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Editors

Managing Closed-Loop Supply Chains

Springer

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With 41 Figures and 11 Tables

Springer

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Preface

Introduction

Closing supply chains refers to taking care of items once they are no longer desired or can no longer be used by their user. Smart management of closed-loop supply chains means profitable recovery of value from these items (products, functional components, materials or packaging). The company closing the supply chain may be the original equipment manufacturer (OEM), a distribution partner or a third party not involved in the forward distribution.

In recent years, the management of closed-loop supply chains has gained importance because of increased legislation on producer responsibility, requiring companies to take back products from customers and to organize for proper recovery and disposal. This legislation is partially due to increased awareness of environmental issues. However, smart companies have also understood that returned products often contain lots of value to be recovered. They manage closed-loop supply chains simply because it is a profitable business proposition.

A number of books on closed-loop supply chain management have been published before. Many of them also pay some attention to industrial practice. However, they do not give much insight in: How are smart companies closing the loop? What does it take to make money in this business? The current book fills this gap in the literature by providing rich descriptions of many industrial cases in a variety of industries and for all types of product returns. More specifically, this book provides:

1. A classification of the types of physical return flows underlying closed-loop supply chains, like commercial returns, repairs, end-of-use and end-of-life returns, with their specific characteristics, opportunities and challenges,
2. A framework for analysis and design of closed-loop supply chains including technical, organizational, planning and control, information, environmental and business economic issues, as well as the interactions between them,
3. A large collection of industrial cases with rich and systematic descriptions using the classification of return types and the framework for analysis mentioned above. Books on industrial practice, co-written by managers, are very rare.

It is precisely the richness and variety of the industrial cases, combined with their systematic description using a standard classification and analysis framework that renders this book unique as well as very valuable for managers, academics and students alike.

This is the second book resulting from the TMR project called REVLOG, REVersed LOGistics and its effects on industry, sponsored by the European Union (ERB 4061 PL 97-650), and carried out by Technische Universiteit Eindhoven University of Technology (NL), University of Piraeus (GR), Aristoteles University of Thessaloniki (GR), Erasmus University Rotterdam (NL), INSEAD (F), and Otto-von-Guericke Universitaet Magdeburg (D). The companion book, “Reverse Logistics: Quantitative Models for Closed-Loop Supply Chains” edited by R. Dekker, M. Fleischmann, K. Inderfurth and L.N. Van Wassenhove, Springer Verlag, Heidelberg, Germany, 2004, focuses on analytical models for the various sub-problems identified in this book and thereby provides a solid base for decision making.

For more information about the REVLOG project, the related research groups and the results obtained via this project, we refer to the REVLOG website: www.fbk.eur.nl/OZ/REVLOG.

Readership

Reading this book does not require specific domain knowledge or experience. Some basic awareness of general management concepts and experience in practice will make the book more valuable to the reader. We made a conscious attempt to make the book useful for the following groups of readers:

- Managers from companies as well as from other organizations like local and central governments (by providing them insight into the opportunities, issues and roadblocks related to closed-loop supply chains),
- Academics and functional specialists focusing on specific sub-problems (by giving them better insight into the consequences of their contribution on the overall problem of successful closed-loop supply chain management),
- Graduate students in operations, supply chain management, economics, or management science at universities or business schools.

In addition, the book should be useful for any manager or MBA student interested in important emerging general business issues of the future.

Structure of the book

The book takes a business perspective on closed-loop supply chains. In the end, this is a business issue like any other. If supply chains will need to be closed in the future, then companies will have to be able to cope with this in a profitable way. Stated differently, legislation may help, but companies will need to find a way to make it work economically, otherwise the situation will not be sustainable. This book shows, by means of many rich industrial cases, that smart companies have found ways to do so already and that we can all learn from their experience.

The book starts with an overview of different types of returns in practice. The type of return has large consequences for the design and management of the appropriate closed-loop supply chain. Subsequently, we turn our attention to specific business drivers, i.e., what determines the specific choices made in designing closed-loop supply chains for all parties involved.

We then proceed with an overview of the managerial aspects related to closed-loop supply chain design and management. This concludes the conceptual framework of the book.

The main body of the book consists of 16 industrial cases. The cases were selected on the following criteria: (1) they are innovative and interesting for a broad audience, (2) at least one member of the REVLOG research team was involved in the industrial project, and, (3) the case had not been published before. Taken together, the cases provide a rich and unique collection of the real managerial issues in closed-loop supply chain management.

The book concludes with a discussion of likely future trends in managing closed-loop supply chains.

Acknowledgements

We are grateful to the European Union for providing financial support to the REVLOG project. Our sincere thanks are also extended to all the managers in the companies and organizations that contributed their scarce time to helping us write the cases. Finally, we acknowledge the help of our colleagues and the support of our respective schools.

Eindhoven, September 2004 *Simme Douwe Flapper*
Rotterdam, September 2004 *Jo van Nunen*
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1 Introduction

Simme Douwe P. Flapper, Jo A.E.E. van Nunen and
Luk N. Van Wassenhove

1.1 A framework for closed-loop supply chain analysis

This introductory chapter presents the general framework used in this book to cluster and describe the industrial cases.

The first component of the framework uses a general picture of reverse flows with different types of returns. We briefly discuss this picture and argue that firms increasingly have to deal with larger streams of returns in different forms over the life-cycle of their products. We then introduce and briefly illustrate the different types of returns and point out that the book is organized in several parts, corresponding to these types of returns: commercial returns, repair and replacement returns, end-of-use returns, end-of-life returns, production return flows and, finally, distribution returns.

The second component of our framework uses a flow diagram for analysis, outlining the need to start with identifying the business drivers, followed by a thorough analysis of the technical aspects, organizational implications, planning and control issues, information system needs, environmental impacts and finally economic impacts. We note that this is just one of many possible ways of looking at a series of important issues in a reasonably logical sequence. We personally found this framework useful as an underlying structure for organizing the different chapters of the book for internal consistency and flow. We discuss each of the components of our framework, explaining briefly what we mean by them and why they are relevant.

We close this chapter by reiterating that the book is divided in parts corresponding to the different types of returns outlined in component 1 of the framework, and that each chapter roughly follows the outline of framework component 2.

Finally, we state our hope that our general framework for analysis, followed by the 16 real-life business cases, will give the reader a good understanding of the rich variety of managerial aspects of closed-loop supply chains.

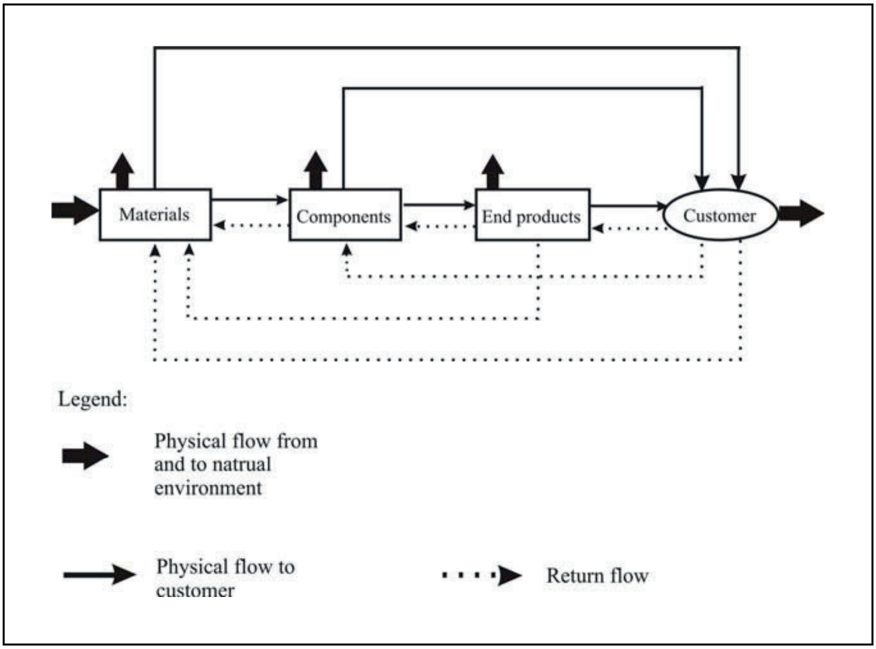

Fig. 1.1. Typical closed-loop supply chain flows

1.2 A classification of closed-loop supply chains

There are many different types of closed-loop supply chains in practice. The classification we use in this book follows the different phases in the life-cycle of a product: the *production phase*, the *distribution phase*, the *use phase*, and the *end-of-life phase* when the product loses its identity, but maybe parts of it (functional components, materials) may find further use. Companies have to decide for each of these phases whether they want to close the corresponding supply chain, i.e., to create a loop, after it or not, see Figure 1.2. Each of these phases has its own specific possibilities and requirements, depending on the type of product, the processes involved and the size of the flows.

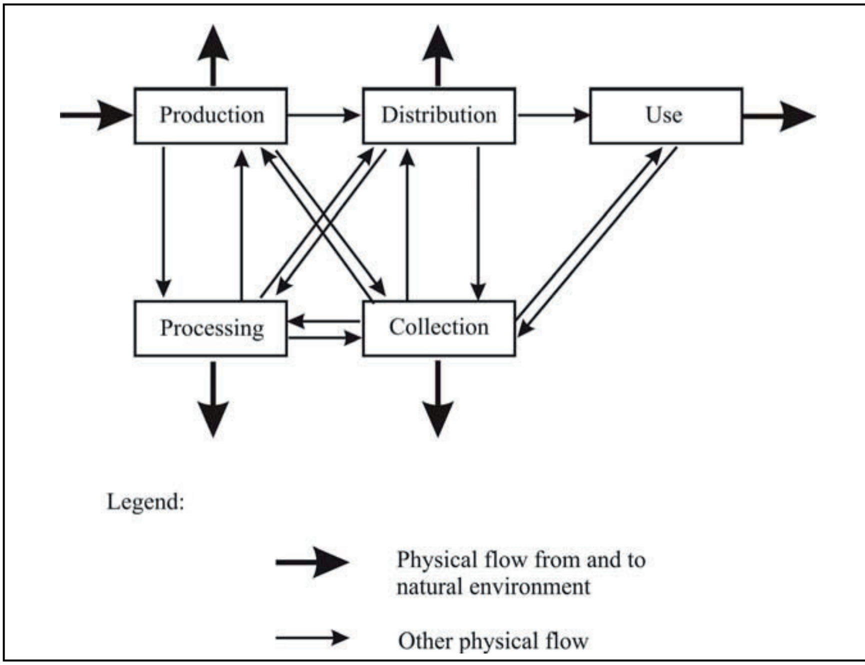

Fig. 1.2. Closed loops related to different phases in the life of a product

Production related

Three main groups of closed-loop supply chains can be distinguished here:

- Obsolete (secondary) materials but also distribution items like pallets and lorries used for internal transportation of materials, components or semi-finished products.
- Production scrap: materials, functional components, as well as defects in process that cannot be reworked. A simple example would be trimming waste from metal stamping in the car industry,
- Production defectives: products not conform to some preset quality levels. Some may be scrapped, whereas others may be reprocessed to a level where they can be sold as initially intended or as a lower quality product. Examples can be found in many industries, including semi-conductors (So and Tang, 1995), cars (Robinson et al., 1990), and many process industries (Flapper et al., 2002).

Distribution related

A distinction is made between distributed products and items used for the distribution of those products.

With respect to products, there are a number of closed-loop supply chains to be distinguished:

- Commercial returns: returns of products that are sold with a return option. Consider the growing number of products sold via the Internet by companies like Dell and Amazon.com. Return rates mentioned in literature vary from 5-50% (Rogers and Tibben-Lembke, 1999),
- Wrong deliveries: products refused by the customer because they were delivered too early or too late, contained defects, or were otherwise not conform to specifications,
- Recalls: returns in the context of actual or expected problems with products. Examples are numerous, including cars (Anonymous, 2004b), (Anonymous, 1991), car tires (Anonymous, 2004a), and bottles (Anonymous, 1990), (Anonymous, 1993).

The latter two return flows, wrong deliveries and recalls, may be considerable and of crucial importance to the company's reputation. Although it is obviously very important to deal with them properly, we do not discuss them in detail in the remainder of this book.

Most products are delivered to their users with the help of distribution items. We pay special attention to the closed-loop supply chains of these distribution items, starting from the users of these items. Note that products like toner cartridges and cellular phones are essentially distribution items. They carry the real product: ink for printers and airtime for phones.

Use related

Different types of closed-loop supply chains can be distinguished here.

There are closed loops related to products that should eventually return to the present owners. This may be in the context of warranties and recalls, or when companies are offering repair, refurbishment or remanufacturing of their products. An example of the latter is described in the Mercedes-Benz case in this book.

There are also closed-loop supply chains in which the present owners no longer want the products and use the opportunity to return them to the supplier. This holds among others for end-of-lease products, like cars and copiers, but also for cellular phones returned to airtime providers.

Products returned at the end of their technical or economical life from the point of view of their present user or their original manufacturer may still start another life in a different (e.g., second hand) market

End-of-life

Here we consider 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. Examples are the nationwide networks for car wrecks (Groenewegen and Den Hond, 1993), white and brown goods (see the chapter on the Dutch white goods initiative in this book), portable batteries in the Netherlands, systems for the collection and processing of glass via containers, and systems for waste paper collection.

1.3 Managerial aspects of closed-loop supply chains

In this section we introduce the managerial aspects of closed-loop supply chains shown in Figure 1.3. These aspects are relevant in the context of every managerial decision, and are not specific to closed-loop supply chains. The reasons for following this specific sequence as the basic framework for describing the cases in this book are outlined below.

First of all, any management team should develop a common understanding of when and why to consider closed-loop supply chains, i.e., a mental picture of the *business drivers* behind closing or not closing the loop in part of a supply chain.

Once the business drivers are known, insight in the *technical aspects* of closing the loop in (part of) a supply chain is required. Based on physical inputs and outputs of the considered closed-loop system, technical feasibility and corresponding costs has to be verified.

The next point of attention are the *organisational aspects*, i.e., who to involve in the recovery network, taking into account both the business drivers and the technical aspects, and ensuring proper alignment of incentives.

Knowing the potential partners, activities should be *planned and controlled* in order to realise the anticipated benefits or to keep costs as low as possible.

With insight into the technical, organisational and planning and control aspects, one can define the required *information systems* (IS) support, where IS support encompasses hardware, software, and the people who supply the data or use the information.

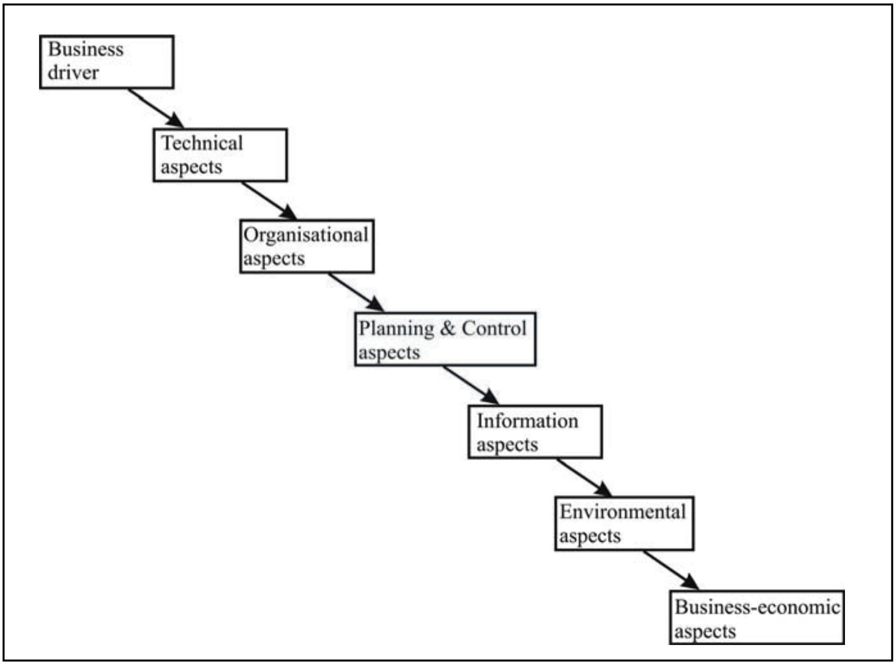

Fig. 1.3. The different managerial aspects of closed-loop supply chains

Now that all components of the closed-loop are specified, it is possible to estimate the *environmental aspects*, i.e., to put environmental tags on closing the system. This is notably important in case one intends to use the system to establish a so-called green image.

Finally, and most importantly, one has to put an economic price tag to all the activities comprising the closing of the loop, i.e., to establish its profitability, i.e. its *business-economic aspects*.

Note that in order to keep things clear and simple, Figure 1.3 does not show the iterations that may be necessary in order to arrive at a viable solution in practice. We repeat that our suggested framework is just one of undoubtedly many possible ways of looking at a series of important issues in a reasonably logical sequence. We use this framework as underlying structure in the different chapters of the book for reasons of internal consistency and flow.

Below, we discuss the different aspects of our framework in greater detail.

1.4 Business drivers

There are many potential reasons why companies may choose, or be forced, to consider closing their supply chains. In simple terms they are usually related to Profit, People, and Planet, or a combination thereof, as depicted in Figure 1.4.

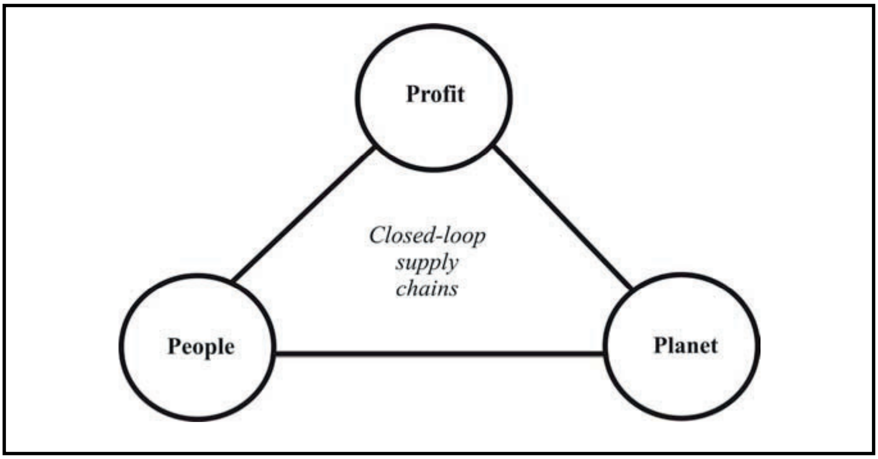

Fig. 1.4. Profit, People, and Planet: the three main groups of business drivers

Profit

First and foremost, there are many direct and indirect business economic reasons for companies to close their supply chains, including reduced costs for input materials, production, distribution, after sales service activities, and disposal. Closing the loop may also lead to protection of market share and open potential new markets.

A growing number of companies, including car and copier manufacturers, offer the possibility to lease or rent their products instead of buying them. With this option comes the responsibility to organize end-of-lease or end-of-rent take-back and the challenge to find another good use for the often well functioning returned products.

Closing supply chains may shorten the delivery time of materials, functional components and products, very important issues in a world with growing competition. Via closed-loop supply chains companies may also become less dependent on their original suppliers. Indeed, in closed-loop supply chains, the supply of materials, functional components and distribution items may be guaranteed. Sometimes, closing a supply chain is the only way to get certain materials at all. This was the most important reason for Philips to set up a special unit for the recovery of materials from production defects just after World War II.

Companies sometimes offer take back options to customers as a service in the battle against their competitors. This may concern both used and unused products, as well as items used for the distribution of products. By closing supply chains companies may portray a so-called “green image” essential for attracting or keeping some customers, as exemplified by companies like the Body shop.

Another trigger for setting up a closed-loop supply chain are recalls: products or items used for their distribution that turn out to be defective when already introduced in the market. Being able to deal with recalls is essential for a good company image as has become clear recently in the car industry (e.g., with the introduction of the A-type Mercedes-Benz).

People

Customers as well as all kinds of *action groups* can force companies to take back their products or distribution items when they are no longer desired. In a number of countries, including Germany, companies selling via the Internet are legally forced to take back products from their customers within a certain period of time after delivery. In countries including the Netherlands and Germany (Boks, 2002), companies are legally obliged to take care of their products the moment their owners want to dispose of them. Increasingly, governments introduce producer responsibility laws (e.g., the Waste Electronic and Electrical Equipment or WEEE Directive and the End of Life Vehicle or ELV Directive in the EU). The same holds for items like packaging and distribution materials like pallets, boxes.

Planet

In a growing number of countries, there is legislation forcing companies to “close” their supply chains because of the limits of our planet in supplying inputs as well as absorbing outputs from activities. There is increased interest and concern for sustainable operations.

For all kinds of products, including refrigerators containing (H)CFK, there exist dump bans in many countries. This forces companies to design more environmentally friendly recovery and disposal options or to avoid some harmful substances altogether (e.g., the Restriction on Harmful Substances or RoHS Directive in the EU). These environmental restrictions may also offer an opportunity as is clear from the processing of whey, a former by-product from the processing of milk. For quite some time whey was dumped into canals and ditches. When this was no longer allowed in the Netherlands, companies generating the whey had to find suitable alternatives. This resulted in many new high value applications of whey as an input for among others the food industry.

Apart from bans on land filling, a number of countries have all kinds of legal restrictions on the amounts of specific waste they are allowed to generate on a yearly basis. Furthermore, in a number of countries, producers and importers are legally forced to include a minimum amount of recycled content in their products. This holds among others for newspaper paper producers in the Netherlands.

Note that the business drivers do not necessarily dictate the specific inputs and outputs related to closing a particular company supply chain. Questions that may also have to be answered with respect to inputs include: “Are we going to collect and process products as a whole or only certain functional components or materials?”, “Are we going to collect and process only (parts of) our own products and distribution items, or also those of others?”, “Are we going to collect and process only unused products, functional components, or materials, or used ones as well?”. Questions to be answered with respect to outputs are: “Will we transform the inputs into complete products (incl. up- or downgrading), functional components, materials or use them as an energy carrier?”

The above overview of potential business drivers concerns the closing of supply chains by the parties involved in the initial supply chain. A supply chain can also be closed by third party companies. For these parties the potential set of business drivers is quite often, but not necessarily, much smaller than that of the parties involved in the initial supply chain. Many of these parties collect from companies to which they do not sell, thereby among others avoiding service and take back legislation drivers. The main driver for most of these third parties is business economics: closing the loop for their clients is their business model. Examples are car brokers and independent glass recyclers.

1.5 Technical aspects

A number of technical aspects have to be taken into account when closing supply chains. Depending on inputs and outputs, the following technical processes may play a role: testing/grading/sorting, where every individual product or distribution item may have to be tested and graded because it may have been confronted with a different usage pattern, and storage, transport, disassembly (including cleaning, separation), repair and reassembly.

How a given instance of a product or distribution item is to be disassembled depends on how it is to be reused, its state and legal obligations, including laws enforcing the removal of hazardous substances. An important issue with respect to reassembly may be technical restrictions on combining used parts as well as on combining used with new parts. This holds for mechanical parts like chains that can show wear, not allowing them to be combined with new parts or parts that are less worn out.

Further technical aspects to be taken into account include the physical layout of grading, sorting, disassembly, and separation lines, as well as decisions on how to perform activities varying from completely manual operations to full automation, including the selection of technology, tools, and skills.

Closed-loop supply chains may require a redesign of the products and distribution items. This redesign may concern the configuration of parts and modules and how these are connected to one another, and the individual design of the parts including their materials content. The redesign may be for better maintenance in order to allow for easier reuse of products as a whole, for recycling to make the recovery of materials from a product easier, or for incineration or final disposal to make their final disposal less expensive. Companies started to install chips in their products to gather information on the usage history with the objective to determine better possibilities for reuse. Companies sometimes even amend the design of their products in order to make it impossible for others to reuse them. Of course, this leads to interesting legal issues. Product redesign for reuse may increase design as well as production and distribution costs but it should lower the overall costs of running the closed-loop supply chain.

1.6 Organizational aspects

The question to be answered next is: “Should we integrate, partially or completely, the closing of the chain for this product with the closing of our other supply chains or with the closing of our competitors’ supply chains, or should we do things separately?”

There are a number of examples of branch or sector based initiatives for closing some or all of the supply chains of the members, like for car wrecks in the Netherlands (Groenewegen and Den Hond, 1993), end-of-life white and brown goods (Boks, 2002), and portable batteries

(Schultmann et al., 2003). Advantages of such collaboration are economies of scale, higher prices for the outputs, and financial and other incentives from authorities. The main disadvantage is that the collaborating companies will find it much more difficult to use the closing of the supply chains to differentiate themselves or to reap the benefits of their specific efforts.

Another question to be answered is: "Whom to involve in which activities for what products or distribution items?" where a distinction should be made between potential partners within and outside of the organisation. These partners should be engaged for at least a minimum period of time and should be able to provide timely and accurate data. In the context of collection activities one needs to decide on how to organize the collection process. Will customers bring their used products to the ir selling points or to special collection sites, or is kerbside collection more appropriate? Who operates the system or parts of it and how is this operation financed? What are the reporting systems and how does one assure compliance with legislation and contractual arrangements? In the context of the WEEE Directive in the different European countries, this issue of organizing collection is a central issue. Different systems in different countries without clear and transparent rules could lead to huge costs for certain companies with relatively small profit margins like producers of consumer electronics.

Potential external partners may be other producers, distributors, logistics service providers, companies specialised in collection activities like car brokers or in processing like recyclers, as well as charitable organisations like the Salvation Army, but also banks and insurance companies and local and regional governmental organizations.

Closing a supply chain may have consequences for the internal organisational structure of the initiator(s). It may impact design, sales, purchasing, production, distribution, after sales services and accounting departments. An important question in this context is: "Should the company introduce a separate business unit responsible for the closing of the supply chain, introduce a special functional department or should the responsibility for the different closing activities be with existing functions?" Closing a supply chain also has consequences on existing relations with suppliers, distributors and customers. It may influence make-or-buy decisions related to parts or new products.

After selecting appropriate partners the next question to be answered is: "How to ensure that these partners behave as we would like them to?" A closed-loop supply chain is a network for which the same general requirements for good functioning hold as for any other value added network involving several partners. Clearly the network should be attractive to all partners. This means at least a win-win situation for all involved which requires insight in the costs and benefits for each partner, as well as into each partner's alternative options. Potential costs are related to activities in the closed-loop network like sorting glass of different colours, disassembly like removing metal caps from bottles, assembly like packing or bundling, storage, transport to a collection point or presence at the moment of pickup. Potential benefits for partners include fees, reduced product costs, no or lower disposal costs, a green image or simply compliance with legislation. Clearly, transparency and alignment of incentives are important considerations in closed-loop supply chain design.

Many performance measures for closed-loop supply chains are similar to those for open supply chains. More specific performance measures would typically be percentage of products collected, average quality of returned products, average collection costs and costs of processing a return.

1.7 Planning and control aspects

Many closed loop supply chains have a number of characteristics making their planning and control requirements different from those of open supply chains. Often the supply of items to be collected shows a large variability in time, quantity and quality. This resembles the uncertainty with respect to time, quantity and quality quite common in agriculture. Because of this, maximum stock levels and disposal decisions are important. Disassembly, resulting in co-products and by-products, and reassembly with constraints on combining used parts and used and new parts, further complicates integrated planning and control of the closed-loop supply chain. Alternative mutually exclusive reuse options, or alternative sources for parts, differing as to required time, resources, and eventual result, may further complicate things, resembling multi-vendor and alternative recipes situations.

