laptops and other IT equipment are the only ones handled in this relationship. The business relationship between Atea Logistics and Eurovironment is essential for Eurovironment as Atea Logistics is its largest refurbishing partner. Moreover, interlinking and adaptations of IT systems between Atea Logistics and Eurovironment provide a means for exchange of accurate data regarding available quantities of load carriers, pick-up/delivery dates and geographical locations of objects. In this manner, information sharing can reduce investments in potentially unnecessary load carriers by ensuring efficient utilisation of those load carriers already in use. An additional benefit of extensive information exchange in the network is the opportunity for capacity planning of Atea Logistics’ facilities in relation to its other relationships with manufacturers, customers and brokers.

The organisational relationship between Eurovironment and the recycling firms is of major importance for the efficient functioning of inter-firm resource adaptations. Eurovironment categorises objects physically with regard to the equipment of recyclers, which, in turn, indicates that this relationship is affected by electronic waste. On the other hand, used and/or refurbished laptops influence the relationships between Atea Logistics and brokers such as Once Again and Inrego. Once Again, Inrego, and other brokers provide information about features currently requested by their customers. Information on the conditions of supply and demand of objects, which is exchanged in organisational relationships between disposers and Atea Logistics, Jemacon Logistics and Atea Logistics, Atea Logistics and brokers, facilitate refurbishing in line with the principles of postponement and speculation in Transvections 4 and 5. In this way, inter-firm cooperation within relationships, affects the appropriate temporal organisation of object flows between disposers and secondary end-users.

When it comes to end-users and brokers of refurbished laptops in Sweden, Posten is responsible for deliveries of both new and refurbished laptops. In this organisational relationship, Atea Logistics adapts refurbished laptops to Posten’s facilities by packing them tightly in wooden boxes, which are compatible with the measurements of EUR-pallets. Hence, Atea Logistics is more influenced by the relationship with Posten than the other way around, as refurbished objects coming from Atea Logistics’ facilities are adapted to load carriers that are standardised in relation to Posten’s transportation network. This is done with the aim of maximising the fill rates of load carriers. As Atea Logistics is a major customer of services provided by Posten, this relationship has an impact on Posten with respect to a certain reserved capacity assigned to Atea Logistics. Nevertheless, Posten has many other relationships of various types, which means that it is not as affected by the relationship between Atea Logistics and Posten as vice versa. As evident, business relationships between actors influence resource combining and recombining. Thus, in the next section resource combining and activity coordination are scrutinised through the actor layer of the ARA model.

5.3 Analysis of organising product recovery in the web of actors

This section aims to examine the actor network surrounding Atea Logistics, which is presented in Figure 5.7. Analytical concepts that are associated with the actor layer of the ARA model are used in order to discuss business relationships in this network.