In short, closed-loop supply chains typically have to deal with more sources of uncertainty making straightforward application of lean and mean production systems based on variance reduction (like six sigma) less obvious.

1.8 Information aspects

The central question to be answered here is "What data is required when and where to close the supply chain?" and derived from it: "Who is responsible for making these data available?"

In order to be able to decide if inputs can be transformed into outputs from a technical point of view, usually both the configuration and the condition of a collected product need to be known. This holds especially in case of refurbishing or remanufacturing, and for the reuse of functional components. Indeed, different copies of apparently the same product may differ substantially depending on how, how often and where these copies have been used, how they have been maintained, whether some or all of their components have been repaired, or replaced, and so on. Often specific support for executing the different technical processes is required, partly or completely based on the information mentioned above. For example, "If this refrigerator contains CFCs, then first remove them using this agreed upon process before taking any further steps". Specific decision support may also be necessary for combining used parts with different quality grades or for combining new with used parts in remanufacturing processes.

Specific information systems are also required for supporting commercial returns and end-of-lease or rental returns. In many respects these resemble usual systems for keeping track of payments, like identification (name, address), bank account, return date, product identification and quantity, and payment conditions. However, the systems also include more specific data like specific configuration details, condition of the returns, reason for return, refund date and amount, service history and so on. As mentioned before the legislator may add heavy requirements with respect to reporting environmental compliance requiring specific and costly accounting and information systems. This is one of the concerns of companies with respect to the implementation of the WEEE directive in EU countries.

From a planning and control point of view systems may be required to keep track of the generation of co-products and by-products during disassembly, maximum stocks levels for timely disposal, variances in yield factors, alternative routings with their probabilities, different grades of the same product, and many other pieces of information specific to closed-loop systems. In many respect these requirements resemble those of the process industry.

Buying or selling used products often requires more and different support than buying and selling new unused products in order to obtain insight into the configuration and condition of the products (pictures, text) and their reuse alternatives (decision trees). Consider cars that have been involved in accidents, stressing once more the need for specific data on individual copies of products instead of general data on types of products. In a number of situations buying used copies of products is seen as an investment based on the expected profits to be realised via the reuse of certain parts of these products. In many such cases it is crucial to build a knowledge base keeping track of experiences in order to improve performance in the used product procurement process. This should be obvious from the above car example.

The required technical data may be registered manually or automatically via sensors and chips. In the former case information suppliers may be producers providing data on initial configuration and condition of a product, users or service personnel registering replacements and maintenance activities. In the latter case one should be aware that extra equipment might be required to read and update the data even though technological advances quickly reduce investments in both sensors and chips (e.g., RFID) and processing equipment.

1.9 Environmental aspects

Estimating the mass and energy flows related to activities required for closing the supply chain is no different from doing the same exercise for production and distribution systems in general, except that hard data may be even more difficult to obtain. This book therefore pays little attention to the calculation of environmental impacts of closed-loop supply chains.

We restrict ourselves to the mass and energy flows related to closing the supply chain, i.e., the flows constituting the starting point for Life Cycle Analysis (LCA) studies. No attention is paid to the specific consequences of these flows on the human being and the rest of the ecological system. The main reason being that these consequences depend on many other, often local, issues like dominating wind directions, whether emissions occur in heavily populated areas, and so on.

There are a number of important reasons to pay close attention to the environmental aspects of closed-loop supply chains:

- Companies may want to use the closing of one or more of their supply chains as a marketing tool, e.g., for generating a green image. One has to be very careful with this since it may backfire as shown by the problems of the Body Shop after stressing the environmental friendliness of their system of bottles,
- Governments increasingly require yearly environmental reports from companies, including mass and energy flows,
- Producers increasingly require their channel partners to provide environmental reports and proof of compliance to regulations,
- Local authorities demand insight into the environmental aspects related to the activities of companies based on which they grant com-

panies a license to operate in their area. This especially holds for companies collecting used items while only interested in reusing some parts,

- All kinds of influential organizations like NGOs, the press and investment houses are keeping a close eye on companies and forcing them to show that their activities are environmentally benign.

1.10 Business-economic aspects

The potential business-economic benefits from closing a supply chain have been mentioned earlier: lower purchasing, production, and servicing costs, smaller disposal costs, new potential markets, extra sales due to a green image or to additional service provided to customers by closing the chain. Of course, some of these benefits are harder to quantify than others.

There are also obvious costs related to each of the different activities in closing the chain. A distinction is made between direct and indirect costs, where the first have a direct relation with the above-mentioned activities, whereas the latter do not.

Direct costs

It is important to distinguish between costs directly related to payments made for obtaining items from suppliers, i.e., costs related to the acquisition of inputs required to close the chain and costs of handling, storage, transport, processing and disposal of (part of) the inputs at special processors, incineration sites or other disposal locations.

Indirect costs

As mentioned before, closing the supply chain may require product redesign resulting in higher initial purchasing, production or distribution costs. For instance, in order to make disassembly easier, components may be connected differently than before using more expensive joints. Or, in order to make reuse of functional components profitable, chips may be built into the components to obtain a quick and reliable insight into their condition upon return. Other indirect costs may be linked to marketing since remanufactured products could obviously cannibalise the sales of new products in particular cases. As mentioned before this may be an important reason to close a chain since it could prevent a competitor from doing so using your products as inputs.

In order to make a business-economic trade-off for a specific case, a distinction should be made between the following situations:

1. Closing the loop is profitable in itself,
2. Closing the loop is not profitable by itself but higher sales (or other benefits) as a consequence of closing the chain outweigh the costs,
3. Closing the loop is not profitable but it is required for obtaining a licence to operate,
4. Closing the loop only results in extra costs and no company will engage in it out of free will.

1.11 Conclusions

This chapter has presented an overview of the types of return flows in practice, the potential business drivers for closed-loop supply chains, and the different managerial aspects related to closing a supply chain.

The following 16 chapters illustrate how a number of smart companies engaged in closing some of their supply chains. Particular attention is paid to the underlying business drivers and managerial aspects as outlined in the framework introduced in this chapter.

Part 2:
Production closed-loop supply chains

2 Reverse logistics in a pharmaceutical company: the Schering case

Ruud H. Teunter, Karl Inderfurth, Stefan Minner and Rainer Kleber

2.1 Introduction

Schering AG is a pharmaceutical company that was founded in 1871 in Berlin by the pharmacist Ernst Schering. During the past 128 years, Schering has developed into an international pharmaceutical corporation with 145 worldwide subsidiaries and partnerships. In 1998, a staff of 22,043 (44% employed in Germany) contributed to revenues of EUR 2.9 billion. The most important sales regions were the European Union (without Germany) with 28%, North America with 22%, Asia with 15%, Germany with 15%, and Latin America with 10% of the total sales. The largest single market was the U.S.

Schering's research and business activities focus on three areas that represent the Strategic Business Units. Fertility Control and Hormone Therapy (36% share of total sales in 1998) became the largest unit in 1997 due to acquisitions. The products of this area mainly serve to overcome acne, to prevent pregnancy, and to treat symptoms of menopause. The Therapeutics business unit (31% share of total sales) focuses on the treatment of leukaemia, multiple sclerosis, peripheral circulatory disorders, and thrombosis. The Diagnostics business unit (23% share of total sales) produces contrast media that help to detect diseases in their early stages. In Germany, Schering concentrates its activities in Berlin and Bergkamen. Berlin houses the headquarters and the research and development department. The production plants are located in Bergkamen.

The production of pharmaceuticals can be divided into three phases. First, so-called active ingredients are produced from raw materials at the chemical production facilities. In the following formulation stage, the active ingredients are combined with other substances in order to give them their dosage form. In the final phase, the goods are packaged and distributed to the customers. Mixing substances, packaging pharmaceuticals, and distributing them is quite straightforward and can be done in a short time interval. The production of active ingredients, however, is very complex and time consuming. In this chapter, we discuss this production phase and especially the two types of reverse logistics processes that are associated with it.

The first type of reverse logistics at Schering is related to the recycling of by-products that are obtained in the many stages of the production process. The by-products often contain valuable materials. As a consequence, reusing them is economically attractive. Unfortunately, reusing does make production planning a lot more complicated. We will discuss these complications and the way that Schering deals with them.

The second type of reverse logistics is related to the reuse and recycling of impure solvents. Solvents are needed in many stages of the production process. After use, impure solvents are cleaned in a distillation facility and then reused, if this reuse option is economically attractive. If cleaning is too expensive, due to a high degree of pollution, then the impure solvents are thermally recycled (if possible). The remainder is disposed of.

There are other less important types of reverse logistics at Schering. Drums that are used for transporting and storing solvents, for instance, are reused several times. In this chapter, however, we restrict our attention to the recycling of by-products and solvents. Both these types of product recovery belong to the field of rework. Interested readers are referred to (Flapper et al., 2002).

2.2 Reuse and recycling of by-products

In many stages of the production process, by-products are generated. Many of those by-products are recovered, reducing the need for virgin materials. To give an impression of the importance of by-product recovery for Schering's chemical production, we present some global data from 1997/98. About 80 active ingredients are produced from approximately 10 raw materials. There are approximately 900 intermediate products of which 112 are by-products. About 630 tons of active ingredients are produced in total, resulting in about 14 tons of by-products. More than 90% of these by-products are recycled.

Business drivers

The main motive for recycling by-products is economical. Most by-products contain enough valuable materials to make recycling profitable.

Another motive is the combination of care for the environment and of attaining an environmentally friendly image. Since 1996, Schering has participated in the German Chemical Industry Federation's initiative "Responsible Care". The goals of that federation are to minimize the burdens on the environment caused by chemical industries. Schering tries to minimize, among other things

- Energy use,
- Effluent (i.e. water for processing and cooling purposes),
- Emissions,
- Impure solvents, and
- Waste consisting of used intermediate packaging.

A Materials Flow Management project group is responsible for an effective execution of the different waste management tasks. Product recovery is a major issue in Schering's waste management activities.

A third motive is provided by the legislators. Chemical industries in Germany face several binding legislative acts. The German Recycling and Waste Control Act forces industries to reduce their waste stream.

Technical aspects

Figure 2.1 illustrates the typical production structure for active ingredients: long, diverging, and with cycles. It is long, because the production of active ingredients requires a large number of consecutive, time-consuming production stages where chemical processes take place. It is diverging, since many (about 80) active ingredients are produced from a small number (about 10) of raw materials. Recycling the by-products leads to cycles.

Many of the production facilities use multi-purpose machines. These machines are used for producing several (intermediate) active ingredients. When such a machine changes from one ingredient to another, it has to be cleaned in order to avoid cross-contamination. Cleaning machines is very expensive and can last an entire week. Hence, sequences of batches of some types of ingredients are formed. These sequences are called campaigns. Unfortunately, this causes large lead times. The accumulated lead time for the whole production chain from raw materials to active ingredients ranges from 3 to 15 months depending on the product route.

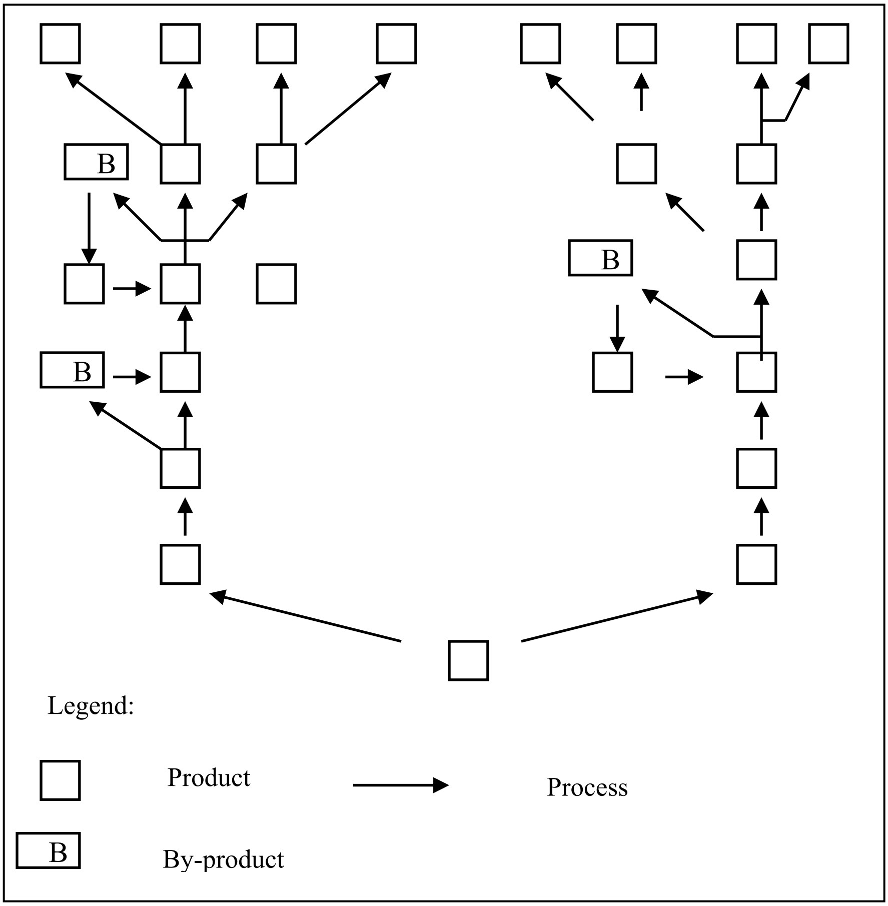

Fig. 2.1. Typical production structure for active ingredients

Planning and control aspects

As was explained before, the recycling of by-products causes cycles in the production structure. Those cycles complicate production planning considerably. Standard planning methods like materials requirements planning (MRP) do not allow cyclic structures. The logistics department of Schering has therefore developed a Mixed Integer Programming (MIP) formulation of their production planning problem. The MIP model uses a planning horizon of 3 years. Such a long planning horizon is needed since lead times can be large, as discussed before. The horizon is decomposed into planning periods of 1 week for the first 18 months and a period of 1 month for the remainder. The MIP model finds the production schedule that minimizes the total set-up and holding costs during the entire planning horizon, under the restriction that expected demand is satisfied and that machine and personnel capacities are not exceeded. The model is rerun every 3 months, in a rolling horizon mode. After running it, the production plants are informed about the optimal weekly production schedule for the first 3 months. The daily production planning is left to the production plants. We refer interested readers to (Teunter et al., 2000) for a complete description of the mathematical model.

Information aspects

Most production planners at Schering are used to working in an MRP environment. Hence, the MIP formulation has been embedded in such an environment. The planners have to provide the technical bill of materials (BOM) with the correct routings for all the products with the corresponding parameter values. The decision support system (DSS) translates this BOM into an MIP formulation and solves it. Hence, production planners need no knowledge of MIP and can do all the planning in their familiar MRP environment.

2.3 Reuse and recycling of solvents

In this section, we discuss the reuse and recycling of solvents in Bergkamen. Most active ingredients that Schering produces there require the use of solvents in one or more stages of the production process.

Business drivers

As for the recycling of by-products, the main motivation for recovering solvents is economical. But other motives like taking care of the environment also play a role.

Technical aspects

A graphical representation of the plants in Bergkamen is given in Figure 2.2. That figure also gives the approximate number of tons of organic solvent that flowed between the different plants/sites in 1997 (all connected via pipelines above the ground). We remark that these are approximate flows, which explains the small flow imbalances. The smaller flows of non-organic solvents are omitted, since these solvents cannot be reused or recycled. Before discussing the plants/sites and flows in Figure 2.2 in detail, we briefly overview the whole system.

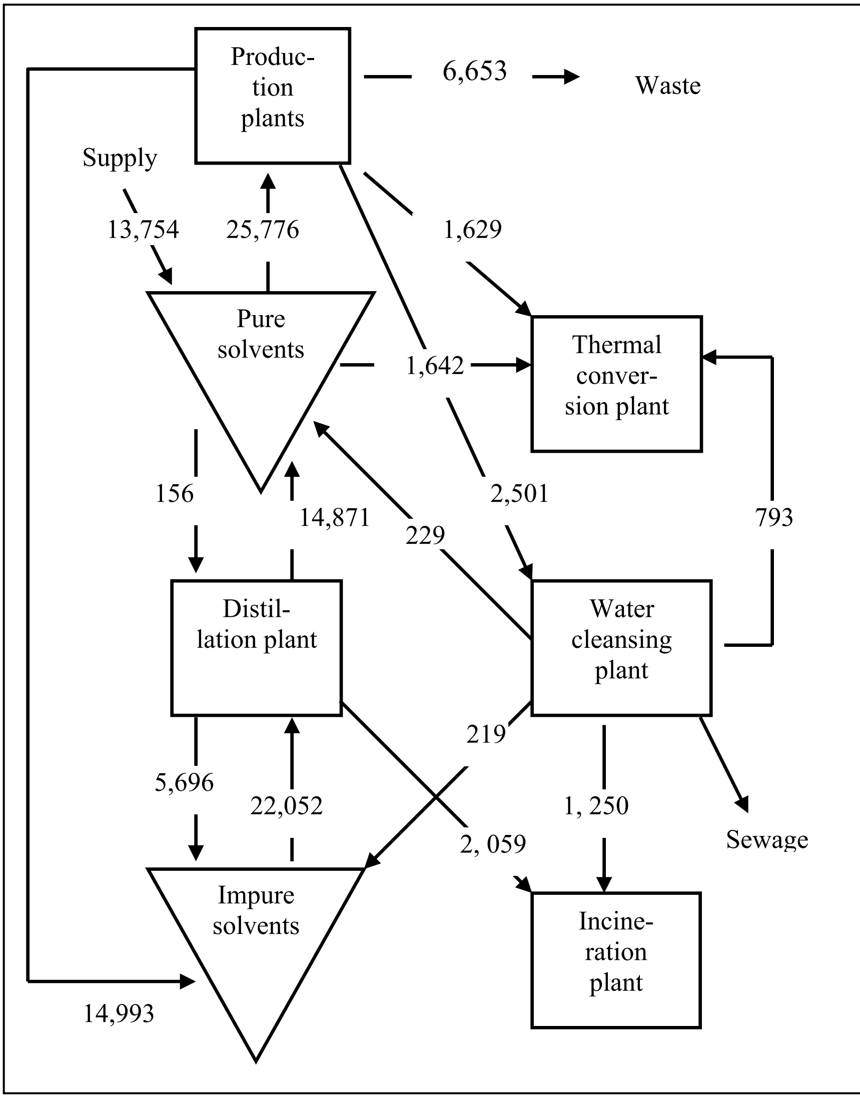

Fig. 2.2. The plants in Bergkamen and the approximate flows of solvents between them (in tons) for the year 1997

If a production plant needs more solvent, the necessary solvent is pumped out of the associated barrel from the stock of pure solvents. After being used for production, many solvents flow to the stock of impure solvents, where they stay until they can enter the distillation plant. The majority of solvents that leave the distillation plant flow back to the stock of pure solvents and are reused. Some impure solvents flow to the thermal conversion plant, where they are used as fuel (this means that energy is generated from the solvents). Other solvents, which cannot be used as fuel, flow to the incineration plant. In the water cleansing plant, solvents are filtered from the production/distillation process water.

At the production plants, active ingredients are produced. For the production of most of these active ingredients, pure solvents are needed. Hence, pure solvents (25,776 tons) flow from the stock of pure solvents to the production plants. After production, the solvents are no longer pure. Those impure solvents that will be reused (14,993 tons) flow to the stock of impure solvents. Those that will be thermally recycled (1,629 tons) flow to the thermal conversion plant. Production also leads to so-called process water containing some solvents. Hence, there is also a small (2,501 tons) flow of impure solvents to the process water cleansing plant. What remains is a waste stream of 6,653 tons of impure solvents that cannot be recovered in any way.

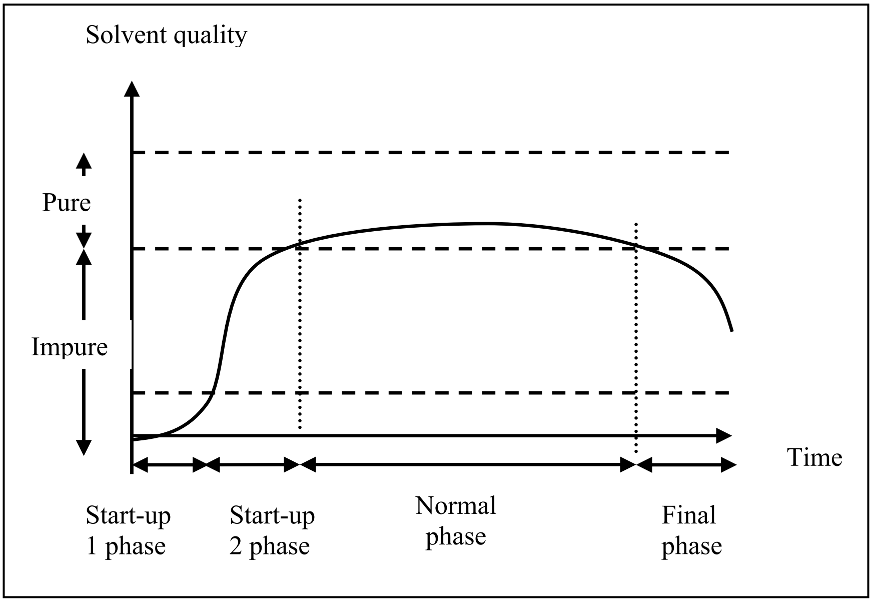

Fig. 2.3. The distillation process

In the distillation plant, impure solvents are transformed into pure solvents. The incoming flows at the distillation plant are the impure solvents (22,052 tons) that will be recovered, but also a small amount of pure solvents (156 tons) that are needed for the distillation process. In order to understand the outgoing flows, we need to describe the distillation process. When a certain amount of some impure solvent is distilled, the quality of the resulting solvent varies over time. This is illustrated in Figure 2.3.

Just after starting the process, the quality is very poor. So poor indeed that the solvent (2,059 tons) flows to the thermal conversion plant, where it will be used as fuel. The time period for which this holds is called “Start-up 1 phase”. After some time, the quality improves to a level that makes the solvent too valuable to be used as fuel, but the solvent is still not pure. In this ‘Start-up 2 phase’ the solvent (5,696 tons) flows back to the barrels with impure solvents and will be distilled again later. This phase ends when the quality reaches a purity threshold.

Then the ‘Normal phase’ begins, during which the solvent (14,871 tons) flows to (one of) the barrel(s) for stocking pure solvent. Eventually, the quality will drop below the required level again. In the “Final phase” that then starts, the solvent (included in the 5,696 tons related to the Start-up 2 phase flows back to the barrels with impure solvents. Obviously, it is desirable to have a long Normal phase. Therefore, in the recent past, Schering has switched from batch distillation to continuous distillation for a number of solvents. With batch distillation, one can only distillate the amount of solvent that fits into a distillation tank. With continuous distillation, one can empty an (often much larger) barrel containing the impure solvent by continuously adding some of the impure solvent. Since switching from batch to continuous production has no considerable influence on the lengths of the Start-up phases and the Final phase, continuous production lengthens the Normal phase.

During the production of many active ingredients, water gets in contact with solvents. This leads to so-called process water that contains a small fraction of solvents. All process water has to be cleansed before it can be drained off. Hence, solvents that are contained in process water (2,501 tons) flow to the process water cleansing plant. During the cleansing process, the solvents are filtered out of the process water. Some of these are pure, but others are not. Hence there is a (229 tons) flow of pure solvents to the stock of pure solvents and a (219 tons) flow of impure solvents to the stock of impure solvents. Most solvents obtained after cleansing, however, have a very poor quality. These solvents flow either to the thermal conversion plant (793 tons) or to the incineration plant (1,210 tons).

It is not always economical to clean and reuse a low-priced impure solvent. But it might still be attractive to recover the energy that is contained in such a solvent. Hence, some impure solvents (1,629 tons) flow from the production plants to the thermal conversion plant. Also, some solvents that are filtered out of the process water (793 tons) flow to the thermal conversion plant. There, these solvents are used as fuel for generating steam that is needed for the production of several active ingredients. As fuel, solvents are about half as good as oil. That is, 1kg of oil and 2kg of solvent approximately lead to the same amount of energy. Sometimes, low-priced clean solvents also (1,642 tons) flow to the thermal conversion plant.

Both during the distillation process and the water cleansing process, some very impure solvents are obtained. These are considered as waste, since they cannot even be used as fuel in the thermal conversion plant. They lead to flows of respectively 2,059 tons and 1,250 tons of solvent to the incineration plant.

Pure solvents are kept in small drums and large barrels. Solvents that are only needed in very small amounts are kept in small drums. The same holds for perishable solvents. Other solvents are kept in one or more large barrels. Most barrels always contain the same type of solvent, but there are also some so-called multi-barrels. The size of most barrels is between 5 and 100 m^3. In 1997, the average stock was approximately 2,000 tons with a value of 5 million EUR.

The reverse flow of cleaned solvents from the distillation plant (14,871 tons) covers 51% of the demand for pure solvents. An additional 1% (215 tons) is filtered from process water in the water cleansing plant. The remaining 48% (13,754 tons) of total demand is purchased from outside suppliers.

The majority of pure solvents (25,776 tons) flow to the production plants. Small amounts of pure solvents are needed in the distillation plant (156 tons). Finally, some low-priced pure solvents (1,642 tons) flow to the thermal conversion plant, where they are used as fuel.

As is the case for pure solvents, a few impure solvents are stocked in small drums and most are stocked in large barrels. Whether a solvent is kept in a small drum or a large barrel depends, again, on its demand rate and on its liability to perish. The largest part of the incoming (14,993 tons) flows originates at the production plants. Another large (5,696 tons) flow is that of distilled solvents that flow back from the distillation plant to the stock of impure solvents. Finally, there is a small (219 tons) flow of impure solvents that have been filtered out of the process water at the process water cleansing plant. These impure solvents all flow to the distillation plant.

Planning and control aspects

In this section, we describe the type of policy that is used for planning the distillation of impure solvents and for controlling the stock of both impure and pure solvents. We do not have sufficient information to discuss the planning and control of the water cleansing, thermal conversion, and incineration plants.

The supply of impure solvent and the demand for pure solvent from the production plants obviously depend on the production plans of those plants. Recall that the weekly production plans are fixed by the logistics department. Since the distillation facility is also informed about these plans, it knows roughly when impure solvents are supplied and pure solvents are demanded. The daily production planning, however, is done by the production plants themselves. The distillation facility is not informed about these plans, and hence they face unknown daily demands for pure solvents and supplies of impure solvents. They use the following policy for controlling the stock of both impure and pure solvents.

If the stock of some impure solvent reaches its critical level, then distillation is started as soon as a distillation tank is available. The critical level is approximately 80% of the size of the barrel containing the impure solvent. Since both the set-up cost and the set-up time associated with distilling solvents are very large, as much impure solvent as possible is distilled at once. Hence, either the amount that fits into the distillation tank (batch distillation) is distilled or the entire impure solvent barrel is emptied (continuous distillation).

In busy periods, it might take a long time before a distillation tank becomes available. If, as a result, an overflow becomes likely, then the inventory controllers try to prevent this by asking production plants to postpone the pumping of impure solvent to the almost full barrel.

If the stock of some pure solvent drops below its safety stock level, new solvent is ordered from an outside supplier. We do not have detailed information on how the safety stock level is calculated, but it depends on the demand rate and on the delivery time of a solvent. The delivery time varies from one day to several weeks, depending on the type of solvent. In general, a full truckload of new solvent is ordered, since transportation costs are very large. For perishable solvents, however, smaller ordering sizes are used.