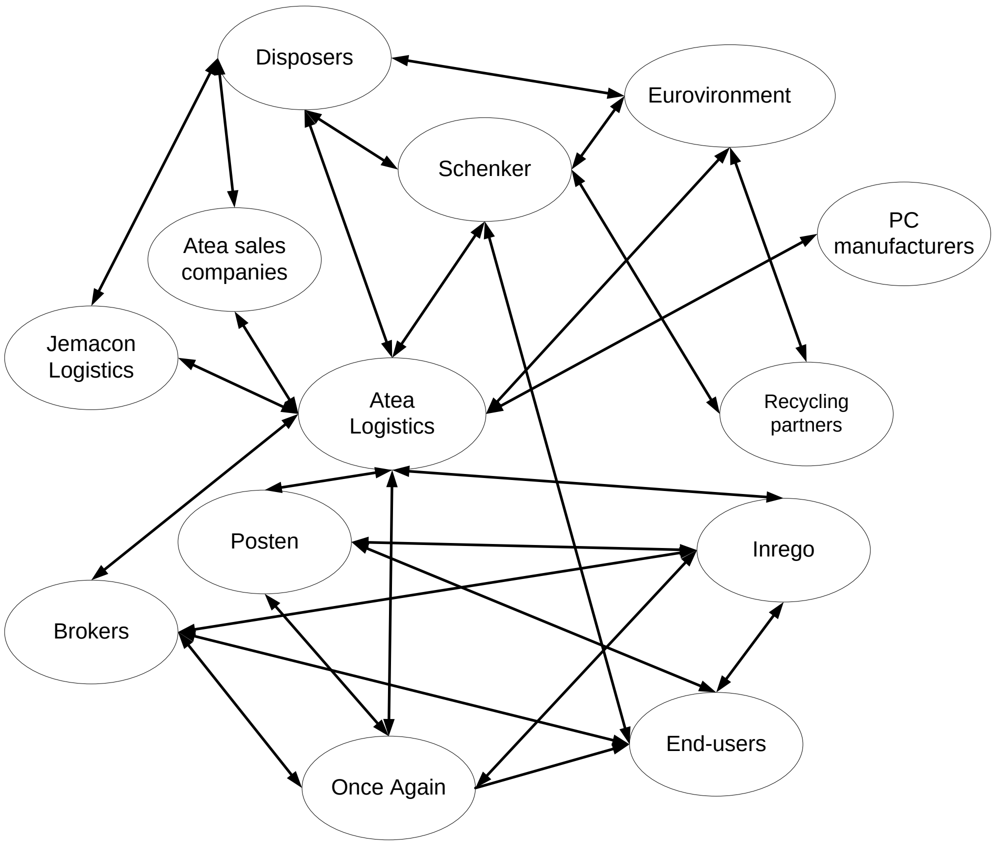

Figure 5.7 Business relationships in the network surrounding Atea Logistics.

Analysis of the actor layer of this network begins with a discussion of the nature of business relationships and positioning of actors. The second and the final part of this analysis scrutinises information sharing in the network.

5.3.1 Business relationships and positioning of actors

Positioning of actors is achieved through interaction in business relationships. Business relationships are thus important for efforts related to specialisation and boundary-setting in the activity and resource layers of networks.

Close collaboration in business relationship between Eurovironment and Atea Logistics has made it possible to achieve flexibility in activity coordination and resource combining of collection and reprocessing operations. Furthermore, continuous adjustments in the activity and resource dimensions of networks have led to the development of sorting rules, which direct the objects into different product recovery options, as efficiently and as effectively as possible. In other words, this relationship has served as an enabler of specialisation and positioning of actors in a counterpart specific way. For instance, Eurovironment and Atea Logistics have positioned themselves towards each other through resource adaptations by linking information systems and databases.

However, the presence of extended inter-organisational communication channels creates some delays and disruptions in cooperative coordination of activities and resource combining between Atea Logistics and Eurovironment. Eurovironment always gets orders (on occasion with incomplete information) through Atea Logistics, and never directly from the sales companies of Atea Group. This may result from the Atea Group's competitive policy towards its internal and external suppliers of products and services. This means that sales companies can choose to procure product recovery services from other suppliers, in addition to Atea Logistics. Therefore, in order to maintain its position, Atea Logistics fosters its direct relationship with Atea's sales companies that are the link between Atea Logistics and disposers (suppliers of used products). Otherwise, sales companies or disposers themselves would choose Eurovironment as their supplier of logistics and product recovery services. In that regard, Atea's policy that allows its sales companies to enjoy a relatively extensive freedom in choosing their suppliers of product recovery services can disturb the development of resource adaptations and a closer relationship between Atea Logistics and Eurovironment.

In addition to mutual adaptations of IT systems between Atea Logistics and Eurovironment, both parties have agreed upon boundaries regarding features of objects, more precisely, boundaries between these two actors regarding classification rules on what objects to assign to resources for transformation at Atea Logistics. In this way, boundaries with respect to differences in the type of products that are handled by Atea Logistics and Eurovironment accommodate cooperation between these firms. An additional advantage of these cooperative boundaries is the establishment of stability in the relationship. This stability can be used to generate improvements in activity coordination and resource combining through actor specialisation.

In addition to accommodation of collaboration, boundary-setting decreases the risk of direct competition between Eurovironment and Atea Logistics, as both of the parties are involved in the business of refurbishing IT equipment. This inter-firm competition between Atea Logistics and Eurovironment is an outcome of the resemblance amongst customers of these companies, who are generally disposers of used objects and buyers of refurbished products (various types of organisations in private and public sector in Sweden and internationally). On the other hand, the fact that Eurovironment is cooperating with other disposers is benefiting Atea Logistics since Eurovironment can spread the fixed costs of investments over several units. This is attributed to joint resource and capacity utilisation.

In contrast, as Eurovironment, in its role of a potential direct competitor, is not involved in coordination of physical flows in LOOP4, there is greater openness and information sharing between actors involved in this business setting. Atea Logistics' main collection partner, Jemacon Logistics, is a more specialised logistics service provider that does not distribute nor reprocess used objects. Thus, there is no risk of direct competition between Atea Logistics and Jemacon Logistics. This relationship exhibits all characteristics of a high-involvement approach to business relationships. Organisational relationships characterised by these kind of high-involvement features usually promote efficient and effective activity coordination and resource combining. Therefore, in LOOP4, the disposers, Atea Logistics, and Jemacon Logistics, have tried to take advantage of spatial proximity of the disposing organisations in joint logistics planning. Through resource adaptations in LOOP4, actors try to increase the efficiency of the resource constellation of the network. In this manner, organisations have created activity links and resource ties with the aim of cultivating and advancing activity adjustments and resource adaptations. This increases capacity utilisation and enhances efficient resource combining as the actors involved in LOOP4 always try to achieve full carloads in transportation.

As regards logistics service providers, such as Jemacon Logistics, Schenker, and Posten, there are economies of scale when both forward, reverse, and/or back-haul physical flows are coordinated. To be more precise, objects can jointly utilise distribution resources, such as pallets, trucks, and hubs with respect to many consignors and consignees. Through the utilisation of standardised pallets Atea Logistics, Inrego, and Once Again have all made adjustments in relation to resource collections by Posten and Schenker. These two large logistics firms have developed resource structures with a focus on these standardised pallets.

Concerning cooperative positioning between logistics service providers it is evident that firms that are procuring transportation of goods create boundaries associated with national borders. For example, Atea Logistics is employing Posten for Swedish deliveries and Schenker for Norwegian and Danish deliveries, irrespective of the content of shipments. From the perspective of logistics service providers it is also apparent that they position themselves with regard to senders and receivers through differentiated resource combining and activity configurations. The most notable difference in resource collections and activity structures is between Jemacon Logistics, and Posten or Schenker. While Jemacon Logistics has created a resource combination that is adjusted for logistics of IT equipment, Posten and Schenker adapt the products in relation to their resource structures for palletised consignments. In other words, as resource adaptations in the business relationship between Jemacon Logistics, disposers, and Atea Logistics are more actor-specific, they require more intense interaction.

Actor positioning through specialised load carriers provided by Jemacon Logistics improves activity coordination, since this equipment is adapted in relation to facilities belonging to disposers, reprocessors, and distributors.

Differentiated positioning between actors in forward and reverse physical flows is evident in the relationship between Atea Logistics and PC manufacturers. Since Atea Logistics now only sells logistics services and does not make a profit on new products, the company has ended up in a less favourable position in its relationships with PC manufacturers who have therefore bypassed Atea Logistics in their sales of new products. When it comes to reverse distribution, Atea Logistics is able to make a profit with regard to products and services. Furthermore, Atea Logistics and manufacturers cooperate in the coordination of activities and resource combining involved in product recovery set-ups. By distributing refurbished products, Atea Logistics is indirectly competing with PC manufacturers, as the refurbished products can end up with end-users that do not desire to replace their old equipment. This situation is usually avoided as most of products are transferred to end-users in other geographical regions. From a wider network perspective, it seems that Atea Logistics has gained a more advantageous position in and through relationships involved in product recovery contexts, as brokers on occasion bid against each other in order to obtain refurbished products from Atea Logistics.

With regard to business relationships with brokers of refurbished equipment, Atea Logistics normally sells these products to brokers, such as Inrego and Once Again. These brokers handle a large number of relationships with a varying level of interaction, in order to leverage supply and demand. Thus, business relationships with buyers, sellers, and intermediaries enable the brokers to search for products throughout the network. In a similar vein, Inrego's and Atea Logistics' relationships that are not characterised by intense interaction and close collaboration are important in finding a match between supply and demand. Both of these brokers could be potentially in direct competition with Atea Logistics because they perform refurbishing activities and combine resources on products that come from disposers via Jemacon Logistics. Yet again, it is crucial to create boundaries in order to promote cooperation and avoid direct competition in relationships which display regular interaction patterns (e.g. when Atea Logistics sells refurbished units to Inrego), and in situations characterised by more irregular interaction processes (e.g. when Atea Logistics buys from Inrego).

5.3.2 Information sharing in the network

Close interactions and information sharing between disposers, logistics service providers, reprocessors and other actors in the network enhance opportunities for synchronisation and continuity of flows. In this way, organisational relationships make it possible to handle interdependence between activities in product recovery arrangements. Sharing of detailed product information between disposers and other actors in the network a relatively longer period of time before the objects are reprocessed creates possibilities for proper organisation of operations inside and between facilities. In other words, machines and trucks require guaranteed, steady flows of used products. Taking this into consideration, Atea Logistics tries to reduce uncertainty with respect to time, place, and form attributes of objects on the level of the network by LOOPs. That is to say, these standardised arrangements entail a predetermined set of activities and resource combinations.