2.4 Conclusions

Schering spends considerable effort in undertaking product recovery activities in pharmaceutical production. The two main recovery activities are by-product recycling and solvent reuse. The main driver for engaging in these activities is economical. Recovery leads to annual savings of approximately 11.5 million EUR, which is about 8.5% of the total production cost. This figure does not include additional savings due to reduced disposal quantities and additional costs due to investments in recovery equipment, of which we do not have reliable estimates. Furthermore, being engaged in recovery activities has additional benefits for Schering that are related to the reduced waste stream: production is in accordance with environmental legislation, the company builds an environmentally friendly image, and there is less strain on the environment.

The downside of the recovery activities is that they complicate production and inventory planning. Especially the added complexity of production planning, resulting from cycles in the production structure, is a disadvantage. A simple MRP approach, as commonly used in practice, is no longer applicable but has to be replaced by a more sophisticated planning procedure. Schering has developed an advanced decision support system which integrates an MIP procedure. Thus it turns out that reverse logistics is also a field which creates challenges for developing advanced planning systems in order to support practical decision making.

3 Reverse logistics in an electronics company: the NEC-CI case

Roland Geyer, Kumar Neeraj and Luk N. Van Wassenhove

3.1 Introduction

In January 1999, NEC Corporation of Japan created NEC Computers International (NEC-CI) as a subsidiary in order to consolidate its PC and server business outside the U.S. and Japan, including its Packard Bell business, which it had acquired in 1996.

NEC-CI, located in Angers, France, manufactured desktops, notebooks, and servers and distributed them throughout Europe, Africa, and the Middle East. The Angers facility had three production entities:

- Desktops: Three fully automated lines including 60 workstations and a semi-automated line with a total capacity of 150,000 units per month,
- Notebooks: One line with a capacity exceeding 20,000 units per month,
- Servers: One assembly line producing tailored systems.

These production lines were designed to achieve a highly flexible manufacturing facility that was able to respond to both the volatile environment of the computer market and the high seasonal fluctuations of demand.

The Business Unit Notebooks and Servers (BUNS) of NEC-CI was responsible for the supply chain for notebooks and servers. BUNS used an advanced computer-aided design system (CAD) that supported the entire production process from inventory control and production specifications to assembly and quality testing. The manufacturing process consisted of acquiring the components such as processor, motherboard, hard drive, power supply, and PC casing from the suppliers, assembling the final product, and then testing and distributing it. See Figure 3.1. All products were assembled to order (ATO).

In the first year of its operation, NEC-CI was expected to have revenues exceeding US $2 billion.

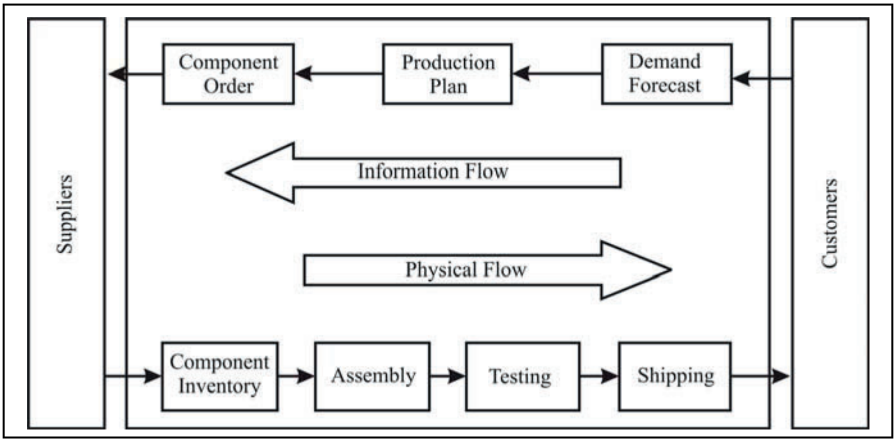

Fig. 3.1. Physical and information flow in the supply chain of BUNS

3.2 Business drivers

In the computer business, supply chains were required to have extremely high flexibility and maintain a fluid information flow between all upstream and downstream members. As the Manufacturing Director explained, "The product life cycle in our business is shortening at an extremely rapid pace. Every three months a new processor is introduced in the market. The growing complexity of software and operating systems requires our products to have more hardware space and higher processing speed. All this results in augmented rate of product obsolescence in our business. Therefore, to avoid significant costs due to obsolescence it is important for us to coordinate with our suppliers tightly, rotate component inventory faster and minimize inventory of product return due to faulty production or delivery."

There were a number of problems with the existing methods of handling returns from customers.

Returns from customers were treated solely as a service issue. The service center at St. Barthelemy replaced all returns under warranty with a new product. Most customer returns were under warranty and were returned within 2 months of sale. Such returns were almost new but were rarely used in any way after they landed at BUNS.

Another problem concerned the way product failures during production were handled. If a newly assembled product failed to perform fully, it was sent to On-Line Repair (OLR), which was BUNS' repair workshop next to the assembly lines. If OLR was not able to fix the problem within a certain time frame, which could be as short as 24 hours, the product was scrapped due to the time pressures that came from the assemble-to-order policy. This meant that the reasons for product failure often remained unclear, and BUNS not only lost the components that went into these assemblies but also faced the cost of their disposal.

In addition, there were a number of obsolete components that remained in stock for long periods of time. These components quickly turned from assets into liabilities in this fast clock-speed computer industry. Some key components such as microprocessors had long lead times and very short life cycles. As a result, the chances of them getting obsolete even before they were used in production were high. Inventory of such components also suffered high value erosion with the introduction of new generation products every three months. Furthermore, the volatile nature of demand in this industry made it difficult to forecast accurately. BUNS did not have a process to collect the information about these forecasting errors and to relay them to all the supply chain partners quickly; nor did it have a process to recover maximum value from obsolete products.

In order to address these concerns, NEC-CI needed to create a more coordinated, real-time process to handle the "quality" issues, to capture and diagnose all process interface problems, and to relay them back to the respective process owners.

3.3 Organizational aspects

In March 1999, NEC-CI created a new unit within BUNS called NSR (Notebook Server Recovery), which would deal with the above problems. NSR developed a new process for dealing with customer returns which aimed at identifying causes of failure, repairing the product if possible, and disposing of the unrepairable unit in a way that would result in maximum value recovery.

NSR also dealt with the rejections during the assembly process. It reached an agreement with the production department that if a product could not be repaired within 24 hours of production, it would be sent to NSR for a detailed analysis and repair. NSR not only repaired such products and sent them back to production but also analyzed the failure information and relayed the results of the analysis back to the appropriate process owners.

Customer returns

The process within NSR that dealt with customer returns was called the Return Material Authorization (RMA). When customers returned a product under warranty, they were required to fill out a questionnaire. This allowed NSR to obtain more upfront information about the problems with the returns. When a customer return was received, the accompanying data was entered into a computer system. The return could be either in an open or a sealed box. If the return was in a sealed box, it was directly transferred to serviceable inventory, otherwise it was extensively tested, in order to gather information about its condition. Then, depending on whether the product was still in the catalog or not, an appropriate disposition was given to it. If the product type was obsolete, the product was repaired, all the labels on the product were removed, and it was sold as a refurbished product without software and warranty to a broker. If the product type was still in the catalog, it was dismantled and the base unit was tested. This process was called Build Out (BO). If the base of the computer was flawless, the disassembled unit was sent to the component inventory and fed back into the regular production process. If the computer base could not be reused for regular production, the product was completely disassembled and all reusable components were used for the production of refurbished computers. This procedure was called Break Down (BD).

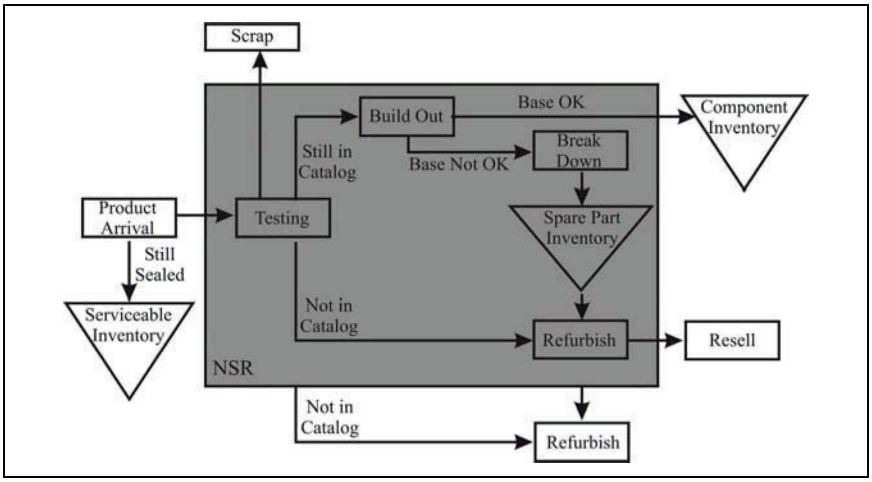

Fig. 3.2. Customer returns (Return Material Authorization)

All material that could not be used for either regular production or product refurbishment was labeled as scrap and was disposed of. See Figure 3.2.

Returns from production

Some newly manufactured products that did not pass the rigorous testing procedures at the end of assembly and could not be repaired within 24 hours were sent to NSR. Such products when received at NSR were disassembled and subjected to an in-depth diagnosis. All the defective components (under supplier warranty) were directly sent back to their suppliers for replacement. NSR repaired, if possible, the malfunctioning components not under warranty. After repair, these components were kept in inventory and were used in the refurbishment of out-of-catalog computers. All defective components that could not be repaired were disposed of as scrap. The whole process of dealing with production rejects was called Dead-in-Production, see Figure 3.3.

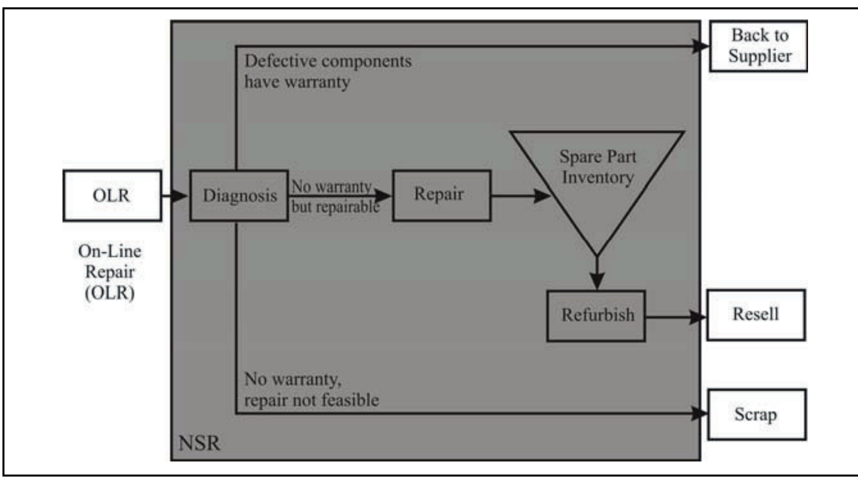

Fig. 3.3. Production returns (Dead-in-Production)

End-of-life components

The key role played by NSR in dealing with end-of-life components was to identify all components that were obsolete and sell them to component brokers to recover as much value from them as possible, thereby minimizing losses due to obsolescence.

3.4 Information aspects

One of the key roles of NSR was that of collecting information about all types of returns and relaying them in a timely manner throughout the supply chain. Firstly, in dealing with the customer returns, NSR obtained valuable information about the frequency and nature of the faults and defects in products returned by customers. It then evaluated and communicated the relevant information to the concerned process owners.

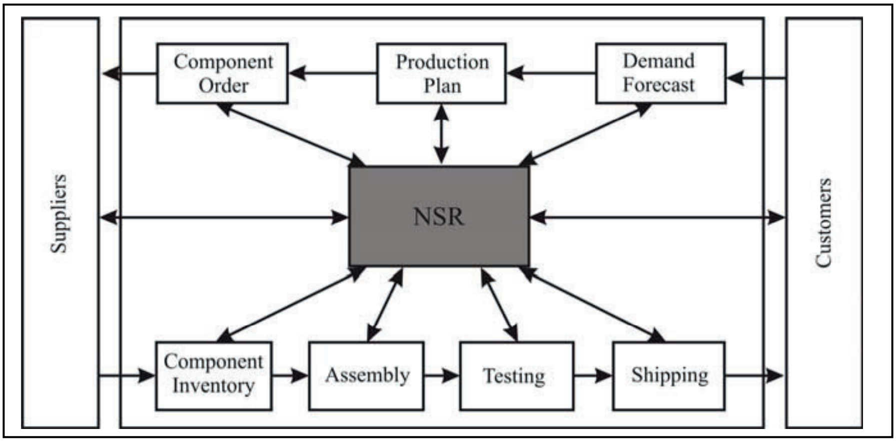

Fig. 3.4. NSR as information broker of the BUNS supply chain

Secondly, NSR collected all details concerning the returned computers from production in a database and analyzed them. NSR then fed this information to BUNS. This allowed BUNS to monitor the quality of the supplier and the supplied components, as well as the quality of the production processes.

Finally, NSR collected and analyzed the data concerning end-of-life components and ensured the adequate flow of information in the supply chain so that all activities from demand forecast to component orders were coordinated with the physical flow from component delivery to product delivery, see Figure 3.1. This helped minimize inventory in the supply chain and the resulting cost of obsolescence.

Thus, as the receiver of all defective products and components, NSR held a unique position within BUNS that allowed it to collect and synthesize information about failures and inefficiencies in the entire supply chain. Analysis of the information thus collected and fed back into the BUNS system helped to reduce these inefficiencies in the future. Sometimes NSR contacted or even coordinated different partners in the supply chain, e.g. the component suppliers and the buyers and production planners of BUNS, to resolve supply chain problems. As a result, NSR moved from a position at the fringe of the supply chain as an institutionalized trouble-shooter or a feedback agency right into the center as the supply chain information broker, see Figure 3.4.

3.5 Conclusions

In the past year, NSR has made significant progress in reducing returns related costs. As a result of better coordination, collection, and relay of information and feedback in the supply chain, the value recovery percentages of returned components has increased from 10-20% of the original purchased costs in the pre-NSR days to 70-80% post-NSR formation.

NSR was an important broker of information that helped to continuously improve BUNS' entire supply chain. On an abstract level, BUNS had learned to use divergences from the optimal system behavior (no returned products or components) to create a feedback loop that nudged the system back towards the optimal level. In cybernetics, these systems are known as self-controlled or autopoietic. In an ideal world, these system divergences should be reduced to zero or, as some company insiders described it, "NSR shouldn't really exist. If NSR managed to fulfill its mission to 100% there would no longer be a need for this unit."

Postscript

This case is based on the situation in 1999. Processes described in this case have evolved significantly since then. Actions taken by the company to deal with product returns were considered appropriate at that point in time.

In 1999, supplier quality levels within the PC industry had become a key issue. Significant progress had been made at NEC with regard to defects in incoming materials and the structure of inbound logistics – both of which had an impact on NSR. For example, a DPPM level of 10,000 to 15,000 for a CPU motherboard was the norm; today the suppliers of the same components (with more complexity on board) do not exceed 800 to 1200 DPPM failure rates. On the inbound logistics side, the majority of suppliers are now at NEC's manufacturing sites checking/testing their components that fail in the NEC manufacturing process. The time required for these activities is much shorter today.

Part 3:
Distribution closed-loop supply chains

4 The chip in crate: the Heineken case

Jan van Dalen, Jo A.E.E. van Nunen and Cyril M. Wilens

4.1 Introduction

Heineken Group is the third largest brewery in the world, with operations on six continents through their own breweries, exports, participation in brewing companies, and licensees. In 2002, the total beer volume produced by the Heineken Group amounted to 108.9 million hectoliters. Production is based at more than 110 breweries in over 60 countries. Net turnover of Heineken in 2002 totaled 10.2 billion Euro, while net profits were equal to 795 million EUR. Today, Heineken Group employs over 48,200 worldwide. The main thrust of Heineken's activities is in Europe, with headquarters in the Netherlands. In the United States, Heineken's most important market outside Europe, beer is imported from the Netherlands. The Group's corporate brands are Heineken and Amstel, which are supplemented and supported by national and regional brands. An example is the Brand brewery, which plays an important role in this case study.

Heineken sells a substantial amount of its beer in returnable packaging materials (RPM), including returnable bottles and crates, as well as kegs. In 2001, approximately 30 million hectoliters (about 47% of the total beer turnover in Western Europe) was packaged in RPM. The use of RPM absorbs substantial resources. Investments in crates, bottles, and kegs are periodically needed to facilitate product introductions or to replace damaged and lost RPM. Also, the handling of RPM involves operations, such as transportation, storage, and the cleaning of used bottles and kegs, which are complementary to the brewing activities.

In April 2000, the Heineken Group initiated the Chip in Crate pilot at the Brand brewery, one of Heineken's brands in Europe. The project's objective has been to measure the total circulation time of Brand crates through the RPM logistic chain, which was defined as the time elapsing between two entries of a crate at the production belt. The measurement results of the project are used as input for calculations of the optimum amount of RPM. The Chip in Crate information complements existing information about the storage duration of crates at the brewery, which is based on daily counts of full and empty RPM. The combined sources thus provide decision makers with information about total circulation times and about the time crates spend in the market, which is relevant for long-term decisions about RPM investments as well as for short-term forecasts of the RPM returns to the brewery.

The purpose of this chapter is to clarify the use of installed base solutions, such as Chip in Crate, to monitor flows of RPM. The emphasis is on explaining the context that shaped the Chip in Crate experiment and on the interpretation and use of the information obtained. Below we describe the RPM logistic chain, discuss the business drivers for product recovery and monitoring reverse logistic flows, and elaborate the technical, organizational, planning and control, informational, environmental, and business-economic aspects of the RPM reverse logistics and the Chip in Crate measurement effort.

The structure of Heineken's reverse logistic process is illustrated in Figure 4.1. We briefly explain the main features of this process before discussing its opportunities for measurement.

The logistic process in Figure 4.1 portrays the flow of RPM as a chain of various storage locations connected by transportation. In the scheme, *S* denotes the storage time at different storage sites and *T* denotes the transportation time associated with shipping lots from one location to another. The upper part of the scheme illustrates the flow of full RPM, going from the left to the right, and the lower part depicts the flow of empty RPM going from the right to the left.

The circulation of RPM through the logistic chain may be considered to commence at the brewery. At the production site, empty RPM is needed to bottle and pack the beer, after which the full crates are stored on the brewery's premises (S_1). From here, full RPM is transported to two storage locations, 's Hertogenbosch (S_2) and Zoeterwoude (S_3), where specific products are sorted with other brands. At this point, full RPM leaves the brewery and is distributed to warehouses or distribution centers of wholesalers and retailers (S_4). The full RPM then goes to retail points of sale (S_5), such as retail stores, bars, or canteens, and finally finds its way to the consumer (S_6). The return flow of empty RPM starts at the consumer, traveling backwards via the retail outlets (S_7) and distribution centers (S_8) to the locations 's Hertogenbosch (S_9) and Zoeterwoude (S_{10}), where empty RPM is collected and re-distributed to a site for empty crates without bottles (S_{12}) and a site for empty crates with bottles (S_{11}). The latter location supplies the RPM for the filling process at the brewery (S_{13}), at which point the circulation of RPM starts all over again. In the case of local brands, such as Brand, full RPM is sometimes shipped directly from the brewery (S_1) to regional retail distribution centers (S_{14}), from where empty

RPM is returned to the brewery (S_{11} and S_{12}) without visiting's Hertogenbosch (S_2/S_9) and Zoeterwoude (S_3/S_{10}).

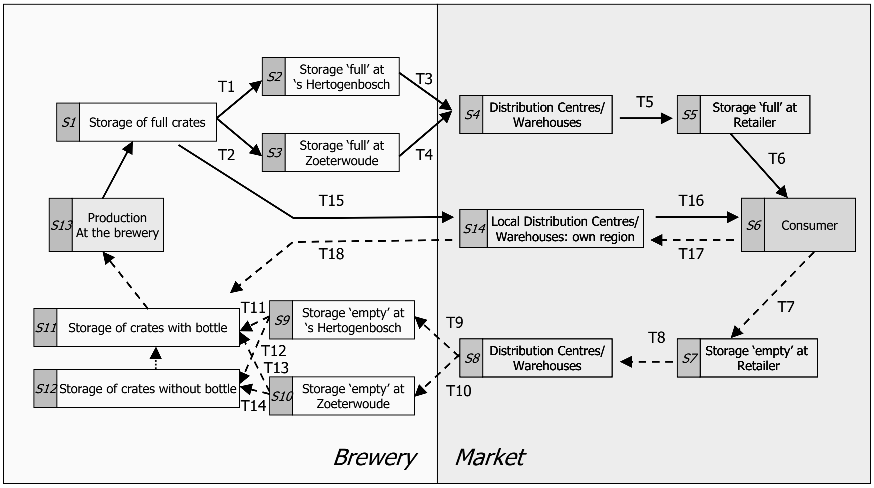

Fig. 4.1. The closed-loop of Brand crates

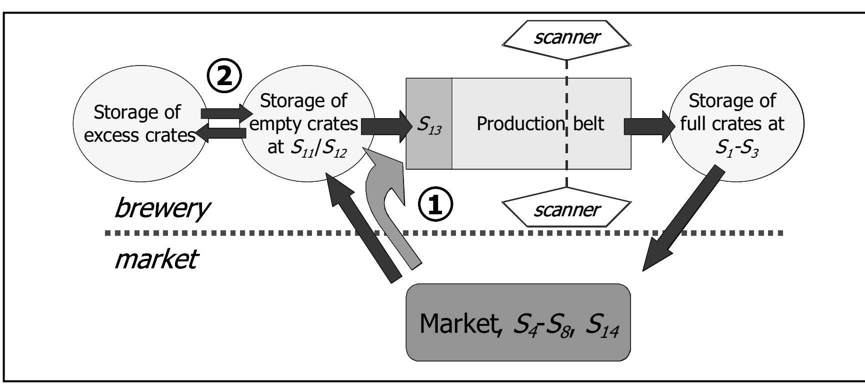

Fig. 4.2. Situation at the Brand brewery

Apart from the storage sites depicted in Figure 4.1, the brewery maintains an area for 'winter storage'. Crates are stored here during the fall when the demand for beer abates and the amount of empty RPM at the brewery accumulates. Crates are retrieved from this area in spring when the demand for beer goes up again and the amount of empty RPM at the brewery lessens. This storage area does not constitute a regular part of the RPM flow, which is accentuated by the fact that it is physically separated from the brewery's production area by a river. The situation is illustrated by point 2 in Figure 4.2, in which the winter storage area is depicted as a sort of appendix to the triangular shape regular RPM flow.

The total time it takes RPM to circulate through the entire logistic chain illustrated in Figure 4.1 is equal to the sum of storage times S_i and transportation times T_j, where the contribution of the transportation times will be relatively modest. The brewery has direct control over some of these times, like the time at the production premises (S_1 and S_{13}) and the storage time at the distribution and collection sites in 's Hertogenbosch (S_2 and S_9) and Zoeterwoude (S_3 and S_9). But it has no control over the other stages: the distribution centers (S_4, $S_{14,}$ and S_8), the retail selling points (S_5 and S_7), and the consumer (S_6). In part, RPM storage times at these locations may be expected to be minimal as cost motives urge warehouses and retail stores to process the RPM logistics with some resolution. In part also, storage time is highly uncertain as it depends on the consumption behavior of individuals (S_6). In either case, Heineken is interested in information about the circulation time of RPM at different stages of the logistic chain to enhance their return forecasts and to initiate efforts to control the return of RPM. Following this interest, Heineken started the Chip in Crate experiment.

The Chip in Crate experiment was launched at the Brand brewery to measure the circulation time of crates through the RPM logistic chain, see Figure 4.1. It was meant as a pilot to gain knowledge about the possibilities of measuring aspects of RPM flows as well as to acquire hands-on experience with the implementation of measurement equipment in the daily operations at the brewery. The start of the pilot coincided with the complete replacement of all 30 *cl* Brand crates. This was a matter of convenience, since the chips required for the project had to be baked into the crates. Furthermore, this decision provided full knowledge about the total amount of crates in circulation and about the percentage of crates with chips (about 1.4% of the crates). Scanners were placed at the production belt to read the chips in the passing crates, see Figure 4.2. In this way, the time between two passes of a crate at the scanners at the production belt, interpreted as the duration of a single pass of a crate through the entire logistic chain, could be measured precisely.

The information obtained with the Chip in Crate experiment is very accurate as far as the circulation times of separate crates are concerned, but it is relatively crude as far as the storage times at different stages of the logistic chain are concerned. In order to estimate the RPM storage time in the market, the Chip in Crate information is combined with separately collected information about all incoming empty crates and outgoing full crates at the brewery.

4.2 Business drivers

The use of RPM follows Dutch packaging regulations, which are substantiated in successive agreements between Dutch industries and the Government: Convenant III (1/1/2003), Convenant II (end of 1997), and Convenant I (1991); see (VROM, 2003). The Dutch packaging regulations are in line with, and at some points even exceed, the European Union's Packaging and Packaging and Waste directive (94/62/EC); see (EU, 1994). According to these regulations, Heineken is committed to take back 90% of its bottles. Crates are recovered integrally as a regular part of the return system.

Investment decisions concerning new RPM balance between two extremes. Traditionally, Heineken has adopted a 'better safe than sorry' strategy: new RPM was ordered in such large amounts that the probability of RPM stock-outs at the brewery, causing disruptions of the bottling process, was practically zero. This approach has led to high levels of excess RPM, much of which was not actively used in the logistic process. In recent years, there has been a growing concern for the financial-economic consequences of maintaining large amounts of RPM stock. This has led to research initiatives aimed at gaining insight into the actual RPM flows in order to forecast the stock of empty RPM at the brewery.

4.3 Technical aspects

Heineken's reverse logistics of RPM concern different types of packaging that travel in different parts of the logistic chain at different speeds. The main types of packaging are kegs, bottles, and crates:

- Kegs of 20, 30, 50, and 60 liters are used for sales to hotels, restaurants, bars, and catering outlets ('Horeca') and for export. Kegs are not always unique; they can be used for different types of beer. For safety reasons, filled kegs are exclusively transported in two layers, while empty kegs may be transported in three layers,
- Bottles of 25, 33, and 50 *cl*. Bottles come in two varieties: brown and green. The brown bottles are used for domestic sales in the

Netherlands, while the green bottles are mainly used for export purposes. The green export bottles are usually one-way,

- Crates for 12 and 24 bottles. Crates are often brand-specific. They have a unique color and a unique brand name printed on them. Crates are mostly used for retail sales to consumers, although they are also sometimes used for sales to hotels, restaurants, bars, and catering outlets.

Pallets, which are also part of RPM, are a different story. Pallets are leased by Heineken, and not owned. They are obtained from a so-called pool, which is also used by other firms.

Each period, a certain amount of bottles and kegs leave the logistic process as a result of technical or economical depreciation. Technical depreciation occurs when RPM is damaged or broken. Bottles have an average lifetime of about seven cycles through the entire logistic chain. After this period, bottles are usually too scuffed or damaged to meet Heineken's packaging standards and, accordingly, they need to be replaced. Crates have a much longer technical lifetime and will often only be replaced when the economical lifetime has ended. By contrast, kegs have a technical lifetime shorter than their economical lifetime and sometimes need to be re-supplied. Economical depreciation occurs when existing RPM is replaced by new RPM without being technically obsolete. This happens approximately every eight to ten years, mostly motivated by marketing considerations. In the case of the Chip in Crate experiment, for instance, the start of the project coincided with the complete revision of all 30 *cl* crates.