Regarding LOOP1, LOOP2, and LOOP3, activities are adjusted to each of these among Schenker, brokers, Eurovironment, Atea Logistics, and the recycling company. The fact that disposers determine whether, when, and where the objects enter the network on a short time basis, imposes uncertainty in form dimension from the perspective of Eurovironment. This uncertainty is translated into time and space uniformities of objects, as physical characteristics of objects need to be determined at Eurovironment's facility. Objects which are diverse in terms of their material content or product features are collected from disposers at the same time and place, with the aim of obtaining economies of scale in transportation. At Eurovironment, categorisation in form dimension steers the objects into facilities specialising in different product recovery options (e.g. to Atea Logistics for refurbishing and/or to Eurovironment for recycling).

For LOOP2 and LOOP3, this uncertainty in form is handled in cooperation between the recycler and Atea Logistics through the establishment of object classifications, grades, and associated sorting rules. These rules have to be modified continuously due to technological development, including advances in materials technology or changes in raw materials in products. Cooperation and interaction between actors have contributed to development of categorisation rules, as actors have learned a lot about each other in social, economic and technological sense. Thus, relationships between actors enable joint learning and development of such rules that can be used as mechanisms for resource combining between companies. As variety in form attributes of objects requires different types of testing and reprocessing facilities, the expertise of classification is essential in order to facilitate routine decision-making and activity coordination between the actors that are involved in collection, testing, reprocessing, and distribution.

Thanks to close collaboration between Schenker and Eurovironment, it is possible to achieve economies of scale and efficient routing during the collection of used objects. One of the reasons for this effective activity coordination is the intensive interaction between Eurovironment and disposers. However, this interaction and information exchange between Eurovironment and disposers is presently limited to the place and time dimensions of used objects as Eurovironment does not exert any influence on the disposers' choice of LOOPs. Since Atea Logistics receives huge share of non-functional units via LOOP2 and LOOP3, which it must send back to Eurovironment, it is crucial to continuously adapt and adjust sorting rules that direct objects between facilities of Eurovironment and Atea Logistics. Thus, joint adjustment of activities and transfer of sorting and grading rules between actors in the network may decrease excessive transportation and storage.

Further down the network, standardisation of rules and classifications of refurbished objects between Atea Logistics and second hand broker, provides reduction of uncertainty with regard to monetary value and quality. Linking of product characteristics and price through the grading of refurbished objects, reduces uncertainty in the network because it creates a common language for the industry. This social contract decreases the need to test, sort and grade products at each step in the network.

5.4 Summary of the case analysis

The nature of business relationships between actors impacts on the organising of product recovery arrangements, in terms of how activities are coordinated and how resources are being combined. Interaction between organisations facilitates cooperative boundary setting between specialised actors (e.g. in terms of types of products that are exchanged between companies). By doing so, companies can differentiate themselves with respect to the supply and demand of their products and services. These boundaries enhance cooperative efforts among firms regarding resource adaptations, and decrease the risk of direct competition. This applies to business relationships with varying degrees of interaction intensity.

Most of the LOOP services (LOOP1, 2, 3, and 4) and associated Transvections (1, 2, 3 and 4) in the network around Atea Logistics operate according to the principle of speculation, in order to generate parallel dependencies between activities. This is the result of used products being sent from disposers more or less autonomously with respect to issues such as quantity, quality and time. Organisations involved in product recovery arrangements are concerned with resource combining and recombining during collection, reprocessing and distribution activities. Logistics service providers coordinate activities with respect to quantities that could be collected during a visit and lead time for pickup orders.

Transvection 5 is organised according to the principle of postponement. Exchange of accurate information facilitates efficient scheduling of simultaneous delivery of new products and collection of used ones. In this way, it is possible to handle parallel and sequential dependence of activities between disposers and end-users of refurbished products in an organised way. In Transvection 5, many objects coming from disposers share same features. This enables reduction of uncertainty with regard to time, place, identity and form dimensions of individual objects for Atea Logistics and other actors. Because information exchange about objects takes place prior to physical handling, Atea Logistics can start promoting objects even though some might not be working after inspection at Atea Logistics. In other words, even if an object does not meet requirements (due to defects, for example) of new buyers, other similar objects can replace the malfunctioning one. Thus, by exploiting parallel dependencies between activities, Atea Logistics utilises business relationships to search for buyers of particular objects in use at the disposer.

Established categories for information handling of objects regarding form, time, place and identity, provide an aid in sorting of objects to facilities where different kinds of product recovery operations are performed. Sorting rules determine the path of products and how raw materials, parts, and objects are combined and recombined with facilities, organisational relationships, and organisational units.

6 CONCLUDING DISCUSSION

The aim of this chapter is to discuss the main conclusions in a summarised manner, including the theoretical and practical implications of the study. The chapter concludes with suggestions for future research.

6.1 Organising product recovery – a network perspective

The aim of this study is to develop a framework for the exploration of different ways of organising product recovery from a relational and network perspective. The research on understanding business relationships and inter-organisational coordination of these resources and activities has been pinpointed as an area that was not previously sufficiently investigated. Moreover, it has been argued that organising product recovery is a complex issue that entails a holistic perspective, as inter-organisational structures influence economic and environmental effects. For that reason, the Industrial Network Approach has been applied in this thesis. This study demonstrates that concepts related to analysis of efficiency and effectiveness of supply and production-distribution networks, which were developed within the Industrial Network Approach, are well adapted for investigating these issues in product recovery.

This theoretical base has contributed to an understanding of the phenomenon organising product recovery from an integrated viewpoint of all three layers of the ARA model through the analysis of the activity pattern, the resource constellation, and the web of actors. One of the theoretical contributions of this licentiate thesis is the multifaceted analytical framework for studying product recovery structures, which according to my belief can be applied to other kinds of networks.

Furthermore, separate analyses of the actor and resource layer with regard to multiple product recovery options are regarded as additional theoretical contributions of this thesis. The research within the area of reverse logistics and Closed Loop Supply Chain Management has been mainly guided by a process-based view. Most of the frameworks are based on generic descriptions of activities, which include acquisition, collection, transportation, classification, product recovery options, and distribution of products, parts, and raw materials to new end-users of the final product, or to intermediate actors who need these objects for production. In addition to an in-depth analysis of activity structures, the Industrial Network Approach has provided a means to understand implications that are specifically related to the resource and actor dimension in relation to organising product recovery.

In the *activity layer* of networks, principles of postponement and speculation, activity similarities (parallel interdependence) and complementarities (sequential interdependence) are as crucial in inter-firm organising efforts within product recovery milieus, as in supply and production-distribution networks. Disposal, collection, various product recovery options, and distribution are in this way sequentially interdependent. Parallel dependence and activity similarities in product recovery, for example, can include the use of the same testing equipment, refurbishing capabilities, transportation facilities and inventories. In addition, actors jointly organise product recovery through the management of both parallel and sequential dependencies between collection, product recovery options and distribution in order to bridge form, time, place, and quantity discrepancies between disposers and actors that utilise these objects either for reprocessing or novel use.

This thesis has shown that activity similarities and complementarities can be used in combination with the concept of transvections for investigation of economies of scale and customisation of product recovery processes. The essence of activity coordination with respect to organising transvections in product recovery arrangements lies in the handling of activity similarities and complementarities of sorts and transformations in transvections. Moreover, the organisation of transvections in time has been depicted through the application of the principles of postponement and speculation. The conclusion is that the principles of postponement and speculation, which were developed in order to illustrate situations in which uncertainty and flexibility have to be managed concurrently, are appropriate for analytical descriptions of temporal aspects with regard to organising activity patterns in product recovery settings.

When it comes to the *resource dimension* of the Industrial Network Approach, and the ARA model, organising product recovery in terms of resource combining and utilisation is affected by the degree of resource adaptations. The application of the 4R model on resource constellations involved in product recovery, shows that developed cooperation and resource adaptations between disposers, logistics providers and reprocessors facilitate improved inter-organisational coordination. Furthermore, as stated above, the analysis of resource interaction and resource interfaces between objects, facilities, organisational units, and organisational relationships provides a complementary view on product recovery, which has been mainly studied from a process or activity perspective. The analysis of the resource layer shows how facilities have been adapted to enhance efficiency and effectiveness in product recovery. An example of this adaptation concerns the adaptation of material handling equipment in relation to the products that are recovered. The design of the product itself plays a crucial role for how product recovery can be organised with regard to resource adaptations. For instance, modular design creates great opportunities for efficient performance of recovery options. With regard to product recovery options, resource combinations might be characterised by varying level of tensions. This is the result of adaptations made in forward physical flows and associated resource constellations, which are particularly inappropriate for resource combining in recycling operations. The 4R model highlights these tensions, which are not as visible as when the main focus is on the processes alone.