The Chip in Crate experiment and similar automated measurement efforts require transmitting devices (chips) and receivers (scanners), which need to be installed and maintained.

Choice of chips. Two different types of chips may be used in processes like in the Chip in Crate experiment: a read-only chip or a read-and-write chip. A *read-only chip* contains a specific code that can be read but not modified. A *read-and-write chip* can be used both for reading and writing data. Heineken decided to use the read-only chip to keep the process simple and affordable. The chips are baked into the crates. The presence of these chips in crates cannot be observed unless use is made of lamps and scanners. As a result, all crates need to be scanned.

Use of scanners and measurement location. Every chip in crate has a unique code that can be read with a scanner. Reading the information from the chips is done crate by crate, since the measurement technique is not sophisticated enough to scan whole pallets or truck loads of crates, or to track and trace separate crates throughout the logistic chain. The scanners to read the chip information were placed alongside the production belt, see

Figure 4.2. This is a natural point of measurement: it is the only process where crates are handled individually (rather than by pallet), in a structured fashion (crates are on a conveyor belt), and under the brewery's control. Two scanners rather than one are needed to collect the information, because the chips are placed in one corner of a crate. As the particular corner is not immediately apparent, both sides of the crates need to be scanned.

Maintenance of chips and scanners. The chips do not require specific treatment in the production process or during the transportation and storage of crates. Samples of chips in crates are drawn to check whether chips are still functioning and whether the data output is correct. This inquiry is performed with a lamp and a manual scanner. The lamp is needed to see whether the crate contains a chip and the manual scanner is needed to check whether the chip is still functioning. So far, the pilot indicates that all chips work properly. The performance of the scanners that read the chips at the production belt is less satisfactory. Experience shows that occasionally no chips are registered, while crates with chips did pass the scanners. Obviously, this adversely affects the quality of the Chip in Crate information.

4.4 Organizational aspects

Various parties contribute to the RPM logistic chain and may have a delaying or accelerating influence on the circulation rate of RPM. The parties are briefly described by referring to Figure 4.1.

Brewery. The brewery is where the production takes place; where full RPM is temporarily stored (S_1), combined with other shipments (S_2 and S_3), and farmed out to distribution centers; and where empty RPM ultimately returns (S_9 / S_{10} and S_{11} /S_{12}) and is washed, tested, and made fit for reuse (S_{13}). Returned crates are processed first returned - first reused (FIFO) as much as possible.

Wholesalers and retailers. Wholesalers and retailers, who buy the beer, store full RPM at their Distribution Centers (S_4) and retail outlets (S_5). They also collect empty RPM from consumers at the same locations (S_8 and S_9). Transportation of full and empty RPM between brewery sites and distribution centers (T_3/T_4 and T_9/T_{10}) is taken care of by Heineken. These shipments occur 'full for empty' as much as possible: truckloads of full RPM are supplied to DCs, and as many empty crates as possible are returned to the brewery. The retailers or wholesaler distributors are responsible for transportation between their Distribution Centers and retail outlets

(T_5 and T_8). The transportation of kegs ($T_{15}/T_{16}/T_{17}/T_{18}$) is entirely performed by Heineken.

'Horeca' distribution centers. The 'Horeca' distribution centers are Heineken owned. They serve to supply kegs and beer in crates to hotels, restaurants, bars, and catering outlets. They also take empty RPM in return. Heineken performs the transportation between brewery and Horeca DCs as well as between Horeca DCs and Horeca outlets.

Consumers. The consumer buys full RPM in retail outlets (S_5), and returns empty RPM at the same or another retail location (S_7). In between, she stores the purchased full and empty RPM at home (S_6). Transportation between retail outlet and consumer is usually taken care of by the consumer and sometimes by the retailer (T_6 and T_7).

4.5 Planning and control aspects

Investments in new RPM are based on the total amount of RPM needed, which in turn depends on the demand for beer (full RPM) and the time it takes for RPM to pass through the logistic chain and reappear at the production belt. As both the demand for beer and the circulation time are uncertain, some extra RPM may be purchased to guard against stock-outs at the brewery. For instance, if the demand for beer is equal to 5,000 crates per week and the crates take 15 weeks to return to the production belt, then initially 75,000 crates would have to be ordered. If, moreover, business policy requires a buffer of 2-weeks demand, then an additional amount of 10,000 crates should be ordered, bringing total investment at 85,000 crates. This stylized example demonstrates the quantities of interest: demand and circulation times. In addition, supplementary RPM investments are needed throughout the year to cover up for RPM losses or for an unexpected growth of demand for full RPM.

The daily supply of crates with bottles to the production belt is based on the expected production. Each week, estimates are made of the expected production and the corresponding need of crates, which are based on a short-term production plan. RPM is supplied at the filling location only at the instant it is needed. All RPM supply comes from storage location S_{11}, see Figure 4.1. If the needed amount of crates with bottles falls below a certain minimum, then empty crates are manually filled with bottles and stored in S_{11}.

4.6 Information aspects

Chip in Crate information typically comes in a series of tag numbers uniquely linked with individual chips in crates together with the dates and times at which they passed the scanners at the production belt. Based on this information, one can determine the average circulation times of crates sold in a particular week. The resulting information may be visualized as in Figure 4.3, which shows the weekly empty returns as a percentage of the weekly sold crates (with chips) for all weeks between the start of the experiment and November 2001 (the most recent date at the time of study).

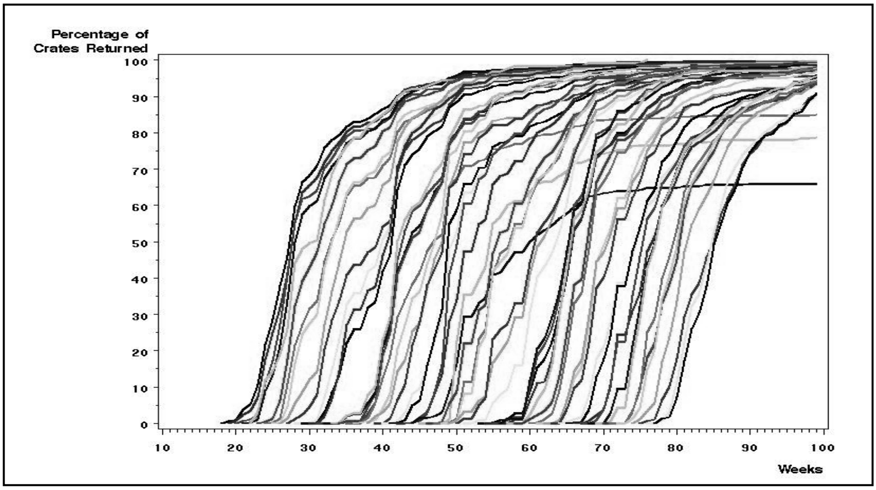

Fig. 4.3. Percentage of Weekly Returned Crates after issue

The return pattern of the empty crates is S-shaped. Consider for instance the returns of the 591 crates (with chips) sold during the first week of the pilot, depicted at the furthest left in Figure 4.3. During the first 3 weeks after having been issued, crates are returned incidentally. Then, the rate of return increases up to 80 returned crates in the 10th week, after which it decreases. 50% of the crates sold in week 1 are returned after 8.5 weeks, while 80% of the crates are back at the production belt after 16 weeks. The average circulation time for the crates (with chips) sold in the first week is equal to 12.5 weeks, reflecting the average time it takes for a crate to circulate through the logistic chain between its observed departure at the scanner (S_{13}) in the first week and its arrival at the same scanner some period thereafter. Note, therefore, that this circulation time includes both the storage time at the brewery and the time the crates spent in the market.

It is worthwhile to point at some further interesting information. First, the return patterns are generally alike with respect to their S-shapes, though their specific shapes differ. Some S-curves tend to be steeper than others, which reflects varying speeds of return. This information may be valuable, because a higher speed of return immediately influences the amount of weekly returns, which affects operations at the storage locations. Also, the variation in S-shapes reflects periodical or other structural changes in the RPM logistic chain, which provide important information to enhance forecasts of returns at the brewery or to evaluate the effects of changes in logistic strategies.

Second, the percentage of returned crates amounts to almost 100% except for the issues in weeks 31 and 26, when only 67% and 78% of the crates seem to return. This interesting finding illustrates the relation between the logistic operations and the measurement effort. A closer examination of these results reveals that promotional actions took place in these weeks, which required specific handling. Crates with filled bottles were sent from S_1 to a packaging firm. Here, the bottles were taken out of the crates and put into special promotion crates, after which the empty crates were returned to the brewery. Normally, this would lead to relatively steep S-shapes indicating extremely short circulation times. However, in this particular instance, the returned crates ended up in the winter storage area, see Figure 4.2, and were no longer used, at least not within the time frame of the Chip in Crate experiment.

Third, the return patterns in Figure 4.3 can be conveniently used to forecast RPM returns in a specific week. Suppose someone is interested in the expected RPM returns for the issues in week 40. These RPM returns all come from sales in earlier weeks. However, some weekly sales contribute more to these RPM returns than other weekly sales. The propensities of RPM returns from particular weekly sales are indicated by the steepness of the associated S-shaped return patterns at week 40. In Figure 4.3, these propensities are found on the straight vertical line at week 40. Multiplying these return proportions in week 40, based on the Chip in Crate information, by the associated total weekly sales of the preceding time period (*all* sales, not just the Chip in Crate sales) gives an estimate of the RPM returns in week 40. In practice, such predictions are desired *in advance* for *arbitrary* weeks rather than *a posteriori* for *specific* weeks. This may be realized by explicitly estimating the statistical distribution underlying the S-patterns and applying the result to specific situations.

The Chip in Crate data allows one to estimate the total circulation times of crates, but they do not convey information about the storage times at different locations, notably the time of RPM at the brewery and the time of RPM in the market. In order to make this distinction, the detailed Chip in

Crate data may be combined with separately administered counts of full RPM and empty RPM at the brewery. These data do not provide direct information about the circulation times of crates, but they do offer the possibility of estimating the average times of RPM at the brewery. For example, if the Chip in Crate based estimate of the total circulation time is equal to about 13 weeks and the joined storage time of full and empty RPM at the brewery is estimated to be roughly equal to 5 weeks, then the average time of RPM in the market would be equal to about 8 weeks.

The result is not at all implausible, though it does point at a peculiar feature of the brewery logistics: the count data indicate that the average storage time of empty RPM at the brewery is about 4 weeks, while the Chip in Crate data report RPM returns already within the first week after sales. This feature is most likely to be explained by logistic operations that are not strictly FIFO, as desired by management. This is illustrated by point 1 in Figure 4.2, where crates take shortcuts through the RPM logistic chain: crates that return to the brewery are immediately stored at the production belt (S_{13}) rather than stocked with the main flow of RPM returns (S_{11}/S_{12}).

4.7 Environmental aspects

The maintenance of an RPM reverse logistic chain has various impacts on the environment. Cleaning crates and bottles is inherently part of the process and consumes large quantities of hot water. In particular, the production of 1 liter of beer currently requires 6 liter clear water (against 20 liters 10 years ago), which is used to produce the beer; to clean bottles, crates, and kegs; and to cool off machines, as well as to keep the brewery clean. Waste water is cleared in own installations before it is returned to the ecosystem. Broken glass is collected in glass containers to be recycled again, as far as the brewery is concerned. Damaged crates or crates gone pale are returned to the manufacturer to be reused in the production of new crates.

4.8 Business-economic aspects

The total replacement value of RPM within Heineken Europe is about 550 million EUR, which is approximately 7.5% of the total invested capital. The economic lifetime of crates (about €3.5 per piece) is about 10 years, after which RPM stocks are replaced. Each year, crates and kegs are bought to compensate for lost RPM. Bottles are more frequently obtained from a bottle pool share with other beer producers. Furthermore, the RPM logistic chain entails substantial labor resources associated with transportation and storage, as well as managerial overhead.

The information obtained with the Chip in Crate experiment can be used to reduce the investment costs associated with RPM. This is illustrated with a back-of-the-envelope sketch of the outlays and investments involved.

Costs of the Chip in Crate experiment. The direct costs of the project consists of outlays for the chips (€2 per piece), the additional cost of baking these chips into the crates (€10 per crate), the two scanners at the production belt (€2000 each), and the lamp (€20) and manual scanner (€500) for the maintenance of the chips. In all, 10,000 crates with chips were purchased leading to a total investment of about €80,000. The cost of the labor involved in the development and execution of the project are not taken into consideration.

Revenues of the Chip in Crate experiment. The revenues of the Chip in Crate experiment are extremely difficult to measure, as the obtained information is not associated with an immediate financial return. Also, the revenues are largely tied to future application of obtained insights in logistic processes worldwide. However, it is possible to compare the RPM investment decisions in a relevant old situation (without using the Chip in Crate information) and the corresponding new situation (with the use of the Chip in Crate information). The investments in the 30 *cl* crates, of which the Chip in Crate crates are a subset, are an example of the old investment decision. Recalling that the Chip in Crate sample constitutes 1.4% of the total number of crates ordered, this latter number follows as 3.57 million crates. Each crate costs about €3.5, which leads to a total investment in the old situation of €12.5 million. In the new situation, utilizing the Chip in Crate information, the required number of crates is 1 million less (calculation rules cannot be disclosed), which leads to a savings opportunity of €3.5 million. So, the expected returns would amply cover the expenses of the pilot project. More importantly, future savings will be even higher when the results of this project are applied to other types of RPM at breweries worldwide.

4.9 Conclusions

The Chip in Crate project data has been a valuable measurement project generating insights into various aspects of the RPM logistic process. Experience has been gained in the implementation of high-technology measurement instruments in core logistic processes. Specific insights into circulation times of crates over time have been obtained. Combining the Chip in Crate data with daily counts at the brewery enables Heineken to estimate the relative times of crates in the market and crates at the brewery. Such information is important as it indicates which part of the logistic process deserves managerial attention. Moreover, the project provided important information about the operations at the brewery storage. The outcomes strongly suggest that the handling of RPM systematically diverges from FIFO, which is unwanted from the managerial point of view. Also, the implementation of the pilot has demonstrated the importance of managerial commitment and a clear allocation of responsibilities with respect to the Chip in Crate measurement process.

Traditionally, RPM investments have been based on experience and simple calculations. The outcomes of the Chip in Crate experiment suggest that these simple procedures have led to a substantial over-capacity of RPM and associated cost of capital. This may have been justified as a way to decrease the risk of stock out. At the same time, the installment of advanced measurement systems provides a means to better control RPM flows, to avoid hazardously low RPM supply at the brewery, and ultimately to cut down on RPM cost.

This Chip in Crate pilot provided insight into the RPM flows for a particular brand that is regionally distributed. Ideally, these Brand results could also be used for the RPM of other brands, such as Heineken and Amstel, and maybe even for breweries in other countries. Research has pointed out that this is indeed the case for almost all European brands. An investment model based on the Chip in Crate data indicates that implementation of the Chip in Crate results leads to a savings opportunity between 5 and 10 million Euro for RPM worldwide. In view of the valuable information obtained about the RPM flow, the Chip in Crate project is appreciated as a highly successful experiment.

5 Recovery and reuse of maritime containers: the Blue Container Line case

Costas P. Pappis, Nikos P. Rachaniotis and Giannis T. Tsoulfas

5.1 Introduction

The transportation of a great variety of goods is done via the sea. For that purpose, containers are used that not only can be transported with ships, but also that are easy to handle with other means of transportation via road, rail, and air. There are two basic types of companies participating in the container trade: liners and feeders. Liner companies do scheduled routes all over the world and, usually, their final destinations are hub ports, where a transshipment of the containers to feeder companies takes place. Feeder companies are responsible for shipping the containers to smaller seaports, so that they are gradually dispatched to smaller markets. The connection of liners and feeders is presented in Figure 5.1.

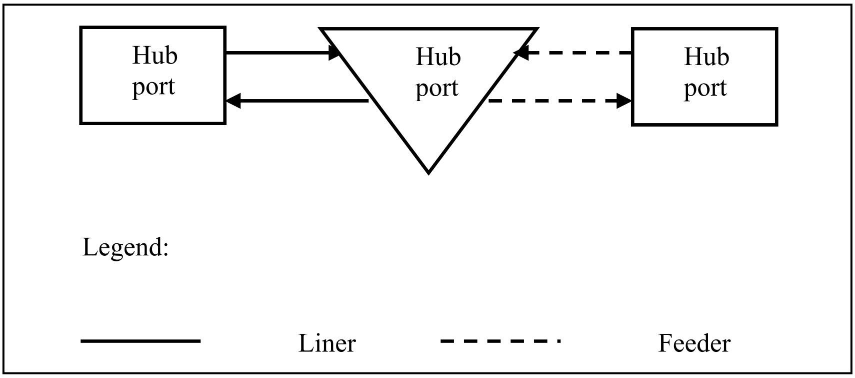

Fig. 5.1. The destinations of liners and feeders in the container trade

Blue Container Line S.A. (BCL) is a small feeder company, which has been active in the container trade since 1989. It covers nearly all Mediterranean seaports as well as the harbors of Costanza and Odessa in the Black Sea. BCL employs about 60 people working in Piraeus and Thessalonica. It has been certified with ISO 9002 certification.

Several seaports in the Mediterranean Sea and in the Black Sea are directly serviced by liners, while a considerable number of other ports are serviced with commercial feeder services, via hub ports. BCL feeder services are provided on a regular basis to 10 liners and feeders. Mainland service may be provided by both truck and rail, from all seaports, after an agreement between BCL and its customers. Since 1993, BCL service is also available to deep ocean liners, providing them with feeder services from nearly all direct ports that the company serves.

BCL's current fleet includes 5 leased ships for containers' transportation. These ships have a total capacity of 1,500 TEUs, where TEU stands for Twenty Foot Equivalent Unit = Unit of measure equivalent to a 20-ft container. BCL's total capacity of containers is 5,500 TEUs. The containers that are not in use or that are being maintained are stored in warehouses. 67% of the containers fleet is used after long-term contracts with all containers manufacturers. 23.5% of the containers are under purchase lease and 7.5% of the containers are sub-leased. The remaining 2% is owned by the company. Depending on the demand, BCL buys or leases used containers from other companies and sells or leases used containers to other companies. The closed-loop supply chain of BCL is presented in Figure 5.2.

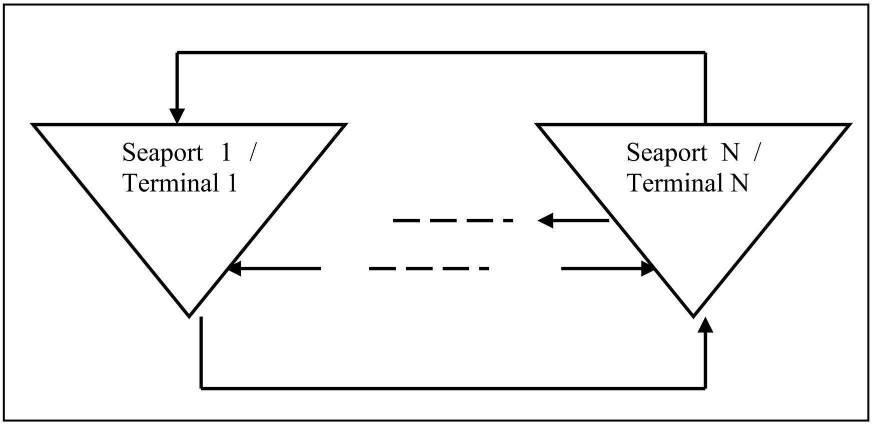

Fig. 5.2. The closed-loop supply chain for BCL containers

The reverse chain for the containers starts at the recipients of the products, which are distributed with the containers. The empty containers are transported by end users who receive products either to intermediate stages, being warehouses located at sea ports or terminals cooperating with BCL, or to the starting ports or mainland terminals. Container-ships, trucks, or railway are used for this transport. The reverse distribution of containers until their reuse (repositioning) depends on the demand, which is affected by several parameters, such as seasonality, state of international trade, etc.

In the warehouses, the containers are subject to maintenance so as to be ready for reuse. The maintenance procedure includes inspection and cleaning of the containers so that they are brought to an as-new condition. Special provisions for the treatment of containers have been established by the International Institution of Containers' Lessors (IICL). Damaged containers are repaired on site. Maintenance is done by third-party logistics operators, which are warehouse companies.

5.2 Business drivers

The primary driver for the reuse of containers is profit. Unlike other packaging, containers may return loaded, and that means profit. Most containers are parts of a continuous flow, making the distinction between forward and reverse chains rather artificial. The percentage of the containers returning empty to warehouses depends clearly on the seaport. For example, 80% of the containers returning to the seaport of Piraeus are empty, whereas only 5% of the containers return empty to the seaports of Naples, Barcelona, Valencia, Istanbul, and Costanza.

Due to high capital cost, it does not make sense to use containers only once or a few times. They represent an investment of the owner company and allow multiple and long-term use.

5.3 Technical aspects

Standardization is very common in containers. This standardization definitely eases their transportation, treatment, and storage. The life of a container depends by all means on the manner in which it has been used and maintained. It is estimated that containers normally last more than 20 years. After its active life as a container, it can, apart from recycling, be used for purposes totally different than for transporting products, e.g. as a warehousing facility.

5.4 Organizational aspects

BCL and similar companies participate in large networks of companies and there is a very high degree of specialization regarding the tasks that have to be done. BCL is involved only in sea-transportation and is the owner or the dealer of the containers. In fact, customers lease the containers for a period of time so that their products can be transported to desired destinations. Due to the fact that BCL's activities mainly occur in the Mediterranean, the company uses Gioia Tauro port in Kalabria, Italy, as an intermediate transportation center.

BCL starts a new contract with a company that wants to use BCL containers on the condition that this company will return the containers in the same condition and that their maintenance will be done according to the requirements of IICL. BCL customers are also responsible for the timely return of the containers. If these conditions are not fulfilled, then a penalty has to be paid.

Warehouse companies take care of maintenance activities. A repair shop for containers exists in the warehouse area at every seaport. However, BCL has chosen for economic reasons to maintain their containers in the seaports of Naples, Valencia, and Barcelona. Containers are insured against damage. Containers may also be stored in warehouses, if necessary.

In every seaport where BCL containers are shipped, the company cooperates with third-party agents, who are responsible for recording the routes of the containers. The agents are also charged with handling the return of empty containers to other seaports and with providing the necessary information to the company.

5.5 Planning and control aspects

The future requirements for containers are estimated based on long-term contracts. The existence of such contracts in the container trade significantly aids companies in implementing their planning and control aspects under predefined constraints. As mentioned earlier, in cases of high demand BCL buys or leases used containers from other companies. Statistical data also assist in planning, since there are parameters such as seasonality that affect the container trade. The existence of appropriate terms in the contracts ensures that the containers will be available when needed.

5.6 Information aspects

Appropriate labeling of the containers further assists in their management, by providing information regarding the owner, the country of origin, the date of manufacturing, their dimensions, contents, durability, and some other technical characteristics. Information regarding the inspection status of the containers is also included on the label. There are two different kinds of inspections:

- Containers that are inspected under the Approved Continuous Examination Program (ACEP) can circulate for 5 years,
- Containers that are not inspected under the ACEP scheme can circulate for 2 years.

As mentioned earlier, the tracking of the routes of the containers is done with the contribution of third-party agents, who provide the necessary information to the company. Documents are used for all transactions within the closed-loop supply chain of containers and they significantly help in providing the necessary data for their routing.

5.7 Environmental aspects

Obvious environmental gains are incurred due to the recovery of containers instead of having them put into the waste stream. By properly maintaining and reusing them their life cycle is multiplied and consumption of natural resources is avoided. In addition, as mentioned earlier, containers are rarely transported empty of cargo so there is no waste of energy caused by their movement. The backwash from the cleaning procedures is properly treated in appropriate plants located in the port area. The policy of the company is “to own no waste”. That is the reason why BCL proceeds to sell its containers when they are reaching the end of their life cycle. Parts of unrepairable containers are used for repairing other containers. What is left, as well as complete containers, is sold to recyclers in order to recover the metals. It seems that there is no organized scheme for the recycling operations in the container trade, but it is possible that they have the same fate as damaged ships, that is they end up in furnaces.

5.8 Business-economic aspects

Costs for new containers

The prices of new containers for the most common sizes are of the magnitude presented in Table 5.1.

Table 5.1. Prices of new containers

Dimension (ft*ft*ft)	Price ($)
20*8*8	1,600
40*8*8	2,500
45*8*8	3,000

Costs related to maintenance:

The maintenance costs depend on the processes that have to be accomplished. The simplest maintenance procedure is to just clean the container and the most complicated ones have to do with fixing or replacing their parts. They can range from 15 Euro to 1,000 Euro.

Storage costs:

The storage cost for a container depends on the seaport. This affects the policy of BCL when it comes to deciding where to store the containers when they are not used. These costs are very high in Turkey, whereas they are quite reasonable in Spain (e.g. 40 days free and after that the cost is 0.40 Euro/day for a 20-ft container). Containers may be stored for free in Piraeus and this justifies the very high rate of containers returning empty to this seaport.

5.9 Conclusions

During their life cycle, containers are in a continuous flow and may be reused. Evidently it is important to apply practices that assist in their appropriate planning in order to minimize the costs associated with storage, maintenance, etc., which leads to better profit opportunities. The various constraints that affect containers flows, such as the differences in the storage costs in every seaport, also have to be taken under consideration. Furthermore, standardization is a factor that enhances the multiple uses of containers. The role of information technology is significant, since it supports containers management by providing the necessary data so that they can be easily tracked. Environmental gains are implicitly incurred by the fact that containers are recyclable and may be reused.

6 Empty container reposition: the port of Rotterdam case

Albert W. Veenstra

6.1 Introduction

Worldwide repositioning of empty containers is a substantial problem for international container transport operators, and a major cost driver. While repositioning takes place between continents and operating areas, many containers also have to be repositioned in port hinterlands, such as that of the Port of Rotterdam. If, for some reason, cost savings could be realized by repositioning in a particular port's hinterland, this could contribute to the competitive position of that port. This case shows some of the empty container repositioning initiatives that have been developed by the Port of Rotterdam community.

6.2 Business drivers

In international container shipping, the carriage and handling of empty containers is a recurrent problem. Drewry Shipping Consultants (2002) estimates a steady 19-22% of total container flows (around 244.5 million in 2001) to be empty. These containers are shipped from so-called surplus areas to shortage areas for approximately $400 per container. This results in a total cost of empty container repositioning worldwide of $20 billion. This is a cost burden that has to be carried by the container shipping community, and it forms a major part of their cost structure.

Common shortage areas are the Far East (14.6 million or 19.6% of the total flow into the Far East) and Europe (20.5 million or 19.7%). Europe, at the same time, is also a surplus area, but at different times and for different container types. Container carriers work together with their strategic alliance partners (other container carriers) to reduce their surpluses and shortages by empty repositioning as much as possible. Given that the surplus/shortage situation is similar for most of these operators, the number of successes is usually small. Alternatives, such as more efficient repositioning of empty containers in the hinterland of ports, are therefore seriously considered by container shipping companies.

6.3 Organizational aspects

Understanding the remainder of this chapter depends heavily on an understanding of the various parties in the transport chain. These will be briefly introduced here.