In a similar vein, *the actor layer* of the Industrial Network Approach provides an additional perspective on organizing product recovery as the role of actors is to coordinate activities and combine resources. The application of the Industrial Network Approach shows that firms that are dealing with product recovery are interconnected through business relationships. The concepts related to the actor layer, such as the nature of business relationships and the level of relationship involvement can capture the impact of interaction processes on organising product recovery. Hence, because networks performing product recovery operations involve relationships between several specialised firms, it has been demonstrated that the investigation of the nature of business relationships and the positioning of actors contribute to an understanding of the organising of these arrangements. Actors have differentiated approaches toward their partners on the supply and demand sides as regards intensity of interaction. Even the less frequent contacts can be essential in order to balance supply and demand. Therefore, business relationships with varying level of interaction and involvement enable matching supply and demand in networks dealing with product recovery. Interaction between actors on a network level enables positioning in a counterpart specific manner towards their partners on both supply and demand side in order to enhance organising product recovery by cooperative resource adaptations, and activity adjustments. Moreover, positioning via interaction is crucial for the dedication and boundary setting of resource combinations and activity structures between a firm and its surrounding actors.

Several authors have shown that production, distribution and use are interrelated and that boundaries between these processes are blurred. From a network perspective, however, this study demonstrates that boundaries between the production, distribution, use and product recovery phases of collection and reprocessing are interdependent. This thesis indicates that product recovery operations are interconnected in a network of inter-organisational relationships between different facilities and actors. From the end-user's perspective, there is no distinction between reverse and forward physical flows as end-users can choose to buy new or refurbished products or raw materials. This means that both of these flows can be regarded and studied as parts of the same network.

6.2 Transvections in product recovery

One of the theoretical contributions of this licentiate thesis is the application of the concept of transvection to product recovery activities. That is to say, in this study, the concept of transvection was used in combination with the analytical tools and concepts associated with the activity layer of the Industrial Network Approach in order to investigate organising product recovery processes in networks. Transvections effectively describe various ways of handling similarities and complementarities among activities with regard to postponement, speculation, and direction of objects into alternative product recovery options. In total, five transvections have been described and analysed in order to illuminate various paths that a product takes from the disposer to the use of the recovered product, i.e. the actors demanding recovered products. Therefore, analytical descriptions of transvections have been used to visualise the path from disposers to recyclers, and the processes between disposers and end-users through remanufacturing and refurbishing.

The transvection in its original conceptualisation captures all activities in a supply chain, from raw materials and continuing into the hands of the end-users. One of the theoretical implications of this thesis concerns the perspective of integrated forward and reverse physical flows, which can be framed within the concept of *extended transvections*. Extended transvections are particularly interesting in light of integrated approaches to forward and reverse supply chains, such as Closed Loop Supply Chain Management. In forward physical flows, one of major discrepancies is between producer stocks and consumer assortments since a *"product appears in a very different setting at these two levels and may be said to belong to the technology of production at one stage and the technology of use at the other"* (Alderson, 1954, p. 12). In extended transvections, objects currently in use belong to assortments of goods that can also be looked upon as intermediate assortments. Disposers maintain inventory of different kinds of products, which are both those in use, and held in a stock that could be reused in its present form or as materials, parts and energy.

Therefore, the function of the business network becomes to find a match between these segments of reverse supply with the corresponding segments of demand. The uniqueness and heterogeneity of reverse supply and demand are dispersed over very wide geographical areas because unwanted items and heterogeneous customer requirements exist at different places. This situation creates discrepancies of assortments in time-place-quantity-form which are resolved through organising of extended transvections in business networks. In a product recovery context what Alderson (1954) coined as 'technology of use' must be connected to 'technology of production'. Another set of activities need to be organised in order to move the goods from one side of the heterogeneity to the other side by capturing parallel and sequential activity interdependencies of extended transvections.

Thus, the viewpoint of an end-user has been incorporated into the analysis of product recovery by describing how refurbished and remanufactured products come into the hands of the end-user. As most of the research about product recovery has been focused on collection and reprocessing activities, this point of view is regarded as a theoretical implication, which can contribute to a more thorough understanding of this actor in reverse physical flows. Research in the field of reverse physical flows and related transvections can give the consumer (organisational or individual) with different needs and requirements a more significant role in the network.

Two kinds of sequentially interdependent activities define a transvection: transformations and sorting (the decision aspect concerned with classification of objects and the direction of objects to the next transformation). It has been demonstrated that sorting and transformations, two principal activities inherent in transvections, are useful for the analysis of these settings.

Recycling, refurbishing, remanufacturing and component retrieval might be regarded as form transformations. Sorting was found to be central in the collection, classification, and recovery logistics activities. In collection and recovery logistics, sorting is crucial for resource utilisation, as it directs objects to distinctive transformation resources. In classification, it is crucial for the choice of recovery option. All in all, sorting influences which transformations the products will undergo, in time, place, and form.