Transport takes place by a transport operator or carrier, for the benefit of a shipper, who has some cargo to ship. In the present case, the cargo is packed in containers. These containers are owned by the transport operator. Usually, the complete transport solution a shipper requires is a combination of several so-called transport legs: a deep sea leg (e.g. from Asia to Europe – Le Havre), a short sea leg (e.g. from Le Havre to Rotterdam), inland shipping or rail leg to some intermediate transhipment area in Europe, and a road haulage leg to the final destination. For reasons of convenience, one of the transport operators (usually the deep sea shipping company) is the contract party for the shipper and subcontracts the transport for the other legs to other trusted transport operators. This situation is called *carrier haulage*. Under carrier haulage, the carrier offers complete door-to-door service to a shipper. There is also a possibility that the shipper itself remains in control of the transport solution it wants. This is called *merchant haulage*.

The different transport legs are connected by container terminals in sea ports and at other locations in the area the sea port services. This service area is called the port *hinterland*. The companies that manage these terminals are called terminal operators or *stevedores*. They offer the transport operators the *transhipment* of containers from one mode of transport to another. For different transport modes, the hinterland terminals have different names: for inland shipping, it is an inland terminal, and for rail, it is a rail terminal.

The stevedores usually do not communicate with the transport operators directly, but with their representatives or *agents* in a certain port. Sometimes these agents are part of the transport operator's company and sometimes they are independent, representing more than one transport company. The agent is responsible for (1) cargo booking, (2) communication with the terminals, and (3) arranging hinterland transport if the transport operator concluded a carrier haulage contract. The agent is also responsible for processing and exchanging the cargo information, the ship's travel information (times of arrival, departure etc), information on the stowage of the ship, and so on. The process of stowage involves loading the ship in such a way that the cargo is evenly balanced for maximum ship stability, with dangerous cargo on top and heavy containers on the bottom.

As soon as (full) containers are delivered to a port such as Rotterdam, an empty container problem occurs as well, but of a different nature compared to the intercontinental one sketched above. The three standard trajectories of an empty container in Rotterdam are depicted in Figure 6.1.

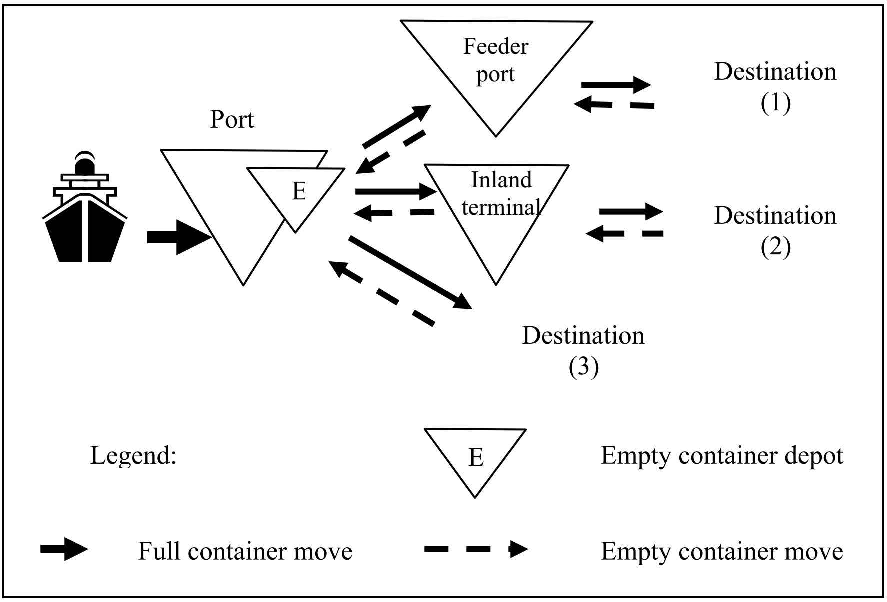

Fig. 6.1. Empty container flow patterns

The trajectories are: (1) the full container is shipped by short sea vessel to a regional, or feeder, port in Europe (Baltic region, U.K., Mediterranean) and delivered by truck to the end destination where the container is emptied of its contents (called *stripping*). From there, the empty container is usually brought back to the port of Rotterdam by truck and short sea vessel; (2) the full container is moved to an inland terminal by rail or barge and from there by truck to the end destination, where the container is *stripped* and delivered back empty (via the inland terminal) to an empty container depot in the Port of Rotterdam; (3) the full container is picked up from the terminal in port, delivered directly to a destination in the hinterland by truck, stripped, and delivered back empty by truck to an empty container depot in the port area. Figure 6.1 shows that all moves of containers are made twice: once full (denoted by the full arrow), and once empty (denoted by the dashed arrow). It is likely, therefore, that without any further interference, 50% of the container moves between the port and its hinterland concern empty containers.

While the main reason for global surpluses and shortages of empty containers lies in global trade imbalances between the main trading regions of Asia (Far East), Europe, and America, the empty container movements in the hinterland of the Port of Rotterdam are due to the desire of carriers to collect their empty containers in the port area. This desire is motivated by the lack of control they have over empty containers once they are outside the port area. In the port area, the containers are available for inspection, cleaning, repair, and so on.

Solutions to reduce the number of empty container movements are focused on moving the container after unpacking directly to a location where it can be used again for loading. This is not usually done by the same truck that delivers the container, since unpacking a container may take considerable time. However, at locations where containers are delivered regularly, a truck driver could pick up empty containers delivered the day before, see Figure 6.2.

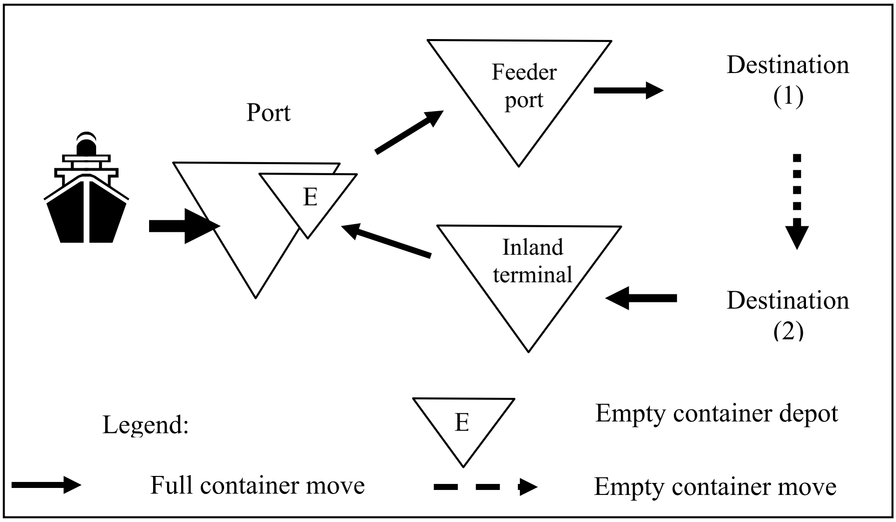

Fig. 6.2. Empty container flow repositioning in the hinterland

Figure 6.2 is a simplified version of Figure 6.1, where the distance over which the empty container has to be moved is potentially much smaller.

The final delivery of the container to, and often also the repositioning of the empty container from, the hinterland of the Port of Rotterdam is usually done by a Dutch trucking company. It seems likely, therefore, that repositioning of containers as depicted in Figure 6.2 from one location in the hinterland to another location will also be done by a Dutch operator. If that is the case, the repositioning move is termed by the transport operators as *cabotage*. In other words, the repositioning of an empty container from München to Milan by a Dutch truck driver is called *cabotage*.

The term cabotage is also used in a different way. In Europe, it is reserved for the transport of cargo from one country to another by a third country transport operator. Until quite recently, this type of cabotage was prohibited in Europe. This has gradually been relaxed, although the transportation of cargo within one country by a third country operator remains prohibited.

The combination of these two different forms of cabotage into one service offers a possibility to reduce the burden of empty container repositioning. It is this idea that forms the basis for some of the empty container repositioning solutions that are described below. The idea, which was developed in the mid 1990s in the Port of Rotterdam, was that it should be possible to use the repositioning of empty containers for incidental cargo that had to be moved in the port hinterland. The empty container could be lent to a shipper who could use it cheaply (given that the repositioning move would cost money anyway, any price the shipper could pay would be better than nothing), and be delivered to an area where one of the carrier's clients would pack it again with export cargo. This case will discuss two instances of how the idea of making use of empty containers for cabotage transport could have been implemented.

The foundation RIL was part of the knowledge cluster in the Port of Rotterdam and strongly related to the port authority until it was dissolved in 2002. It had as its mission to generate ideas and concepts to improve the logistics within the Port of Rotterdam. This includes, for instance, intra-terminal transport, developing new port-based transport equipment, and efficient empty container handling. It was expected that the improvement of internal port processes would contribute substantially to the competitive position of the port vis-à-vis other European ports. RIL was responsible for the interest in developing cabotage arrangements for the repositioning of empty containers.

In principle, helping the carriers with their empty container repositioning in the European hinterland, and relieving them of this substantial cost factor, could indeed increase the competitive position of the Port of Rotterdam. Given further that this solution requires the cooperation of various parties that are more or less under the influence of the Rotterdam port cluster of companies, a central role of the port authority seemed natural.

RIL considered two parties that could play a role in empty container repositioning: inland terminals and ship agents.

The role of the inland terminals in repositioning empty containers

It has been mentioned that a substantial part of empty container movements flow through inland rail and barge terminals. For instance, P&O Nedlloyd and Maersk SeaLand transport 80% of their import containers into Europe under carrier haulage by barge and rail. A substantial number of these containers travel the same routes back empty. The empty containers are usually stacked at these hinterland terminals for short periods waiting for loading onto a train or a barge that will bring the empty containers back to Rotterdam. These terminals play a rather passive role in the transport chain from door to door. Under the transport regime of merchant haulage, the shipper or forwarder arranges all the services in the transport chain. These parties also decide which transport modes and which inland terminals to use. Under the alternative regime of carrier haulage, the liner shipping operator takes care of the transport service for the sea leg and usually the hinterland transport. In Europe, both forms are used in hinterland transportation. In both cases, shippers or transport operators, and not the hinterland terminal operators, decide how to reroute the empty containers back to Rotterdam. The operator of the terminal in the hinterland does, however, have access to superior information on empty container surpluses and shortages. They can deduce patterns from the movements of empties in and out of their terminal. In addition to this, they also know most of their competitors, and some companies in fact operate a number of terminals spread out through the hinterland. To complete this picture, hinterland terminals usually serve companies in a 10–15-kilometer radius around the terminal. They know these companies very well, and can easily identify incidental transport demands to areas close to other inland terminals.

In this way, it is possible to envisage a terminal operator, who observes a temporary surplus of containers on a terminal, to lend some of these containers to its clients for shorter or longer trips within the hinterland, ending up in areas where there are temporary shortages of empty containers. By doing this, the terminal, the terminal's client, the transport operator, and possibly the container shipping company might benefit.

It is not surprising, therefore, that RIL made some attempts to set up an information exchange service between hinterland terminals to help container carriers optimize their empty container repositioning. Until now these attempts have failed due to a variety of reasons:

1. The carriers consider the demands and requirements of their clients in the hinterland proprietary information that they do not want to share with competitors,

2. The carriers prefer to stack their empty containers in the Port of Rotterdam area rather that having them move around the hinterland, where they have no control and do not know exactly where their containers are, and
3. After initial set-up periods, the terminals usually did not manage to financially sustain the information exchange service required.

The role of the ship agents in repositioning empty containers

The container shipping company's agent was already introduced above. In situations of carrier haulage and a variant called agency haulage, the agent plays an important role in arranging the physical hinterland transport. In the first case, the agent represents the carrier and just executes its wishes regarding mode choice and intermodal connections. In the latter case, the agent is free to take containers into the hinterland by whichever mode is the most efficient and the cheapest. According to one source, agency haulage represents 21% of hinterland transport for the Port of Rotterdam (RIL, 1997).

The agents, in the same way as the inland terminal operators discussed above, have superior information that could be used to find cabotage trips that could be matched up with empty container repositioning moves. RIL was involved in developing initiatives for exchanging the relevant information between agents.

It is important that agents representing different carriers work together to solve repositioning problems. The aggregate empty container imbalances in Rotterdam are in fact not so substantial: empty container surpluses add up to 8,400 for 20-foot containers and 3,500 for 40-foot containers. But these low figures obscure the combined surpluses for all agents in absolute terms: 41,000 20ft containers and 57,000 40ft containers (Zeeman 1997). Some agents have an import surplus, some have an import shortage, some have a surplus mainly in the summer, some have a surplus in the winter, and so on. In other words, cooperation and information exchange between agents in the port would reduce empty container repositioning substantially.

In principle, the agents have access to the same information as inland terminals concerning locations of empty containers and demand for empty containers. Due to their contacts with transport operators and forwarders, they are also in a good position to fill these empty containers with cargo during repositioning.

Initiatives, however, have again not been successful because of the same three reasons mentioned in the previous section.

The important parties in the two arrangements described above are the container shipping company and its agent, inland terminal operators, and incidental shippers. Exchange of information is required between the shipping company and terminals or agents, between the terminals, and between the agents. The two cases above showed that information sharing is a critical factor in the success of empty container repositioning schemes. To secure the proprietary character of this information, setting up an independent information exchange entity could be considered.

Such initiative was taken by the company that is responsible for building the port community system in Rotterdam: Port Infolink BV. This company is, among others, the successor of RIL. In November 2002, at the initiative of a number of short sea shipping companies in Rotterdam (all of whom struggle with their empty container repositioning problem), this company developed an information exchange website called *Boxsharing*. The functionality of this website is very simple: it is a database system with a search facility. The members of the initiative can put their own empty container surpluses in. They can also search the database for empty containers of colleagues that they might want to use. As soon as such containers have been identified, the database provides contact details and a standardized email service. This leads to a repositioning exactly as depicted in Figure 6.2.

Currently, this system contains data about a little over 300 empty containers stationed all over Europe. This is only a small portion of the actual surplus of empty containers for two reasons:

1. Companies do not report all their empty containers for strategic reasons, and
2. Not all shipping companies participate in the initiative.

Intercontinental container shipping companies are especially reluctant to participate. Their global operational cycles are such that they cannot guarantee that containers owned by their short sea colleagues will be returned within a reasonable time frame of a few weeks. Their containers can easily make cycles of three or four months travelling around the world.

The Boxsharing initiative could be considered more successful than the cabotage initiatives of RIL because it is supported by the container transport operators, and the information exchange is financially sustainable because this is currently funded through Port Infolink BV. However, it is a much simpler solution than the RIL ideas discussed above, because it focuses only on empty container repositioning and not on the potential matching of these movements with incidental cargo.

In the future, Boxsharing could be upgraded to also match empty containers with incidental cargo by connecting it to a cargo exchange initiative such as cargotrans.net or eurotrans.net. There is some reluctance to proceed in this direction, however, because the result could be a complete loss of control over the empty containers. As long as competitors are using them for limited periods, the empty containers will not disappear from sight. If, through a freight exchange website, unknown transport operators will start using the empty containers, there is no control anymore on the damage, theft, and the location where they might end up. As long as such risks are not mitigated, the extension of the functionality of Boxsharing is not expected.

6.4 Planning and control aspects

The owner of the problem with regard to empty container repositioning is, for the most part, the container shipping company. They own the containers, and an empty container is a non-revenue generating piece of equipment. Their natural focus is on sea transport. Many carriers, therefore, only optimize the repositioning of empty containers by sea. See, for one of the very few examples, (Gao, 1993). Almost all container shipping companies use models such as the ones mentioned in (Crainic et al., 1993) and (Choong et al., 2002). These work to optimize their empty container operations. They usually employ separate models for the short-, medium-, and long term, and they try to work together with alliance partners to solve their repositioning problems jointly.

The general model that can be used for the repositioning of empty containers is the standard transhipment model. However, the application of this model is severely complicated when it is applied to repositioning in the hinterland. In principle, this requires a combination of a scheduling problem (when to reposition), a routing problem (which container to reposition from where to where), and an allocation problem (what mode to use for the repositioning). See, for a detailed discussion, (Crainic et al., 1993). Given also that not all container transport in the hinterland is controlled by the transport company (only 40% of containers in Europe move under carrier haulage [private communication with a representative of Maersk Logistics Benelux]), the globally operating container shipping companies have never really focused their attention on repositioning in the hinterland.

6.5 Information aspects

The information requirement for a (partial) solution to empty container repositioning through cabotage is quite extensive. Information is required on empty flows for different container types, on surplus and shortage areas all over the European hinterland, and on cabotage transport requirements, availability of trucking services, and requirements of equipment for the container shipping companies. Only an independent party can collect and coordinate all this information and protect sensitive business data.

6.6 Environmental aspects

In Europe, a substantial part of transport policy is focused on deterring road traffic and the support for shifting freight to other modes. In fact, substantial subsidies are available nationally and internationally to develop intermodal transport solutions that achieve a reduction of road haulage.

The efficient routing of empty containers contributes to this objective. A matching of empty container flows with cargo flows would potentially lead to a further reduction of truck kilometers. Therefore, a successful initiative can be expected to have a positive environmental impact.

6.7 Business-economic aspects

The potential for using empty containers for transporting cabotage cargo can be illustrated by the following simple calculations. Every year, total empty container costs are (Synergie,1996):

1. Handling of the empty container: $150 (based on 2 x 5 moves of $15),
2. Transportation costs of repositioning between ports: $400 ($200 per trip, 2 out of 5 moves are empty moves),
3. Transport between port and empty container depot: $125

Total: $675.

For the 10 million containers that exist globally, this amounts to $6.75 billion. The above calculation assumes two repositioning moves per container per year. Therefore the repositioning cost is about $335 per container.

This repositioning cost is incurred by the container shipping company and its agent. Repositioning savings immediately translate into cost savings. If, however, an empty container move can be combined with incidental cabotage cargo, still more costs can be saved (Zeeman, 1997). The cabotage transport operator saves his container hire costs for the duration of the transport. This is about $1.70 per day. Average hire period is 20 days. Total hire is therefore about $34. The container needs to be cleaned and handled; these costs are usually borne by the transport operator, but it seems reasonable that the container shipping company or the agent pays for these. The transport operator therefore saves these costs, about $80, as well. The client of the cabotage transport operator will demand some of the cost savings. Assume this is 80% (of $114 = $91).

Table 6.1. Summary of cost savings

	Savings ($)	Payments ($)	
Shipping company and agent	335	30	Handling
		50	Cleaning
Cabotage transport operator	114	91	Transfer to shipper
Cabotage shipper	91		

Total savings in the transport chain equals $540 – $171 = $369. This does not include any payment the cabotage shipper might be charged for the cabotage trip. The total imbalance among Rotterdam-based agents mentioned above was 98,000 containers. The maximum potential cost saving in the Rotterdam hinterland can therefore be estimated at $36.2 million.

6.8 Conclusions

Worldwide repositioning of empty containers is a substantial problem for international container transport operators, and a major cost component. While repositioning takes place between continents and operating areas, many containers also have to be repositioned in port hinterlands, such as that of the Port of Rotterdam. It seems that, with the right arrangements, substantial cost savings could be realized with repositioning in the hinterland of the Port of Rotterdam. If these arrangements can be made in a sustainable way, this could contribute to the competitive position of Rotterdam.

This case reports on some of the initiatives that have been developed in the Port of Rotterdam community. While the efforts of the carriers mainly aim to minimize empty container moves, some port community efforts could achieve much bigger savings by combining repositioning moves with incidental cabotage moves. In this way, different players in the port hinterland benefit by saving some of their costs: container hire, repositioning costs, and container handling and cleaning. The case discusses the potential role ship agents and inland terminals could play in such schemes.

The success and failure of these initiatives can largely be attributed to the substantial information requirements and the failure of especially the ocean container carriers to provide their private information to competitors and other parties in the hinterland transport chain. A recent initiative (November 2002), called Boxsharing, was developed to share information about empty containers among short sea shipping companies. This initiative concentrates very much on exchanging information on empty containers only. It shows some potential, however, for gathering cabotage information and matching this with repositioning moves at some point in the future.

The Port of Rotterdam seems to have the possibility of increasing their competitive position by offering their clients, the container shipping companies, cost reductions. Cost savings of empty container repositioning combined with cabotage cargo are potentially substantial. The Port has to assert its position as cluster manager to maximize these benefits and thus increase its competitiveness.

Part 4:
Commercial returns closed-loop supply chains

7 Commercial returns of sun-protection products: the L'Oréal France case

Roelof Kuik, Jo A.E.E. van Nunen and Job Coenen

7.1 Introduction

L' Oréal is active in three main sectors: cosmetics, dermatology, and pharmacy. In 1998, L' Oréal had 47 manufacturing plants and 88 distribution centers worldwide. In that year, the total turnover of L' Oréal was nearly 11.5 billion Euros.

Within L' Oréal, the world leading cosmetics sector, which accounts for the major part of L' Oréal's turnover, is structured around four divisions. Figure 7.1 shows sales by division for the year 2001.

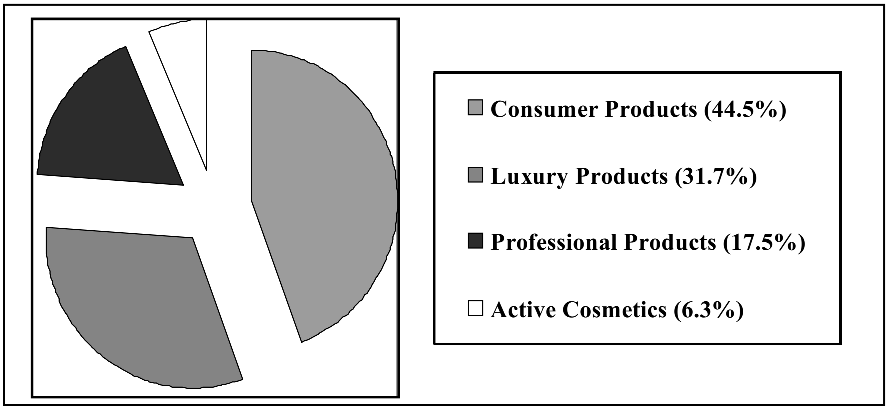

Fig. 7.1. Sales share by division in 2001 (http://www.loreal.com)

In this chapter, we focus on the Ambre Solaire brand, which covers a range of sun-protection products like milk, oil, and spray products. Ambre Solaire consists of 26 stock-keeping units. GARNIER, one of the companies within the cosmetics sector of L'Oréal, is responsible for the Ambre Solaire brand.

Ambre Solaire products are, to a large extent, shipped to GARNIER's customers before the start of the summer season. By the end of the season, demand for Ambre Solaire sun-protection products decreases considerably.

GARNIER's customers, the retailers, have negotiated the possibility of returning unsold products. GARNIER refunds to the retailers the original purchase price. For example, at the end of the 1998 selling season, about one-third of the gross sales was returned. Although the return percentage of 30% is high, it is not exceptional. Other industries face similar sizes of product returns, see, for example, (Rogers and Tibben-Lembke, 1999).

Product returns form a major component in the total distribution costs. In 1998, it was not obvious to management whether the return of 30% was structural or incidental, nor was it clear how the high levels of returns influenced the costs per distribution channel or retail organization. Therefore, a research project was set up to analyze the return flows and to formulate proposals to resolve the return issue.

7.2 Business drivers

Although GARNIER is the market leader in France in sun-protection products, it was at that time not in a position to fully monitor, control, and plan the distribution process from manufacturing all the way up to the consumer purchase. The retailers determine how much is stored to cover demand in the summer season and what is returned at the season's end.

In order to understand the drivers of commercial returns of sun protection products, the following observations are made:

- Consumer loyalty to brands is declining. Consumers increasingly tend to make their purchase decisions while at the retail outlet. In response to this trend, manufacturers are spending more on sales promotions at the retail floor to convince consumers to buy their product,
- Retailers react to the decline in consumer loyalty by introducing their own brands. These private brands offer retailers substantially higher margins than products sold under a manufacturer's brand, see, for example, (Bell et al., 1997),
- Consolidation at the retail side is another major trend. This consolidation helps retailers create larger markets and increase purchasing power. Moreover, consolidation also helps to reduce logistics costs. Due to small margins, cost reduction is a major concern in retailing, see (Birkin et al., 2002),
- Removals of barriers for trading and transportation across borders and information technology have resulted in a single European market and in integrated supply chain management systems. This en-

ables manufacturers to look for effective production and distribution solutions.

Based on the above observations, it is clear that GARNIER is interested in maximizing product availability at the retail floor. From these same observations it is also not surprising that GARNIER offered retailers to return unsold products at no cost as a routine part of the service provided. Returned products that are still shiny and clean, that do not have obsolete packaging, and that have been manufactured less than two years before, are eligible for reuse on the French market. Sometimes damaged and older products can be sold on secondary markets. Approximately three-quarters of the returned volume can be reused. Taking products back is environmentally less harmful than product disposal. Being environmentally responsible can thus be viewed as a further reason for allowing products to be returned.

7.3 Organizational aspects

The customers of GARNIER are mostly large retail organizations and a few distributors. Based on their level of centralization, customers are divided into two categories: "Circuit Direct," with de-central contacts mainly through retail shops, and "Circuit Société," with central points of contact mainly through the regional distribution centers of the retailers.

The larger part of sun-protection products is presented to consumers in so-called assortment displays. At the beginning of the season, these displays are distributed together with the products. There are three different types of displays containing 984, 492, or 252 products, respectively. The size of the display reflects the size of the retail outlet in which it is placed. For each display in a store, the retail organization receives a fee. In the summer of 1998, over 5,000 Ambre Solaire displays were in retail outlets.

Retailers like Auchan, Carrefour, and Continent are an exception. These retailers deny displays for a combination of reasons such as lack of space and fear of competition with their own private brands.

GARNIER has several owned and outsourced facilities to handle the returns from retailers and their distribution centers. Figure 7.2 shows the return flows together with the consolidated forward flows.

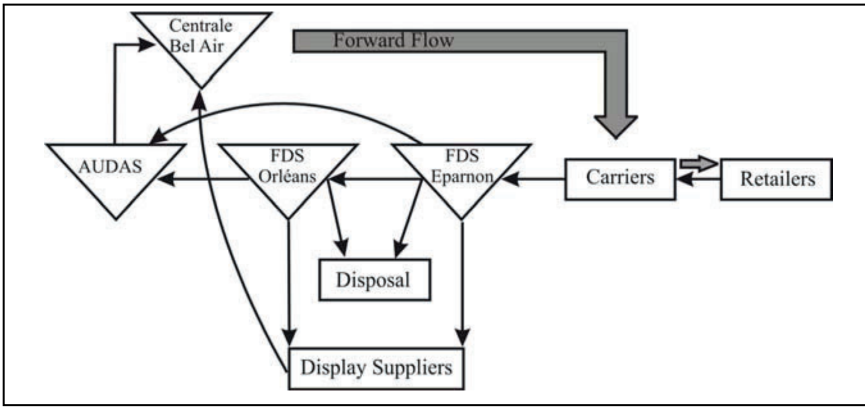

Fig. 7.2. The return process

The parties in Figure 7.2 and their roles in the return process are:

- Centrale Bel Air: This is the central distribution center of GARNIER in Rambouillet, France,
- FDS: This is the third-party logistics service provider handling the return flows,
- FDS Eparnon: Here the selection of the returned products and displays is made. Full good pallets are sent to AUDAS. Partially filled pallets or bad full pallets are forwarded to FDS Orléans for further processing. Displays are sent to the display suppliers who repair or upgrade displays,
- FDS Orléans: Here the second selection of the returned products and displays is made and distribution to the relevant parties is organized,
- AUDAS: This is the third-party logistics service provider handling returned products and also storing the production output in winter when the storage capacity of Centrale Bel Air does not suffice,
- Display Suppliers: The production of displays has been outsourced to several manufacturers, who also play a role in the recovery process of damaged displays,
- Disposal: Disposal in this context means either destruction, which holds for damaged and/or expired products, or sales to developing markets outside France for products that do not comply with the new French product range for the next season, i.e. obsolete products.

As mentioned before, at the end of the summer season the return process can be initiated. This return process consists of the following steps:

1. The retail organization notifies GARNIER that it wishes to return a number of products,
2. Either GARNIER's distribution warehouse or salesperson sends, depending on the type of customer, a return form to the retail outlet or the retailer's regional distribution center,
3. The retail representative communicates the number of units to be returned. The salesperson authorizes the return, say at Day N, after the process was started,
4. The salesperson notifies the distribution warehouse Centrale Bel Air by transmitting the return form via mail or fax [Average: Day N+7],
5. The distribution warehouse orders a regional carrier to pick up the returns [Average: Day N+10]. Mostly the carrier is granted some freedom in setting the pick-up date in order to allow for efficient transport [Average: Day N+30],
6. The carrier delivers the returns to FDS Eparnon [Average: Day N+31]. FDS Eparnon makes the first selection and check of the goods returned and transfers relevant information to Centrale Bel Air [Average: Day N+45],
7. Products that can be reused according to FDS Orléans are shipped through the third-party logistics service provider AUDAS to Centrale Bel Air,
8. The display suppliers send the recovered displays to Centrale Bel Air.

7.4 Planning, control and information aspects

The product's main selling season runs from March until September. The delivery season from GARNIER to the retailers has its peak in March and April, although replenishment deliveries continue until the end of the season. Demand for the products is highly seasonal and exceeds production capacity in the peak periods. Accordingly, inventory has to be built up prior to the selling season. The complexity of the planning process is further increased by uncertainty on the volume of product returned as products can be returned until the first of March of the next year. At the start of the production planning cycle, the information that is used stems from data provided by AUDAS at the end of November. This information is based on the return forms filled in by retailers and on estimates on the total volume of products that can be reused in the French market. The information is updated on a continuous basis during the returns period. An overview of the activities reflecting the seasonal demand pattern is given in Table 7.1.

Table 7.1. Schedule of activities

<table>
<tr><th></th><th>J</th><th>F</th><th>M</th><th>A</th><th>M</th><th>J</th><th>J</th><th>A</th><th>S</th><th>O</th><th>N</th><th>D</th></tr>
<tr><td>Production</td><td colspan="3">Production</td><td colspan="6">Procurement and Inbound Logistics</td><td colspan="3">Production</td></tr>
<tr><td>Logistics</td><td colspan="3" rowspan="2"></td><td colspan="7">Outbound Logistics (order taking, assembly, delivery)</td><td colspan="2">Return flows</td></tr>
<tr><td>Marketing</td><td colspan="5">Promotion</td><td colspan="4" rowspan="2"></td></tr>
<tr><td>Sales</td><td colspan="3">Sales</td><td colspan="5">Sales forecast</td></tr>
</table>

7.5 Business-economic aspects

GARNIER wishes to maintain and strengthen its market leadership in its competition with Nivea and Club Med by pushing sales personnel to install displays on the shop floor as early as possible, well before competitors. The amount of products shipped to the retailers often exceeds the maximum demand. Analysis showed that this strategy resulted in a high percentage of returns. The strategy was supported through a bonus system for sales personnel. This bonus system had three components: the number of stores carrying the brand Ambre Solaire, the amount sold at the beginning of and during the season, and the amount returned. The bonus for sold products was dominating the other two, so sales personnel focused on this bonus.

A second reason for returns was caused by the fact that the number of different products in a display does not adequately reflect the distribution of the demand. The demand distribution differed per region, whereas the displays had a standard composition. The result was many returns of partially filled displays.

At the outlet level, returns were also caused by replenishment orders in large cartons containing a minimum of 24 units.

The costs to handle return flows were substantial. They consisted of transportation costs, handling costs for selection and reconditioning at the distribution centers, inventory related costs, and costs for product disposal, see Figure 7.2. It turned out that a percentage decrease in return volume would have an effect on the margin of nearly a third of that percentage. Note that any resold return required at least two additional transport legs: one from the customer to GARNIER and one from GARNIER to the customer. It also appeared that the return costs are considerably higher for products returned from the Circuit Direct than those from the Circuit Société. In the Circuit Société, the regional distribution centers (RDCs) manage the flows, using facilities as a buffer between the Centrale Bel Air warehouse of L'Oreal and the retail outlets. The return rate also turned out to be higher for the Circuit Direct than for the Circuit Société. As might be expected, sales at the retail level prove more difficult to predict than the consolidated demand at a central RDC.

7.6 Conclusions

Based on the above analysis, several improvements were initiated. The first proposal for change entailed a fine-tuning of the incentive scheme for sales personnel. Gross sales at the start of the season became less dominant within the new bonus system. However, maintaining sufficient product availability and exposure should be taken into account. Furthermore, the fine-tuning could be supplemented by incentives for the retailers to reduce the number of returns. A reduction of the packaging size from 24 units to 12 units was proposed to enhance flexibility in replenishment. More flexibility in the composition of the displays would also enable a better match to the varying needs of retail outlets. However, these proposals would require large investments in packaging lines.

Enhancing the responsiveness of Ambre Solaire's supply chain in the long run involves implementing procedures and systems that create the ability to react faster to changes in demand and actual inventory throughout the chain. A sine qua non for establishing this is the installment of an adequate information system capable of providing timely information on inventory status and transport throughout the distribution channel. As the retail inventories in the RDCs are part of the channel, such arrangements will require the retailer's cooperation and a minimum level of transparency with respect to local stocks. Efficient Consumer Response could well provide the framework to undertake such initiatives. Since retailers believe it would endanger their powerful negotiation position, sharing information between producers and retailers in the French retail market was not popular in 1998. A start was made to show the win-win situation to the retailers and to implement new supply chain concepts.

Postscript

The above case description is based on the research done in 1998 at GARNIER (Coenen, 2000) and concerns the French market. Many of the recommendations based on this research have been implemented between 1998 and today. Other improvements have since been made to the (return) organization of GARNIER. So, the actual organization has considerably improved since 1998.

8 Commercial returns of printers: the HP case

Sylvia Davey, V. Daniel R. Guide Jr., Kumar Neeraj and
Luk N. Van Wassenhove

8.1 Introduction

The imaging and printing solutions group (IPG) was one of the biggest business units of the Palo Alto, California,-based Hewlett Packard (HP), accounting for $20 billion of its $42.4 billion in revenue in 1999 and the majority of its profits. HP was the market leader in virtually every category of imaging and printing solutions related product. Some of the products of the IPG group included Liquid Inkjet, Laserjet, and other imaging solutions such as scanners and cameras.

In the United States, the inkjet imaging solutions division had product returns averaging 6.6% of sales dollars and 5.7% of units shipped. In North America, consumers expected to be able to return products as a matter of convenience. As a result, in 1999, the return rates for North America were six times higher than the return rates of the rest of the world. On a total of 6 product lines of inkjet printers, over 50,000 units per month were returned through hundreds of retail locations all over the U.S. A key characteristic related to the volume of return was the strong influence of seasonality (e.g. Christmas) and end-of-life for individual product models. Another important aspect about product returns was that the return rates varied across different channels and across product lines. Mass merchandisers and large office equipment and supplies retail chains such as Comp USA, Office Max, etc., had return rates of about 10% compared to PC-direct resellers who had a return rate of about 4.5%. Product returns were higher for high-end products and very low-end products. The level of returns across channels also depended on their returns policy.

8.2 Business drivers

There were three main drivers for product returns: reseller overstocks, unfulfilled expectations of the end-customers, and product defects. Reseller overstocks, i.e. excess inventory at the resellers that either could not be sold as planned or were unlikely to be sold in the near future, were due to the mismatch in the quantity HP shipped to the resellers and the quantity resellers actually sold. If the reseller thought that it could not sell the excess units, it returned the inventory to HP. HP was obliged to reverse the sales transaction and refund the sales dollars after deducting a small fee for processing the returns. An internal study carried out by HP revealed that the resellers often misrepresented stock returns as customer returns in order to avoid paying the processing fees. The commonly cited reasons for returns from end-customers included unfulfilled customer expectations (in terms of print quality, print speed, compatibility), improper knowledge about the characteristics of the printer purchased, and consumer behavior (rentals, remorse, or a lower price). Misleading sales clerks, uninformed consumers, and unreasonable expectations from the product were also key drivers for customer return. Only a small percentage of returned products were actually defective, and in comparison to the total sales volume the figure was insignificant. Table 8.1 provides an overview of reasons for product returns, return categories, and the frequency of their occurrence in 1999.

As the product life cycle for printers grew shorter, there were additional demands on the product returns process. Since many products were returned towards the end of the product life cycle, there were fewer opportunities for HP to recover the full value of the product. In addition, due to the long lead times required for collecting quantities adequate for carrier pickups, products were delayed from disposition until later in their life cycles.

In view of the magnitude of costs and revenue loss involved, HP developed a comprehensive strategy to reduce the losses due to returns and to recover maximum value from the returns. The key premise of HP's product returns strategy was to view all activities related to product returns as a business in itself. The idea was not only to reduce the "total business cost" associated with product returns but also to generate maximum sales revenue from the remanufactured products. Pursuant to this strategy, HP had formulated a two-pronged strategic plan.

The first prong of the plan was to drive the reduction of total business cost. The total business cost was a function of the volume of returns as a percentage of sales revenue and the costs incurred in managing the reverse logistics operations. To reduce the total business cost, HP developed plans for reducing each of the cost drivers. A reduction in returns volume was achieved through several initiatives including working with value chain partners to reduce the causes of returns, making changes in returns policy, and encouraging channel partners to minimize returns. The reduction in handling cost was achieved through improved management of the product returns process, network optimization, outsourcing, and reselling.

Table 8.1. Return categories and their frequency of occurrence in 1999

Rationale for Return	% Within Category	Remarks
50% Defective		
Install/Basic use	55%	Customer did not know how to install or use printer
True failure	40%	The printers were actually defective
Easy excuse	05%	Customers found it convenient to call it defective
25% Performance		
Software	40%	Software failure
Print quality	30%	Print quality not what the customer expected
Print speed	30%	Print speed was slower than what the customer expected
15% Compatibility		
POP/Packaging	15%	Packing information not sufficient on compatibility issues
Sales techniques	85%	Sales person did not inform customer about compatibility issues
10% Customer behavior		
Better deal	40%	Customer get a better deal elsewhere
Remorse	30%	Customer “felt” his money was not well spent
Rentals	30%	Customer misissued the returns policy in order to use printer for a short period

In achieving the objective of reducing total business costs, HP faced a number of issues. The volume sold through mass merchandisers and office products suppliers was increasing. Both of these retail channels had return rates much higher than other channels. Some low-end product lines were being returned at rates higher than expected. To add to these problems, the retailers did not understand the returns process very well and had no incentive to control returns. The retailers thought that it was just another service that the manufacturers had to provide and perhaps did not fully appreciate the value erosion that returns caused in the supply chain.

The second prong of HP's strategy was to generate maximum sales revenue from the remanufactured products. This strategy required a detailed analysis of the cost of conducting these activities, return on investment, reverse logistics structure, processes related to remanufacturing, strategic partnerships and alliances, and target markets. In order to be successful, HP had to actively engage in activities related to the generation of demand for the remanufactured products and the choice of appropriate channels for distribution.

There was considerable debate within HP on the marketing of remanufactured products. Skeptics argued that product returns should be treated only as a consequence of new product sales and that active marketing of remanufactured products might cannibalize the sale of new products. An estimate for a product line suggested that one out of every four remanufactured units would cannibalize the sale of one new unit. This estimate, however, was only an heuristic guess and not backed by any consumer studies.

8.3 Technical aspects

Over the years, due to the introduction of the concept of late point differentiation on most of the inkjet product lines, reuse of parts had become much more simplified. Most of the products and product platforms within a product line were already being designed in such a way that a majority of components were common across platforms. Thus reuse within a product line from one platform end-product to another was easy. However, it was difficult to use products between product lines. HP was trying to develop a culture within its design groups where stealing a design from another product designer was not only rewarded but also expected. This was in contrast to the "we need to invent" spirit, where a design engineer preferred to develop entirely new designs for every product.

8.4 Organizational aspects

When a reseller called an HP call-center to return a product, the call-center checked the validity of the return, i.e. whether it was an HP product or not, see Figure 8.1. If the return was valid then the product could flow through one of the two reverse logistics channels: carrier pick-up or non-carrier pick-up. The carrier pick-up program was run with major resellers where individual return shipments could run as high as 12,000 units per delivery. The non-carrier program was operated for small retailers and individuals, and the average shipment size was limited to one or two cartons. The total volume of returns was evenly split between the two programs. All returns were delivered either directly to the Lincoln Returns Depot in Lincoln, California, or to a returns depot in Memphis and then were forwarded to the Lincoln depot. Approximately 60% of the returns were sent to Memphis and forwarded to the Lincoln Returns Depot.

The activities carried out at the Lincoln Returns Depot were visual inspection of the product; relay of information to HP for issuing credit to the resellers for the returns; and forwarding the physical material to the recycling vendor, Testing & Refurbishment (T&R) facility, also located in Lincoln, California, adjacent to the Lincoln Returns Depot, or to the Shipping Depot depending on the disposition/condition of the product. There were three possible dispositions for these returns: products obsolete on receipt at the returns depot, products received in sealed boxes, and products received in open boxes. The obsolete products were sent to the recycling vendor, sealed boxes were forwarded to HP's shipping depot, and the opened boxes were sent to the T&R facility. The unopened cartons were returns from reseller overstocks. HP issued a credit to the reseller for overstock returns after deducting a fee for processing these returns. The fee, however, was set by the market and did not cover the total reverse logistics cost. A number of resellers tried to avoid paying this fee by opening the carton and presenting them as customer returns. It was estimated that up to 10% of returns were of this type.

The Returns Depot and the T&R operations were outsourced to separate third party service providers. HP had contracted a recycling vendor for recycling materials that could not be remanufactured.

The activities carried out at the T&R facility were sorting, testing, repairing, and remanufacturing. All products received at the T&R facility were treated as defective and were tested extensively for technical fault. If a product passed the test and did not have any cosmetic damage, then it was deemed fit for resale and shipped to the Shipping Depot. If the product failed the test or had cosmetic damage, then it was disassembled, individual components checked, repaired, and reassembled, and dispatched to the Shipping Depot. If the product could not be repaired, then its individual parts were tested, repaired (if necessary), and sent to the Spare Parts Sales Network for reuse or sale. If components were found to be obsolete or damaged, then they were sent to the recycling vendor as scrap.

The Shipping Depot re-packaged the material received from the Returns Depot or the T&R facility, maintained inventory of finished goods, and shipped them to the resellers in the secondary markets where they would typically fetch a price 15% to 25% lower than a new unit.

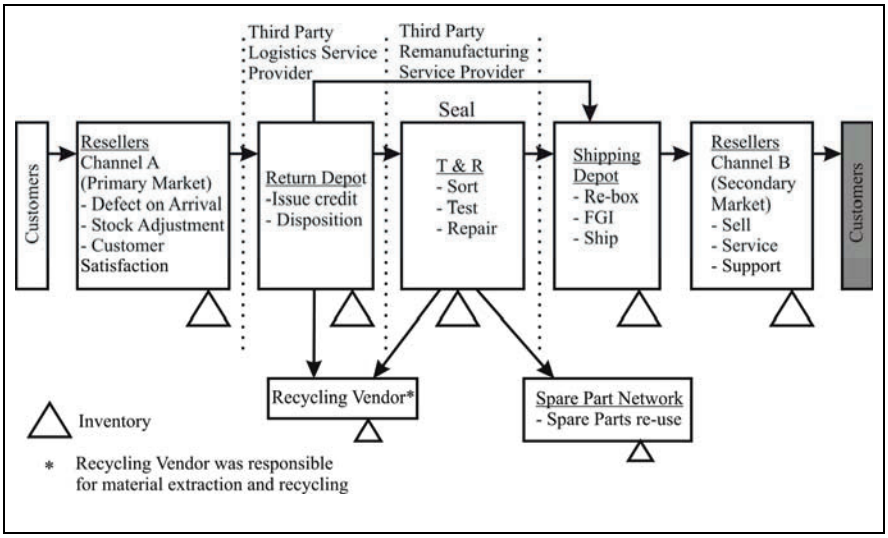

Fig. 8.1. Product returns process flow

The lead-time required at the Returns Depot to inspect and provide disposition was 2-3 days. The inventory in the reverse logistics channel up to the Returns Depot (including inventory at the resellers waiting to be transported) was about 100,000 units. The T&R facility had another 3 months of inventory. HP was targeting to reduce cycle times in the returns process by setting up an integrated returns facility where items were loaded, entered into the system, and disposed of (re-box, repair, remanufacture, or scrap) all in one continuous step.

The returns process at HP was internally organized by product line. A Worldwide Product Returns Manager led each product line. The organization was further divided into geographic regions. A supervisor, who had several program managers reporting to him, headed each region. Program managers were responsible for different activities such as the Swap (exchange) program, business planning, testing and refurbishment services, the disposition program, and the returns avoidance program. The organization chart was as shown in Figure 8.2.

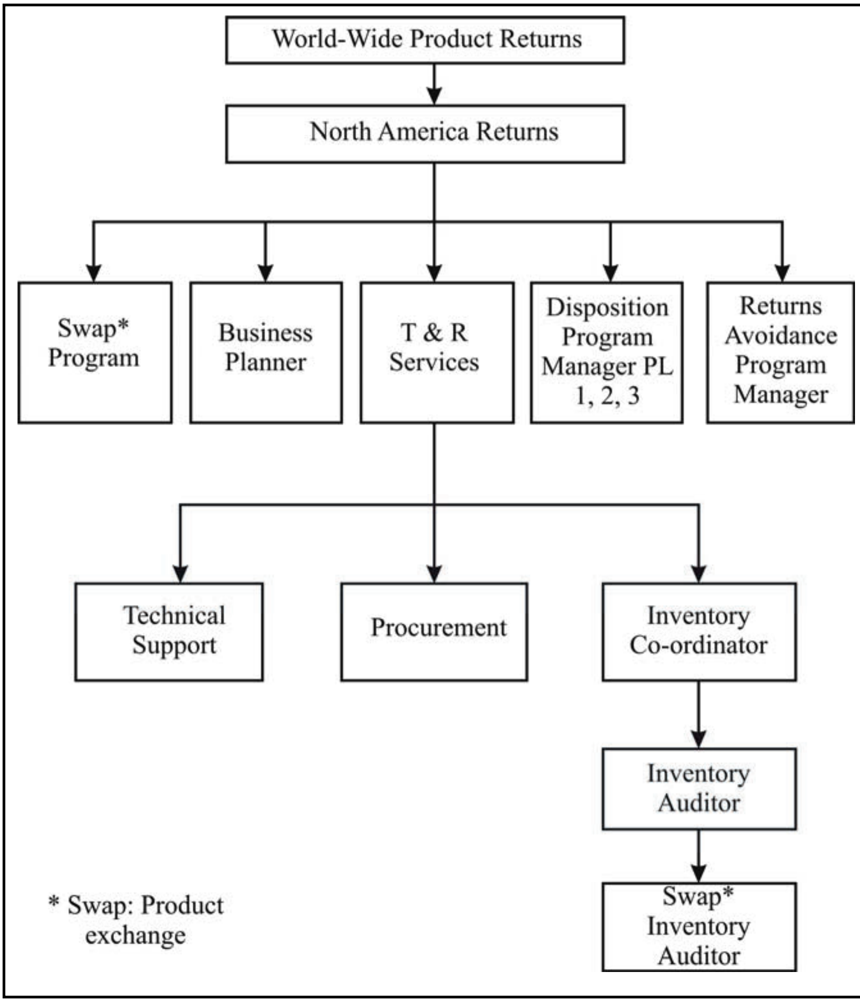

Fig. 8.2. HP product returns organization

8.5 Business-economic aspects

In 2000, HP incurred $45 million (annualized) costs in remanufacturing related activities. HP realized that there were a number of opportunities for improvement in this area. Traditionally, value recovery was far below the amount needed to offset losses due to product returns.

HP developed decision models to aid the decision makers in finding the best use of the returned units. The objective of these models was to recover as much economic value as reasonably possible, thereby reducing the ultimate quantities of waste. The model used the following disposition criteria:

- Product life cycle: In what stage in its life cycle is the product?
- Product value and condition: What is the product value and in what condition has it been returned?
- Economic "best use": What use can be made of the returned product to get maximum value?

The model gave insight into several questions related to handling returns, such as whether to recover and resell the returned products as remanufactured, or to use the recovered products in support processes; to disassemble the returned product into components for internal use or as spare parts; to resell "as is"; or to scrap/recycle the returned products. The returns categories by condition of the products and their frequency of occurrence were as shown in Table 8.2 below.

Table 8.2. Return categories by condition of the products and their frequency of occurrence

Category – Inkjet Returns	% Occurrence
New – sealed box	15%
Cosmetic damage	15%
Easy repair	30%
Hard repair	20%
Component (only high-value components)	5%
Scrap	15%

Having remanufactured the printers, there was then a need to develop a market to sell them. The fundamental principle on which remanufacturing activities were carried out was to recover maximum value from product returns. Most of the remanufactured products could be sold profitably in the "secondary markets". These secondary markets were also known as "B Channel B," as opposed to the primary distribution channel. There was one person within HP exclusively responsible for developing a market for remanufactured products. Remanufactured stock had a unique business problem. In a normal manufacturing environment, companies could produce at a rate aimed at matching demand. If demand changed, they could adjust the rate of production accordingly and ensure that there was a minimum finished-goods inventory. In a remanufacturing environment, however, HP did not have control over the rate at which the returns would flow, at least, in the short- and medium term. Therefore, a pile-up of remanufactured stock would develop if the demand for these did not match the rate at which the returns were being received. HP was considering several initiatives primarily based on online auctions to deal with remarketing issues. HP generated $50 million (annualized) from the sale of remanufactured products in 2000 in the U.S. and Canada.

HP carried out an EVA@ analysis (EVA is the registered trademark of Stern Stewart) to see if it made economic sense to engage in remanufacturing related activities. This was done to verify if remanufacturing activities would generate sufficient return to at least cover the cost of capital. The EVA@ analysis was key in determining whether HP should engage in remanufacturing activities itself or whether it should outsource them to third party service providers specializing in remanufacturing and for whom running remanufacturing operations was financially attractive.

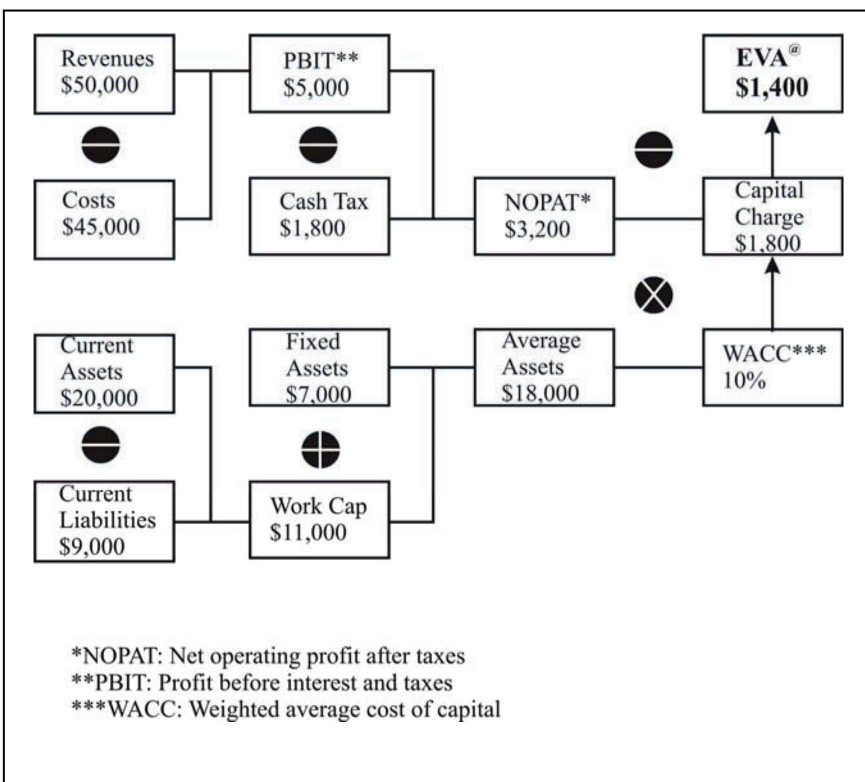

Fig. 8.3. EVA@ Calculation (all numbers in $'000s)

8.6 Conclusions

HP developed a comprehensive strategy of dealing with the problems associated with product returns and designed a reverse logistics structure that generated positive return on investment for the company. On the cost side, HP was developing ways of reducing customer returns by working with the value chain partners to minimize the causes of returns. At the same time, it was taking actions to reduce the total business costs by reducing the cost drivers. On the revenue side, HP was exploring ways of minimizing the mismatch between the volume of returns and the sale of remanufactured products. However, developing the secondary market in a way that would not cannibalize the sales of new products still remained an unresolved concern for the company.

9 Commercial returns in a mail order company: the Wehkamp case

René M.B. de Koster and Joost P. Zuidema

9.1 Introduction

Wehkamp was founded in 1952 by Herman Wehkamp in Slagharen, a little village in the East of the Netherlands. At this moment, Wehkamp is not only the largest home-shopping company in the Netherlands, but with over half a million visits per year it has the best performing webshop as well (www.wehkamp.nl). Since 1962, Wehkamp has been part of The Great Universal Stores, with headquarters in London. In the fiscal year 2001/2002, it had a turnover of about 318 million Euro and an operating profit of 30.2 million Euro before interest and taxes (annual report 2001 / 2002). The home-shopping market in the Netherlands is growing rapidly, as can be concluded from Table 9.1.

Table 9.1. Turnover of home shopping in the Netherlands (source: www.thuiswinkel.org, annual report 2001)

	1998	1999	2000	2001
Turnover in billion Euro	1.01	1.10	1.28	1.47

Wehkamp's main office is located in Zwolle and its warehouses are situated in Dedemsvaart (33,000 square meters) and in Maurik (32,000 square meters). The holding company (GUS Holland BV) has subsidiaries in the Netherlands, Belgium, and Germany. Wehkamp employs about 1,250 people, 300 of whom work in DC Dedemsvaart.

For mail-order companies, reverse logistics has always been a big issue as they face substantial flows of returns. Wehkamp is no exception in this. The flow of returned goods is most crucial for fashion products and consumer electronics with short life cycles. The distribution center (DC) in Dedemsvaart is dedicated to these goods, and will be our main focus.

Wehkamp offers a competitive alternative within the retail trade by offering, among other benefits (see www.wehkamp.nl):

- A wide assortment (50,000 to 80,000 stock keeping units), and
- An optimal price/quality ratio.

The number of SKUs (stock keeping units) varies over the year, since a large part of the assortment is renewed completely twice a year. During the peak period between two seasons, where the old products are phased out and the new products have to be received and stored, 80,000 SKUs have to be handled.

Customers can order via multiple channels. Traditionally, customers ordered by filling in coupons and transfer forms. In the seventies, Wehkamp introduced Videotext, but this was not a big success. More successful was voice response, which came up in the eighties. People could order with an artificial sales representative called Jimmy. With the advent of the Internet and e-commerce in the last decade, Wehkamp now offers customers the opportunity to order online. They started with an auction on the Internet, mainly to enable bidding on leftover goods, and at this very moment it is now possible to order any product from the catalog through the Internet.