Sorts and transformations have been connected to resources for performing these activities. Resources for transformation might be trucks, refurbishing equipment and software while resources for sorting are, for example, information systems, databases, knowledge, and experience of sorting rules and instructions that guide sorting decisions. As demonstrated, resources utilised in sorting steer objects into the appropriate facilities for transformations. Therefore, sorting rules play an important role in organising product recovery from a practical and theoretical perspective.

6.3 Organising, sorting rules and information exchange

The organising in networks has been defined in this thesis as inter-organisational activity coordination and resource combining. The organising of resources and activities is supported by sorting rules, which require that information between actors be exchanged in a proper way. Therefore, one of the crucial issues with regard to organising product recovery refers to how information exchange between firms should be organised in order to handle uncertainty relating to the complexity, lack, and abundance of information. In this regard, the Industrial Network Approach has made it possible to analyse information sharing, which facilitates organising product recovery across company boundaries. This network perspective enabled an analysis of information exchange and its connection to coordination of forward and reverses physical flows in terms of various product recovery options.

The significance of inter-firm information exchange in organising the matching of heterogeneous supply and demand has been pointed out by Alderson (1965). He claimed that information ranging over these two sets has to be matched before physical activities are performed. Therefore, when information exchange in networks is organised in accordance with economic utilities and related transformations, it may serve as a useful aid in inter-organisational handling of uncertainty. Hence, accurate structuring of information that describes time, place, identity, and form characteristics of objects has an impact on organising physical flows.

Interaction between firms in networks is essential for organising product recovery with regard to activity coordination and resource combining. Both activity coordination and resource combining require information sharing through common classifications of the form, time, place, and identity dimensions of objects. These information categories allow for efficient transmission of information between actors. Information classes describing each object’s form, time, place and identity features support sorting rules, which guide the objects through the activity patterns and resource constellations of networks.

These sorting rules and classifications have a number of functions, which are connected to all three layers of the Industrial Network Approach. First, they are used to register changes in order to create distinctions and alikeness among objects in the time, place, form, and identity dimension, in order to steer the objects to the appropriate resources for transformation. Second, common information classes provide the means for coordination and synchronisation of sorting and transformations in extended transvections, as they direct the objects in the time, form, place, and identity dimensions, in order to connect ‘technology of production’ to ‘technology of use’ as raw materials, components, and products are continuously being reused in different shapes and end-products. Finally, on the actor layer, sorting rules create boundaries with regard to classification of objects that firms are allowed to handle in their facilities. In this manner actors create counterpart specific boundaries to facilitate cooperation in terms of dedicated and differentiated activities and resources. By doing this, they also try to avoid direct competition.

In order to organise the *activity* pattern of product recovery processes, there has to be a structure of effective information classification, as well as rules on how to sort products so as to enable knowledge sharing throughout the network. Sorting rules accommodate routine decisions that are associated with direction and re-direction of the objects in the network. In this manner, sorting rules, either qualitative or quantitative, are crucial as they influence similarities and complementarities in the activity structures.

Resources in product recovery arrangements are mutually adapted in their interfaces and features, with the aim of enhancing productivity of their utilisation. Rules for sorting consist largely of if/then situations related to qualitative and quantitative aspects of objects, and these are stored or reside in such resources as machines or human knowledge. There are rules for assigning object to different resources with respect to qualitative and quantitative factors, such as distance, size of the vehicles and inventories, machines and other assets. In this way, a combination of sorting rules and object features provide guidance of objects through facilities, belonging to various organisational units that deal with product recovery activities. Hence, sorting rules are utilised to classify information about objects in order to direct particular items into adequate resource combinations.

The coordination of activities and combining of resources through sorting rules is the task of *actors* in business networks. The significance of sorting rules in the actor dimension is reflected in the perceived importance of the object attributes by different actors. Similarities and distinctions among technical properties of items, packages, load carriers and recycling equipment have varying degrees of importance to actors with regard to desired performance of collection, reprocessing, and distribution. Moreover, sorting rules set the boundaries around actors in terms of object classifications, which, in turn, enhance inter-organisational adaptations between companies that would otherwise be perceived as direct competitors. This leads to specialisation of actors in the resource and activity dimension of the network. From a network perspective, sorting rules, such as grading systems, contribute to reduction of uncertainty as these rules decrease excessive transportation and the need for inspection by each actor who deals with the object in some way.