In 2001, the division of Wehkamp's sales orders through the different channels was 20% via the Internet, 30% via Jimmy (voice response), 40% via telephone, and 10% by mail. CEO Marsman emphasizes the importance of the Internet as a sales channel: "The Internet is a must for our organization. It is the way of selling that perfectly matches our business strategy: selling on distance." The paper catalog will not become obsolete, at least not within the next 10 years; every year about 1.6 million paper catalogues are still distributed.

Until recently, Wehkamp categorized its products into two main groups: fashion and hardware. In 1998, a third product group, WSS products (Wehkamp Supermarket Service) was added, with about 660 ambiently stored supermarket products (food, pet food, detergents, personal care) sold in overpack quantities. The distribution center in Maurik is used for the storage of large hardware products like furniture and white and brown goods. In the distribution center in Dedemsvaart, small hardware, WSS, and fashion products are stored.

In 2001, Wehkamp had about 6 million small orders (orders with few lines). More than a quarter of the products were returned. Furthermore, Wehkamp dealt with approximately 600,000 voluminous shipments related to large items, of which about 50,000 were returned. Wehkamp has some 750 suppliers, located in 40 different countries. In 2001, there were about 1,400 truckload deliveries with 30,000 purchase orders. Currently (2002), the company has 4 million customers in its database, including a million active customers that order at least once per season. During a very busy day, Wehkamp processes in total approximately 50,000 orders. These peak days are usually the result of a new catalog distribution. These catalogs are distributed over a period of several weeks to limit peak effects. On a non-busy day, the number of orders still amount to about 20,000. The latter is more likely to happen at the end of a season when a new catalog is about to come out. The average number of items per order has stabilized at 1.8 for smaller products that are delivered from Dedemsvaart. Larger products that are delivered from Maurik are generally ordered individually. The average overall transaction value is confidential, but is more than 45 Euro.

In order to distinguish itself from competitors, Wehkamp offers competitive prices and high service levels at the same time. A real competitive advantage is the delivery lead-time: next-day delivery when ordered before 9 p.m. The company has always charged its customers for delivery; home delivery can be looked upon as an extra service when compared to regular shopping, and for that reason the customer has to pay an additional price. Besides, every mail order company is charging for home delivery. However, no fee is charged in the case that a customer returns the product.

9.2 Business drivers

Wehkamp has different return types. We see mostly end-of-life (EOL) returns in Maurik (it is compulsory to take back white and brown goods when a customer buys a new product) and commercial returns in Dedemsvaart. WSS products are rarely returned. In this case, we will primarily focus on the commercial returns as these form the large majority.

It is part of Wehkamp's business concept to make both ordering and returning products as easy as possible (see the previous discussion on service levels) in order to enhance customer relations and to ensure customer retention. This policy results in many product returns during the season, especially fashion products. The return percentage for fashion is sometimes up to 40%. The overall average in Dedemsvaart mounts up to 28%.

Returns are considered an important source of supply to the warehouse, since seasonal products are usually only delivered twice per season, whereas returns are received throughout the season and hence can be used to fill backorders. The returned goods are usually of better quality than the new products, since every single unit is checked for faults.

9.3 Technical aspects

On receipt, every individual return item is unpacked, checked for condition, and, if possible, restored to “new” status. The state in which products return is quite diverse. Fashion must be checked for stains and use. Special equipment is used for this purpose, such as workstations specializing in particular product groups, packaging machines, and an automated clothing cleaner.

Special product carriers are used within the return area (small bins) and for internal transport to the storage areas (large rolling bins) that are not used elsewhere within the operation.

9.4 Organizational aspects

Handling returns is, in part, integrated with the forward processes (one or more resources, such as workers, storage systems, external transport, or material handling systems, are shared for handling forward and return flows). In this section we briefly discuss these processes.

Collection

Daily, thousands of customers order by phone or via the Internet. Depending on the type of product, the storage warehouse is determined. Products from DC Dedemsvaart are as much as possible packed in one parcel per order. Transport and delivery from Dedemsvaart has been outsourced to DHL-Selektvracht, further denoted by Selektvracht, a third-party logistics provider (3PL) with a very dense network, see Figure 9.1. After having received the ordered products, the customer has some time to decide to keep the products or not. WSS products cannot be returned. If the customer decides to return an item, he or she has to call Wehkamp to agree on the day of collection. Next, Wehkamp informs Selektvracht, who schedules the pick-up on an existing delivery route carried out in the customer’s area. If there are no such routes yet, the pick-up may be delayed, or the customer can decide to bring it to a close post office herself. On many occasions, pick-ups can be realized within 24 hours after request, within a few hours time window agreed upon with the customer. Pick-ups arrive at Wehkamp’s DC in large trucks, via Selektvracht’s three sorting centers. The same trucks are used for pick- ups of the new orders at Wehkamp’s warehouse and for transport to Selektvracht’s DCs and depots.

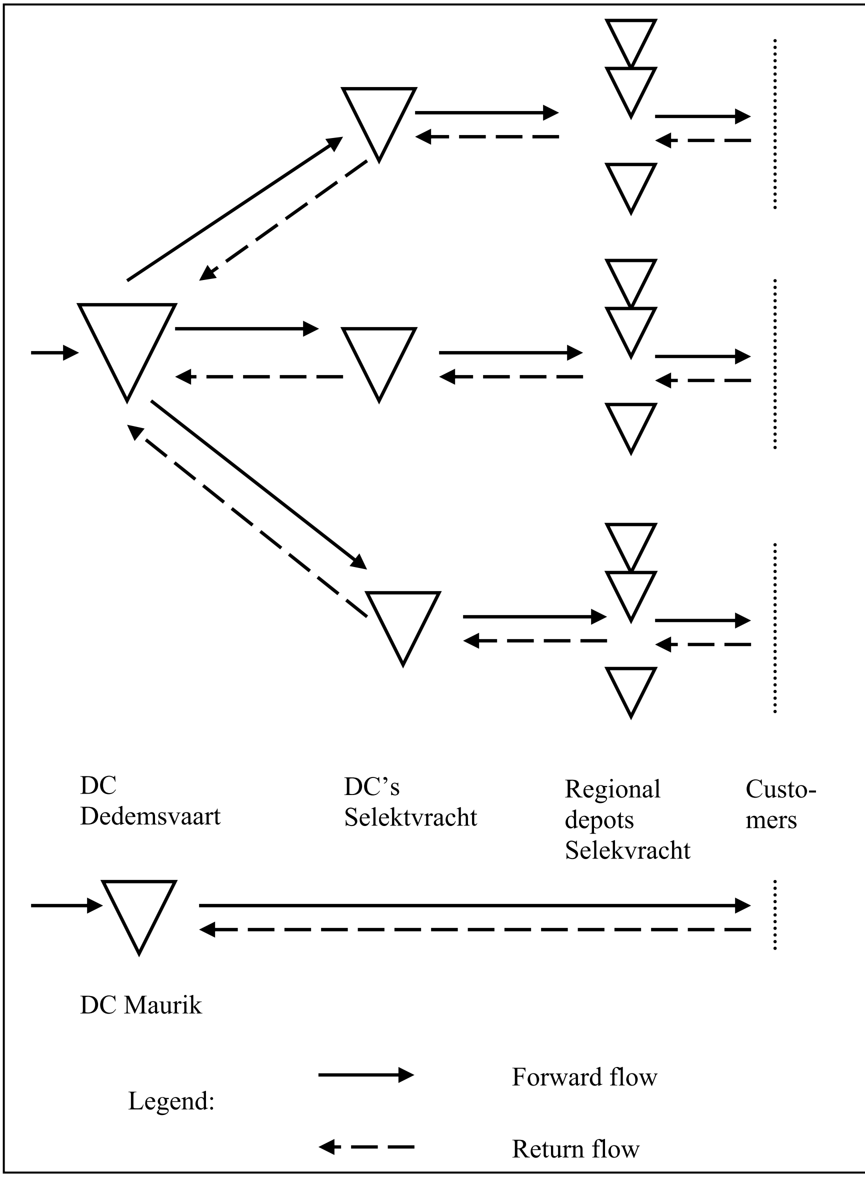

Fig. 9.1. Distribution structure Wehkamp

Return handling

The warehouse in Dedemsvaart has a large separate area (separated from the receiving area of purchased goods) dedicated to handling returned items, see Figure 9.2. About 25 people per shift (two shifts) are involved in the sorting and reconditioning (ironing, cleaning, relabeling, repackaging) of such products.

Fig. 9.2. Return department (right) with unsorted returns (left)

Figure 9.3 schematically shows the returns receiving and handling processes.

Returns are received in mixed roll cages. First, the products are sorted per product category (such as fashion, shoes, media, home appliances) within these roll cages. Next, multiple operations have to be carried out. People working in small teams process the returns per product category: they unpack the fashion products, check them for stains, recondition (for example, iron or steam) the product, and grade and repack it. Sorted roll cages are released in a FIFO sequence per team. The work has been divided into small unit handlings to create more efficiency. Recently, it has been decided to mechanize the process by installing a conveyor system that sorts bins with returns to the right work station. This is in accordance with (De Koster et al., 2002) who claim that more of the same, i.e. a large volume of similar types of products, are likely to be handled more efficiently than a group of products with divergent characteristics. Furthermore they argue that for retailers that handle a high volume of returns, it is more efficient to unload and sort returns in a separate area with specialized equipment and work procedures.

Generally, 5% of the returned products at Dedemsvaart need repair or are disposed of. After repair, products are generally fit for sale at the original price. Returned items are put in rolling bins per warehouse subzone and are brought to the storage area.

Return storage

At the storage area, the products are sorted back to their initial pick locations as long as this location is still being used for the very same product. Wehkamp is considering whether to consolidate returns with the original (new) products at the storage locations (the current situation) or to put them in a separate location. The consolidation leads to a smaller storage area, but longer storage throughput times. Furthermore, during picking the pickers can not make a distinction between new and returned units. De Koster et al. (2002) mention that if the market for returns is the same, then retailers generally combine the storage of returned products with newly purchased products.

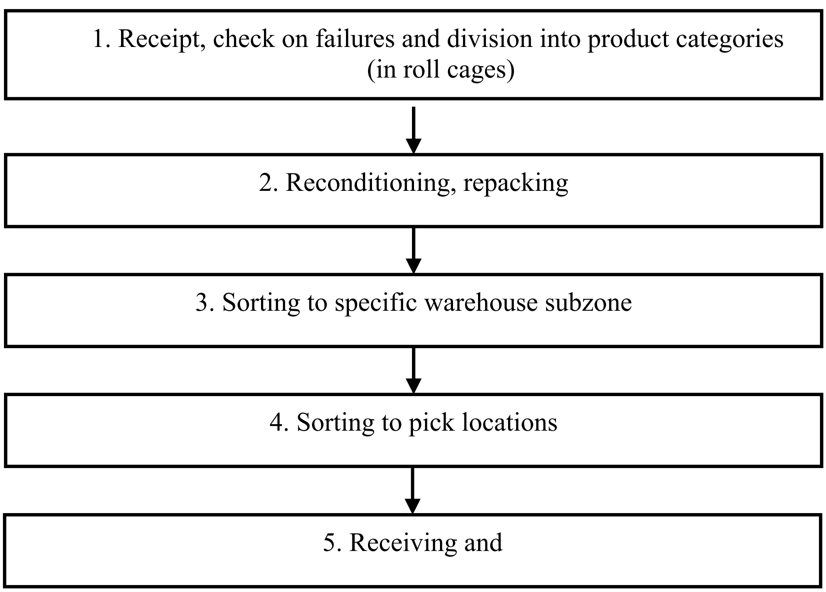

Fig. 9.3. The return handling processes

Leftovers

After the end of the season, there are usually leftovers. In order not to cannibalize Wehkamp's own market, these are sold for largely reduced prices in different markets. Only in exceptional cases can leftover products be returned to the suppliers.

9.5 Planning and control aspects

In view of the large number of returns and the resulting high costs, it is necessary for Wehkamp to handle them efficiently. Therefore, planning and control decisions must be taken in several areas.

Forecasting and (re)ordering

Sanders et al. (1998) state that it is important to make a distinction between products with a limited selling-period (one season) and products with an unlimited selling-period. Wehkamp also makes this distinction. For non-seasonal products, historical sales data is used to estimate both gross demand and returns for the coming season. Once the demand has been estimated, Wehkamp's purchasing department knows how much to order before the start of the season.

For seasonal products, such as fashion, there is no historical data, which makes demand very hard to forecast accurately. Especially fashion products have a high risk of becoming obsolete at the end of the season. Generally these products have a long delivery lead time and high minimum order quantities. In order to estimate the demand for fashion products, Wehkamp makes an initial rough estimate for the season and orders a small fraction of this quantity long before the season starts. Then Wehkamp issues a precatalog (preview) for a select (representative) group of customers some weeks before the start of the season. Based on the sales data from this group, Wehkamp adapts its demand forecast for the whole season and determines the remaining order quantity per product. The expected demand for a certain product during the season is an extrapolation of the average sales of that product in the preview period. Most fashion products are ordered only twice a season (once before the preview period to cover preview and early-season demand and once two weeks after the start of the preview period to cover demand during the rest of the season).

Returns play a specific role in the ordering process, because they affect stock levels. Based on historical data and experience with the product category, Wehkamp estimates the fraction of sales that will be returned over the whole season and takes this into account when making the order decision.

According to Fisher et al. (2000), it is necessary to track and predict forecast accuracy and to adapt it over the season. Wehkamp indeed adapts its demand forecast, based on the sales and returns in the preview period. The second order quantity equals the forecast, corrected for returns. This means that demand variance and the cost of lost sales are not explicitly included in the order quantity decision. The profit might be higher when, especially for high-margin and fast-moving products, the purchase quantity is higher. For some products with nearby suppliers, there may also be some opportunity to adapt the forecast and to reorder more frequently during the season.

Collection of returns

Wehkamp integrates the delivery route with return pick-ups from customers. In contrast to retailers that have stores, this means that Selektvracht cannot pick up the returns on a fixed schedule. See also (De Koster and Neuteboom, 2001). Schedules have to be constructed dynamically. Items to be picked up from customers are electronically forwarded to Selektvracht frequently, after which they have to be planned into a route. This requires a high degree of flexibility on the part of Selektvracht in rescheduling routes at a late stage. This is, for the large part, left to the individual drivers. These drivers operate always in the same area, which implies that they know their regular customers.

9.6 Information aspects

Usually, customers report returns to Wehkamp by telephone, which are then transmitted to Selektvracht. In order to schedule pick-ups in delivery and pick-up routes, Selektvracht uses standard truck routing software. Wehkamp uses similar software to check Selektvracht's invoices (one of the components is kilometers traveled). For return handling, Wehkamp uses tailor-made software. This software supports the identification, grading, relocating, and customer crediting process. Recently, this return functionality has been integrated into a standard warehouse management system. Once a return is received, it is confirmed in the information system, where it is decided whether the client should be refunded or not, based on whether or not this product category may be returned (unsealed CDs, for example, may not be returned), the condition of the product, payments made, and date of original purchase. Often, the customer has not paid yet, so refunding is not necessary. If a customer has paid, (s)he is refunded automatically. The returned products receive a label that can be used to trace the number of returns of each particular item, so that items can be monitored individually. Frequent returns may lead to a closer inspection, as the product may have deficiencies.

9.7 Environmental aspects

Environmental issues do not play an explicit role in Wehkamp's operations. In unpacking and handling returns, mostly paper and plastic waste is generated. This is sorted per type, picked up by specialized companies, and recycled.

9.8 Business-economic aspects

Returns bring about high costs. For any returned product, Wehkamp faces twice the transport cost (delivery and collection) and three times the initial handling cost (handling cost and return handling cost, which in turn is at least twice the initial handling cost). Return handling is much more expensive than initial handling (order picking), since every individual unit is inspected, graded, conditioned, repacked, and stored. In order to decrease the number of returns, Wehkamp may think of measures that keep customers from returning products. One of these measures could be the charging of delivery fees, regardless of whether the customer actually keeps the product or not. As a consequence, customers may hesitate to buy articles of which they are not sure. Unless customers are willing to risk paying a charge for nothing, decreasing sales will then be unavoidable. However, most probably the number of returned products will fall accordingly. On the other hand, these measures may affect the customer service and consequently it may jeopardize long-term profitability. Since invoicing delivery cost also involves costs and because of the potential risk, Wehkamp has not tried to charge delivery cost in case of a return.

9.9 Conclusions

Although Wehkamp has a large return percentage and the returns bring about high costs in handling and collection, Wehkamp rather sees returns as a customer service element and a challenge than as a threat. By offering services such as delayed payment and rapid, easy, and free-of-charge returns, which can rapidly be collected at a time indicated by the customer, Wehkamp creates sustainable customer relations. This ensures preservation and even increase of market share and profits. Realizing profits is only possible with a very efficient logistic system. This is the area in which Wehkamp particularly excels, as can be concluded from their winning the Dutch Logistics Award in 2001.

Part 5:
Repair and replacement closed-loop supply chains

10 The repair of electronic equipment: the OMRON case

Roelof Kuik, Jo A.E.E.van Nunen, Jacky Gerrits and Marco H.P. Hogenboom

10.1 Introduction

OMRON, with its headquarters in Japan, is a leading international corporation supplying products and services in the fields of industrial automation, automating services, medical healthcare, and information processing. Typical products are card readers, vision systems, sensors, counters, relays, and connectors. OMRON manufactures its products globally in over 30 factories and has 71 subsidiaries in 35 countries. It is organized in 5 divisions as shown in Table 10.1.

Table 10.1. OMRON divisions and their shares in the turnover in 2002 (Year ends March 31, 2003: see annual report of 2003)

Divisions	**Percentage share in turnover**
Industrial Automation *(Motion controllers, sensors, switches, relays, PLCs)*	37.8 %
Electronic Components (*Automotive devices, micro lens arrays, card readers)*	25.9 %
Social System Solutions *(Public transportation systems, traffic and road management systems, parking systems)*	21.8 %
Healthcare *(Blood pressure monitors, fat analyzers, fitness equipment)*	7.9 %
Other *(Consulting services, modems)*	6.6 %

OMRON Electronics Europe (OEE) has its headquarters in Hoofddorp near Amsterdam in the Netherlands. OEE is responsible for the activities in the EMEA area consisting of Europe, the former Soviet Union, the Middle East, and Africa.

OEE consists of more than 20 fully owned subsidiary companies, including national sales companies in almost all of the European countries and a European Logistics Center (ELC).

This chapter mainly focuses on the activities of OEE for the business unit (BU) Automation & Drives (A&D), which is part of the Industrial Automation division. The ELC and the European Repair Center are also located in the Netherlands near an OMRON manufacturing plant of Automation & Drives in ‘s Hertogenbosch. This collocation of ELC, ERC, and the manufacturing plant creates opportunities for sharing resources, materials, and supply.

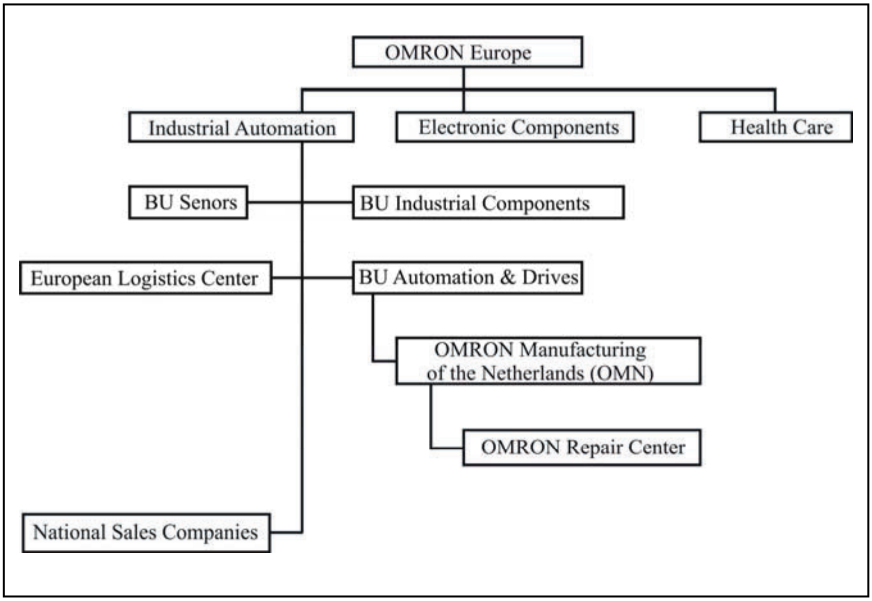

Fig. 10.1. Organogram OMRON Electronics Europe

ERC is part of BU A&D, as about 80% of the repair activities concern products of A&D. It also functions as the European repair center for products of the BUs Sensors and Electronic Components. The National Sales Companies (NSCs) work for several business units and may, in large countries, consist of multiple regional sales offices.

OMRON’s customer base consists of system builders, original equipment manufacturers (OEMs), and distributors. For example, its motion controllers and flux-vector motor controls are produced for OEMs of elevators and robots. The customers of the OEMs are companies like Toyota, Nokia, and Unilever.

Problems with products are solved at three levels. At the first level, the problems are solved by the OEMs themselves since they normally have good technical expertise. Application engineers of the NSC can handle advanced technical questions concerning the use or functioning of products. Finally, the ERC is responsible for handling the remaining problems.

10.2 Business drivers

The products that are sent to the ERC for repair are normally quite valuable, with prices ranging between 50 and 3,000 Euro. The failure of an OMRON product can interrupt critical processes of users. These interruptions can have high opportunity costs and have to be resolved without much delay.

ERC was established in the mid-1990s. In the first year, ERC encountered startup problems as many NSCs continued to do difficult repairs against high costs at the national level. As a consequence, the ERC capacity was underused and the quality of the repair process was not up to standards. The behavior of the NSCs could partly be explained by the fact that the lead time of ERC was up to 6 weeks. Moreover, necessary investment in training and equipment could not be justified on the basis of the low demand for repairs. Therefore, in the startup period, 7% of the repairs were forwarded to the repair center in Japan. To change the above situation, an OMRON Repair and Return project was initiated in 1997.

10.3 Technical aspects

As mentioned before, OMRON manufactures products that are part of larger technical systems. Rapid technological development implies that during a product's lifetime and a system's lifetime many versions and upgrades may co-exist with a similar or extended functionality. Therefore, preserving compatibility of the OMRON repaired products with the system of which they are a part is a major challenge.

Products are built out of subassemblies that in turn consist of components. OMRON uses the strategy of repairing products at the component level instead of at the subassembly level. This approach has a number of advantages:

- The variety of subassemblies is much larger than the variety of components. So, doing repairs at the component level reduces the cost of inventory. Moreover, the value saved by repairing at the component level instead of at the subassembly level can be considerable,
- Since components are more generic, doing repairs at the component level helps to maintain compatibility with the technical system,
- Repairs at the component level provide better information about the cause of failure. This information is transferred to the customer, who considers the corresponding repair report as an additional service element,
- The repair report is also used as feedback to OMRON or the third-party manufacturer.

10.4 Organiszational Aspects

When the OMRON Repair and Return project started, the repair flow in Europe was as shown in Figure 10.2.

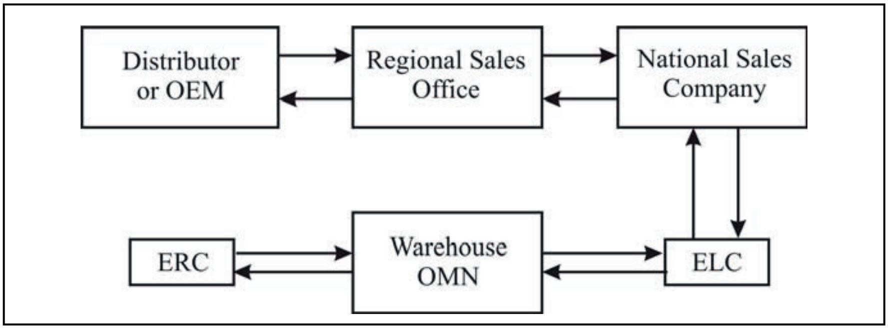

Fig. 10.2. Initial repair flow

The user of a technical system informs his supplier when a failure occurs. The supplier, an OEM or distributor, investigates the reported failure. If an OMRON product causes the failure then OMRON's regional sales office or NSC is contacted. The proposed repair solution depends on the prevailing contract, the warranty conditions, and the preferences of the OEM or distributor. Often the defective product is removed and temporarily replaced. For a repair by the European Repair Center, the NSC issues a repair material authorization to the customer. The defective item can then be shipped through the parties as shown in Figure 10.2.

After repair at the ERC, the reverse process is followed and the repaired product is reinstalled in the system. A detailed overview of the repair activities and the materials used in the repair process is attached to the repaired product. The NSC is billed by the ERC for the repair. The NSC in turn bills the distributor or OEM.

Each transport in the process took close to a week. Thus, the total duration added up to 6 weeks on average, whereas the product spent approximately only 1 week at ERC. If a repair needed to be completed in Japan, then an additional delay of 10 weeks was incurred. Most of the delays were caused by consolidation strategies that made transport more efficient. The batch deliveries, implied by the consolidation in transport, created an unbalanced load on the repair facility a well as unpredictable lead times.

The long delays made NSCs reluctant to hand over repairs to the ERC. Indeed, many an NSC had the standard practice of employing an unofficial 'Local Repair Center' that lacked proper quality assurance and hence created a lot of hidden costs.

In summary, the analysis of the process and its performance revealed several problems: long lead times (6 weeks), inefficient double substitution of defective products, much paper work as the whole process needed repairs to be traced back to original customers/users/applications, and repair inefficiencies at both the national and the European level. For example, for lack of sufficient scale it was hard to justify investment in specialized diagnostic equipment to reduce the number of repairs in Japan.

First Redesign

In order to at least partly overcome the above problems, OMRON in a partnership with DHL introduced a new 3-layer process to handle repairs as depicted in Figure 10.3. Note that this redesign is comprised of two transportation legs and four information legs.

The following process is supported by this structure:

- Customer contacts an NSC because of a problem,
- NSC communicates about the problem and
  - solves the problem via communication by telephone, etc., or trains the customer in the correct operation, or

- in the case repair is required, informs the customer about (i) the procedure, and (ii) the costs (including transportation).

- When the NSC issues a repair material authorization (RMA), the procedure is faxed to the customer who is supposed to contact DHL and agree on a pickup time (which if announced before 3:30 p.m. will occur the same day before 5:00 p.m.),
- NSC informs ERC about the RMA by means of a repair order containing a failure description. ERC will bill the NSC for a fixed percentage of the sales price of the item to be repaired. The NSC uses the After Sales Application to create RMA numbers. This database runs on the OMRON intranet. The NSCs have online access to this database, so they can not only create RMA numbers but also follow the activities and the status of a repair online,
- If the above options do not apply the NSC tries to sell a new product or component.

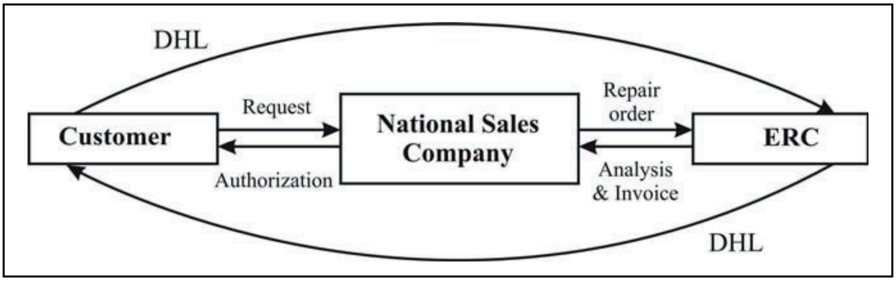

Fig. 10.3. First redesign repair process

The lead time for the new process is less than 5 days, of which at most 2 days are spent at ERC, for 95% of the products under repair. The 5% incurring a long lead time are special products like safety curtains that need to undergo repair at a special facility. Once a repair is completed, a repair report made. This repair report is added to the repaired product on the box and is sent to the customer directly.