6.4 Practical implications

Several issues related to the practical implications of organising product recovery have been identified. In accordance with research previously conducted in this field, one of the results of this licentiate thesis is that product recovery is frequently associated with uncertainties. For instance, uncertainty in the form dimension causes unnecessary transportation and classification.

Uncertainty is therefore strongly connected to organising product recovery. This uncertainty takes the form of variability of volume or a low level of economies of scale, and variability in quality, as well as labour intensive selection/disassembly of products, parts and materials. A supplementary variability relates to the type of the returned product or the allocation of a product to specialised purposeful reprocessing facilities. In addition to handling uncertainty of supply, firms in product recovery arrangements cope with uncertainty of demand, as well. As illustrated, balancing of supply and demand uncertainty is managed by establishing a differentiated approach to relationships. Some relationships display a high degree of regularity and intensive interaction among actors, while others do not.

The uncertainties in timing, volume and the state of the product can increase transportation work or inventory maintenance costs if the fill rates are not taken into account. This, in turn, can diminish economies of scale of consolidated and centralised flows in remanufacturing and recycling, as well as transportation. Another important factor in reducing uncertainty is the involvement of the disposers of IT equipment, i.e. disposers that want to discharge their products. These actors can succeed in an efficient and effective sorting.

As disposers usually represent demand for new products and related logistics services, they can increase their involvement in the organising of product recovery set-ups that handle items after use. Increased participation of disposers and enhanced inter-organisational coordination between disposers and other actors involved in product recovery could be implemented through voluntary high-involvement business relationships. This can lead to structured information exchange through sorting rules that would help to establish routinised activity coordination and resource combining.

Collaboration between different parties in the network, such as third party logistics providers, recycling/remanufacturing firms, intermediaries, and disposers, can decrease the uncertainties associated with product recovery. This reduces the environmental impact, as well as the costs of unnecessary transportation of goods that are suitable for other recovery options than that of the present facility. With a greater involvement from disposers and joint planning between remanufacturing companies, and logistics service providers, economies of scale and more precise planning of transportation, collection and reprocessing could be achieved.

Joint investment by several actors in business relationships could lead to instalment of IT systems for tracking and tracing of products in real time instead of scanning and inserting these data manually. In this way, all kinds of relevant data could be collected and used when executing activities and in the planning and monitoring of these processes. This reduces logistics costs and improves customer service as a third party logistics provider collects used units (instead of an employee who uses the equipment) from the working place and installs new products simultaneously.

Several disposing organisations do not manage their stock of PCs, laptops, and accessories from either the informational or the geographical view of proximity between products in use. New objects are purchased without taking form, time, and place characteristics of objects into consideration. Unorganised purchasing of new objects in these dimensions by disposers has an influence on organising product recovery. For instance, the form and time dimension of the objects mirrored in the product sales life cycle, determine, to a great extent, the path of the product to a suitable reprocessing facility. This is especially true for returns in electronics industry, such as PCs for which the reduction in prices increases toward the end of the sales life cycle. A seven years old laptop will most likely end up as new raw materials, for example. By taking into consideration product life cycle and the place dimension of objects, such as geographical location and geographical closeness of different business units, disposers (end-user) would facilitate the economic direction and distribution of objects into adequate facilities. In this way each replacement of products would occur in accordance with the product life cycle.

6.5 Further research

This licentiate thesis has shown that the concept of transvection can be translated to accommodate reverse flows as a type of extended transvections. That is one of the reasons why transvections are apparently appropriate for future studies of organising product recovery in business networks. The focus of this licentiate thesis has been on analysing individual transvections. Future research could include the development of tools and analytical frameworks in order to study interconnections between different transvections. This means that interrelatedness of different transvections would gain importance. For example, one of the results of this licentiate thesis is that actors arrange decoupling points in the network where they sort products in time, form, place, and identity, so that products become differentiated. With respect to the development of the theoretical framework, it is essential to connect these sorting and decoupling points to sorting rules and classifications and to gain an understanding of how they influence the direction of products, materials and parts between facilities.

Firms use different rules and industry-wide grading systems in order to coordinate activities, combine resources and direct and redirect objects between different facilities. Regarding inter-organisational rules and grading systems, one research issue is how to identify different principles for goods classification, theoretically. An initial idea is to distinguish between sorting and transformation rules. In addition, actors provide instructions to each other on how to coordinate activities and combine resources. This requires an exploration into the relationship between instructions and rules, or at least more clearly defined terminology to describe these coordination mechanisms. Sorting rules and classifications are therefore concepts for future exploration and a more rigorous framing, both in a theoretical and empirical sense.

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