DHL charges OMRON for shipments based on weight classes. Tariffs per weight class are uniform: distance to ERC plays no role.

This new 3-layer structure, together with the new way of billing, realized the following benefits for OMRON and its customers:

Customer benefits:

- Transparency of repair costs: customer invoice includes transportation costs,

- Fewer shut downs because of replacing products: the 5-day lead time allows for non-critical machines to await the repaired product, thereby avoiding double substitution (product replacement activities have been reduced by 90%), and
- Lower costs.

OMRON benefits:

- Elimination of batching in transportation leveling the load on the repair center,
- A further willingness to centralize on the part of the NSCs, resulting in more volume and thereby creating opportunities to scale up operations at the ERC and to decrease the repair engineering time by 30%,
- A reduction of items needing repair in Japan to a fraction of a percent,
- A reduction of after-sales costs by 30%, and
- A simplification of the process between an NSC and ERC by charging a fixed price for repairs to NSCs.

Second Redesign

As experience with the 3-layer solution grew, the necessity of having the NSCs involved in the process gradually became harder to justify, and a further redesign was deemed necessary. In the first redesign, the NSCs had the administrative task of recording and authorizing repair activities for repairs of products for their customer base and notifying the ERC accordingly. This frequently led to spurious information, as an RMA extended to a customer might not be followed by a shipment. The customer could decide on second thought not to have a defective product repaired. This would make the information at the ERC inconsistent with actual receipts: products announced as being underway for repair arrive later than expected or never at all.

In order to overcome these problems a further redesign of the information exchange was necessary. In this new information and communication system DHL plays a central role. When an NSC issues an RMA it is registered in OMRON's central European Repair Database (ERDB). From the ERDB customer details are uploaded to a European EDI Gateway of DHL. This European EDI Gateway of DHL sends a booking confirmation to the NSC and an email (or fax) with an airway bill (AWB) to the customer. The customer thus does not need to take the initiative after the initial reporting of the failure: upon the issue of an RMA, the information system automatically generates a pickup request to the local DHL station.

The first leg covering the pickup of the product to be repaired at the customer and its subsequent delivery at OMRON's European Repair Center is depicted in Figure 10.4.

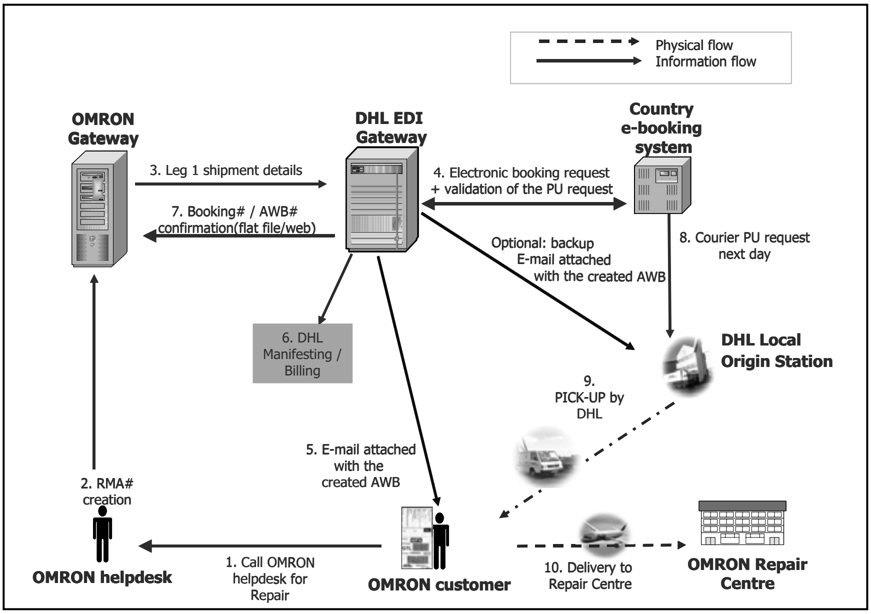

Fig. 10.4. Future structure of the first leg: Customer to Repair Center

The point of contact between the OMRON organization and DHL is now at the European level and optimization of the transportation can be done by DHL at an aggregated level. Moreover standardized and transparent procedures can be applied for all participating NSCs.

The EDI Gateway of DHL informs the OMRON customer electronically in advance of the pickup (PU). At the same time, the DHL EDI Gateway also provides the customer with a printable form of the AWB.

The communication for the second leg, the leg representing the transportation of the repaired item from the repair center back to the customer, also runs through the European gateways of the OMRON and DHL organizations. For both legs, there is no stocking point for repairs and this reduces the delay between the report of a defect and the installation of the repaired item down to a bare minimum. Of course, this arrangement comes at a cost premium but this is traded off against the superior service to the customer.

Furthermore the quality of the logistics processes has been improved by DHL by offering the service of DHL-standardized protective packaging to the customer.

10.5 Conclusions

The process for dealing with defective OMRON products needs to be responsive: often OMRON products are critical to the primary processes of users. No stoppage of these processes is allowed. Therefore, failures have to be resolved without much delay.

In the old structure such responsiveness was attained by

- Double substitution,
- Unofficial local repair, and
- Unofficial local inventories of spares.

The ensuing repair process was inefficient and, due to the unofficial character of some parts of it, opaque.

In the new structure responsiveness has been achieved differently. Fast transportation has eliminated much of the need for temporary replacements, local repair and local stock. At the same time it has opened the way for further centralization of repair activities creating scale for high quality repairs resulting in a minimum of defective items sent to Japan and a dramatic reduction of the lead times.

Stimulated by the redesign, the number of countries that channel repairs through ERC has grown steadily. In the current situation, in 2003, nearly all of the repairs are done at ERC.

The entire journey of centralization and process redesign has brought OMRON the following advantages:

- An improvement of transparency and quality control in its repair process,
- A reduction of the number of product replacements by 90%,
- A dramatic reduction of lead time,
- A reduced repair costs by 30%,
- A balanced load on the ERC making the lead time of repairs at ERC predictable and reliable,
- A transparent and efficient repair costs billing system resulting in hardly any negotiations on repair costs,

- Outsourcing of the responsibility for the repair transports to the logistics service provider DHL,
- An improved and integrated information and communication system.

Currently the web-based information exchange is being introduced. This enables the tracking and tracing of the repair process by customers. The information required for this is already in place in DHL's information system. The step to be taken is making this information available to customers.

11 Tire recovery: the RetreadCo case

Laurens G. Debo and Luk N. Van Wassenhove

11.1 Introduction

Retreading is the process of replacing the worn rubber outer layer of a tire with a new rubber layer. By retreading it is possible to save up to 80% of the material cost of a tire. Current technologies allow for the retreading of tires such that their quality, dependability, and performance is comparable to new tires, and retreaded tires are sold for prices 30 to 50% lower than new tires. Retreading can therefore be both economically interesting and environmentally beneficial. While these advantages are significant, retreaded tires fail to capture a significant share in consumer markets. In this chapter, we identify economic drivers of retreading by describing the products, services, and operations of RetreadCo.

RetreadCo is a wholly owned subsidiary of NewTireCo, a major European-based new tire manufacturer. RetreadCo has operations in France, Germany, Belgium, and Luxemburg. Its main plant retreads more than 4,500 tires per day and employs 700 people in manufacturing or commercials functions. RetreadCo retreads passenger car, van, heavy truck, and earthmover tires and produces retread rubber for export. Thanks to its close relationship with NewTireCo, RetreadCo continuously invests to improve the processes, materials, and performance tests. RetreadCo retreads used tires of almost every brand and uses a licensed technology for used NewTireCo tires. With the acquisition of RetreadCo, NewTireCo obtained a strong position on the European retread market. Similarly, in North America, NewTireCo entered the retread market by acquiring an independent tire dealer with retread operations.

11.2 Business drivers

NewTireCo's competitive strategy is to be present in each consumer segment. Especially in the truck tire segment, there is an increased demand for "cradle-to-grave" tire management solutions, including the processes of purchasing, retreading, and disposing of a fleet's tires.

Given increased environmental awareness, legislators are mounting the pressure on the tire industry to find ways to control the scrap tire problem. In Europe, tire legislation of each member country is shaped by two Directives of the European Community. The Landfill Directive of 1999 established a ban on the landfilling of whole tires starting in 2003 and shredded tires in 2006. The End of Life Vehicle (ELV) Directive of 2000 requires car manufacturers to take back all ELV and to remove the tires, ensuring that they do not end up in landfills. In addition, the Directive also sets targets for reuse, recycling, and recovery that have to be attained by car manufacturers, who pass a part of the required effort on to the tire manufacturers. Individual member countries have the freedom to implement the appropriate legislation (Shulman, 2000). In France, for example, legislation is being developed to make the new tire manufacturers responsible for proper disposal of non-retreadable used tires (ADEME, 2002). A fund will be raised by the tire manufacturers, collecting a tax of 0.75€ on the sales of new tires. When buying a new tire, consumers can, without paying a disposal fee, leave their used tires at the tire dealer. Any tire reprocessor that disposes of these tires in an environmentally friendly way will be rewarded from the fund. However, it is possible that with such a fund retreadable tires would be diverted to other reprocessors. As finding good casings for the retread industry will then become more expensive, retreads will become less competitive with respect to cheap, non-retreadable budget tires. This, in turn, may have a negative environmental impact, which is the opposite of the legislator's intentions.

11.3 Technical aspects

Figure 11.1 shows a cross-section of a tire. One recognizes the tread, which is the outer rubber layer that is in contact with the road surface, and the casing, which is the inner structure of the tire. During the retread process, the tread is removed and replaced by a new one.

The necessary technological steps of retreading are illustrated in Figure 11.2.

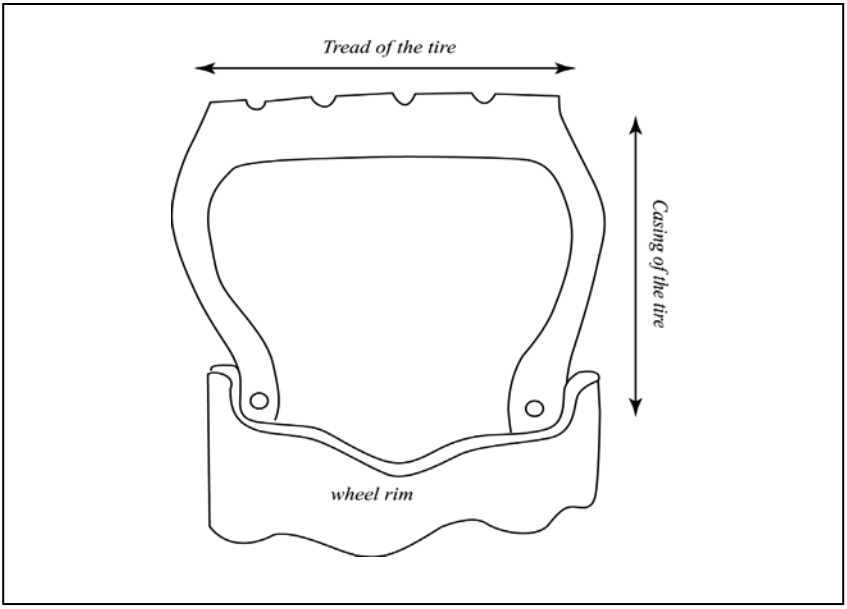

Fig. 11.1. Cross-section of a tire: tread and casing

As the new tread will be built upon the used casing, a critical first step in the retread process is the *inspection* of the casing of the used tire. Casings with defects may cause premature breakdown and have to be rejected. RetreadCo uses non-destructive testing of the inner structure of the casing by means of electromagnetic fields. A tire that passed the inspection is subsequently *buffed* (i.e. the tread is pealed off by means of a buffing rasp) to the appropriate dimensions for the given tire type. RetreadCo uses computer controlled buffing machines to achieve high precision. The buffing process makes the casing accessible to repair possible damage. After this operation, the casing is ready to receive a new tread. There exist two processes to apply a new tread to a casing: the *mold cure* process and the *precure* process. Uncured tread rubber is applied to the casing in the mold cure process. The casing with tread rubber is then put in a vulcanization chamber in which, under the correct pressure and temperature, the uncured rubber vulcanizes and binds with the casing. In the mold, the appropriate tread pattern is formed. For the precure process, cured tread rubber, already with the appropriate tread pattern, is applied to the casing by means of a cushion layer. Similarly, as in the mold cure process, the casing and tread are then put in a vulcanization chamber, where the cushion layer vulcanizes and binds the tread to the casing. RetreadCo offers both processes and produces precured tread rubber for export. As a mold is required for every tread pattern, the mold cure process requires higher investment costs for a retreader than the precure process.

After the tread has been applied by either process, the tire undergoes a *final inspection*, before being sold as a retreaded tire. By law, all retreaded tires are marked on the sidewall in order to differentiate them from new tires.

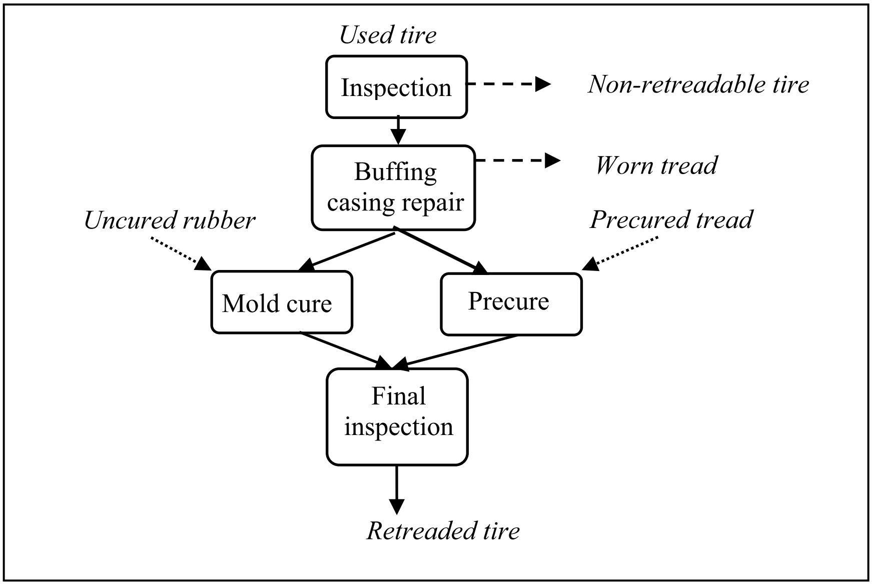

Fig. 11.2. Schematic representation of the retreading process

Passenger car tires are characterized by tire dimensions, speed rating, comfort, grip, traction, wear rate, etc. Technically, RetreadCo is able to cover more than 80% of all European passenger car tire types, including retreaded tires with the highest speed ratings (that allow speeds up to 210 km/h or 240 km/h).

11.4 Organizational aspects

RetreadCo has invested significantly in the development of good relationships with tire dealers in order to have sufficient supply of good casings. It has a fleet of more than 70 trucks and more than 150 trailers that continuously collects used tires and delivers retreaded tires to a network of more than 1,500 dealers. The extensive network that gives access to good casings is a key competitive advantage of RetreadCo.

Below, we discuss two different commercial retread systems. We focus on the flows of retreadable used tires. Non-retreadable used tires, also referred to as “scrap tires,” will be discussed in the following sections.

The nominative system

Big fleets often cooperate with a tire dealer for tire management, see the upper part of Figure 11.3.

The tire dealers identify and mark used tires that are sent to RetreadCo for retreading. These tires are retreaded and sent back to the tire dealer. Lead times are typically three weeks. The fleet thus reuses its own casings. The price reflects the cost of retreading only. The dealer disposes of the non-retreadable tires.

The customer system

Collection of used tires from small fleets or individual vehicle owners is more complicated and typically also involves tire collectors, see the lower part of Figure 11.3.

Owners usually leave their tires with the dealer when they buy new tires. They pay a disposal fee for this. The dealer stores used tires in bins. On a regular basis, a tire collector empties these bins and separates the non-retreadable from the potentially retreadable tires. The dealer, in turn, has to pay a fee to the tire collector. The tire collector disposes of the non-retreadable tires and sells the retreadable tires to retreaders like RetreadCo. RetreadCo inspects and retreads the tires. The retreadability of these tires is typically more variable than for tires acquired in the nominative system. RetreadCo markets these tires as ‘retreaded tires’. Buyers thus use a casing that was previously owned by another customer. The price they pay reflects the acquisition cost of the casing and the cost of retreading.

Note that the following logistic activities are typical to both nominative and customer systems: picking up used tires from their point of origin, bringing them to the retread plant, and sending retreaded tires to the point of reuse. One way to keep the logistic costs low is to have a decentralized network of retread plants. This is possible with the precure retread technology, which requires relatively low investment costs. For the mold cure retread technology, which requires high investment costs, a more centralized network is necessary in order to keep average retread cost low. Such a network, however, increases the logistic costs.

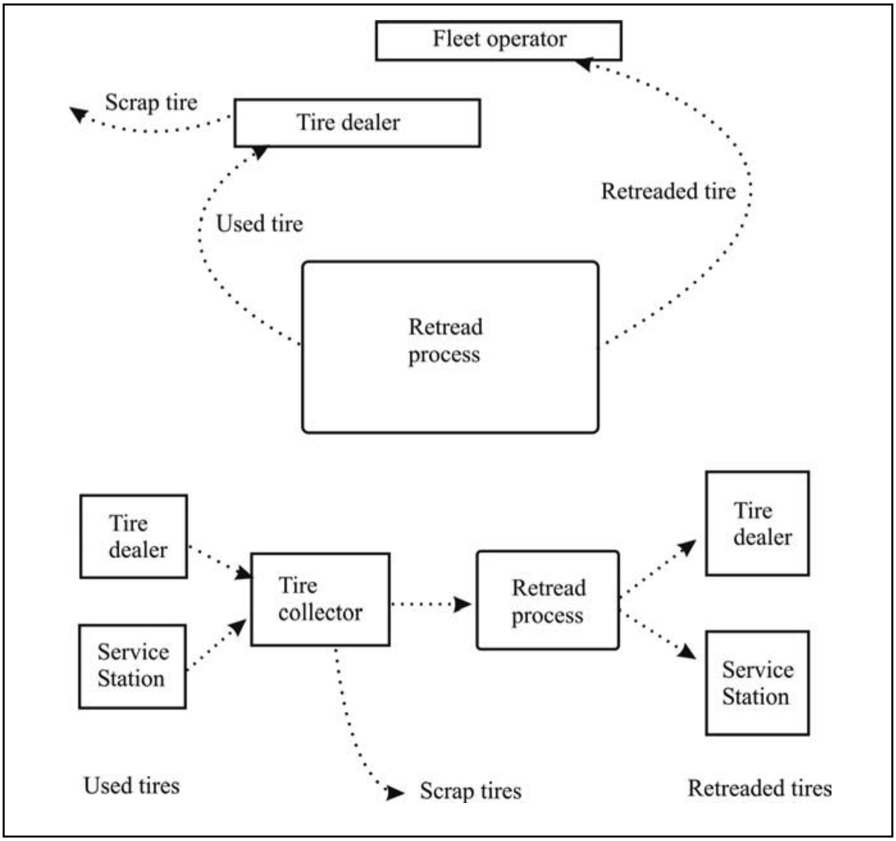

Fig. 11.3. The nominative (top) and customer (bottom) system of retreading tires for big truck fleets and passenger cars respectively (simplified version)

11.5 Information aspects

One of the most important causes for tire failure is under- or over-inflation (Deierlein, 1997). Due to uneven contact between the tire and the ground surface, the tire heats up locally and this causes failure. Therefore, information about the pressure and temperature is very valuable for cost-efficient tire maintenance decisions. Tire manufacturers are currently developing “smart” tires with sensors that record the temperature and/or inflation during the operation of the tire. The information is exchanged with an external computer system via RF signals and can be used to take the appropriate tire-related decisions.

Tire manufacturers developed software packages that allow fleet operators to track (a sample of) tires of their fleet: not only the temperature and pressure history, but also tire age, number of retreads done so far, tread type, etc. This information is analyzed and exchanged with the retreader, who performs the appropriate operations. Note that the sensor has to withstand the curing process when retreading. The cost of the sensor (to be mounted in every tire) is currently too high, impeding a major breakthrough of this technology. However, one expects these costs to drop in the future.

11.6 Environmental aspects

Retreading has great environmental benefits as it reduces the amount of scrap tires. Scrap tires cannot easily be buried in landfills. Because of gasses trapped inside the toroidal structure, they tend to surge to the surface of the landfill and break the landfill cover. They are therefore often banned from landfills by legislators in North America and Europe. Scrap tire stockpiles are good breeding places for rodents and mosquitoes and have a negative impact on the health of the local population. Fires of scrap tire stockpiles are extremely expensive to extinguish, can last for many weeks and pollute air, soil, and groundwater. Furthermore, scrap tire piles are aesthetically unpleasant.

There exist roughly three markets for scrap tires: (a) tire-derived fuel, (b) engineering applications, and (c) rubber recovery (Lund, 2001), (Rubber Manufacturers Association, 2002). The high-calorie value of scrap tires can be recuperated as tire-derived fuel in cement kilns, paper mills, power generators, or industrial boilers (Ferrer, 1997). Scrap tires as a whole can replace other materials currently used in civil engineering applications. For example, used as sub-grade fill in the construction of highway embankments, scrap tires are cheaper and weigh only one-half of conventional soil fill. Finally, size-reduced rubber obtained from processing scrap tires is used in asphalt rubber, athletic and recreational applications, and even production of new tires in limited quantities.

The “scrap tire problem” can thus be alleviated by promoting retreading and developing technologies that increase the capacities of the alternative outlets for scrap tires.

11.7 Business-economic aspects

In this context, a distinction has to be made between passenger car tire retreading and truck tire retreading.

Business-economic aspects of passenger car tire retreading

In spite of the technological capabilities, markets for retreaded passenger car tires are declining. This is also the case at RetreadCo, whose retreaded passenger car tires share dropped from 10% to less than 5% over the last couple of years. Below, we discuss three possible reasons that impede the development of healthy markets for retreaded passenger car tires.

Bad Perception of the Quality of Retreaded Tires

Even though the bonding of the tread of a retreaded tire is through the vulcanization process and is thus as good as for a new tire, retreads have suffered for a long time from a reputation of bad quality. This problem originated during the first years that retreading was available on an industrial scale (Préjean, 1989), while retreaders were still experimenting with new processes. An obnoxious persisting myth about retreads is that the debris, which is often found on the highways, is due to retreading. According to studies of the Tire Retread Information Bureau (TRIB), a non-profit US-based organization promoting recycling of tires through retreading, the main cause is improper inflation. TRIB tries to "dispel the myth of rubber on the road" through various publications. However, numerous buyers of replacement passenger car tires still prefer new tires to retreaded tires even if the latter ones are significantly cheaper. This negative image has been reinforced by a few retreaders that put retreads with very variable quality on the market, giving the whole industry a bad reputation. In order to improve the image of the retread industry in Europe, the European Commission regulated the retreading process (ECE 108 and ECE 109), imposing testing standards to retreaded tires similar to the ones of new tires. RetreadCo was one of the early compliants to these regulations. For other smaller retreaders, compliance with the regulation is expensive and may force them out of business.

High Logistic Costs

Mostly, retreading of passenger car tires follows the customer system. Consequently, the supply of retreadable tires is very variable in quantity as well as in quality. Due to unreliable supply and the costs associated with sorting retreadable casings from non-retreadable ones, the logistic costs of the customer system are relatively high, compared to the logistic costs of the nominative system.

Competition from Budget Tires

Labor costs are an important cost factor in the production of new tires. Therefore, manufacturers produce tires in countries with cheap labor rates for export to Europe and North America, where they compete with retreaded tires for market share. These "budget tires" typically have a low level of retreadability. Often, the price difference between a budget tire and a retreaded tire is too small for retreaded tires to overcome the negative perception of retreads. As a result, the market demand for retreaded passenger tires is low. Besides, because of the budget tires, fewer retreadable used tires are available on the market, which increases the collection costs of retreadable tires and the cost of retreaded tires, making the price difference with budget tires even smaller. RetreadCo suffers from competition from budget tires that may even be put on the market by NewTireCo.

Because of the bad perception, the high logistic costs associated with the collection system, and the competition from budget tires, retreading passenger car tires is currently hardly profitable.

Business-economic aspects of truck tire retreading

Typically, tires are the second most important expense item for fleet operators, immediately after fuel and labor cost, accounting for 11% of total operating costs (Moore, 1999). As retreading is cost effective, almost all truck tires are retreaded. A truck tire can be retreaded up to three times. Big fleets often have specialized tire maintenance management programs and software. Regular maintenance improves the retreadability of a used tire. Therefore, the nominative system is the one most often used for truck tires, which eliminates the intermediation of a tire collector and makes collection less expensive. The tire cost performance is usually calculated as the "cost per mile", which includes maintenance costs, retread and replacement costs, and downtime costs. Different factors like pressure, driving behavior, tire rotation, tread depth, tread pattern, and geographic conditions determine the cost per mile. As retreaders have extensive technological knowledge and thoroughly inspect the fleet operator's casing before buffing, they often provide useful information for the fleet operator to improve tire management and reduce the cost per mile. In the U.S., some retreaders even offer tire consulting services to fleet operators. Mostly, a scrap tire analysis is performed and opportunities for improving tire management are identified (Skydell, 2002).

Retreading truck tires is cost-efficient for fleet operators and profitable for retreaders for the following three reasons: with the nominative system, logistic costs are relatively low, the material savings are substantial, and the related tire management services are valuable. This is also the case for RetreadCo.

11.8 Conclusions

Retreading tires seems to be an environmentally friendly and economically interesting business activity, as a significant fraction of the materials of a new tire is reused. Retread markets for truck tires are indeed healthy. However, markets for retreaded passenger car tires are declining. This case highlights the importance of consumer behavior, collection systems, legislation, and competitive strategy of new product manufacturers to the existence of markets for retreaded tires. In (Debo, 2002), these observations are developed further in a more general, theoretical framework.

12 The closed-loop supply chain of service parts: the Whirlpool case

Marc Deneijer and Simme Douwe P. Flapper

12.1 Introduction

Whirlpool Nederland B.V., further denoted by WP-NL, is part of the Whirlpool Corporation, with headquarters in Benton Harbor, Michigan, USA. WP-NL is involved in the marketing, sales, distribution, and service activities for white goods, including washing machines and refrigerators produced by Whirlpool, Bauknecht, and Ignis. Yearly, about one million new products are sent out from a distribution center (DC) in the Netherlands to trade partners in the Netherlands and Belgium.

The service department takes care of the after sales service activities to users and trade partners, but is not involved in the initial installation of products at the user nor in the collection of complete products from the users. Both of these activities are taken care of by the trade partners who actually sell the products to the users. In order to take care of the outdoor service activities, the service department of WP-NL employs about 60 service engineers. The department also has contracts with a number of independent service companies to fulfill service requirements.

WP-NL does not have its own service parts center. The service parts are held centrally for all of Europe, in Varese, Italy.

Yearly, about 45,000 parts are replaced by the WP-NL service engineers and the independent service engineers contracted by WP-NL. If a service engineer replaces a part, the used part comes free, as does the packaging used for the distribution of the newly installed part. What happens with the latter parts and package materials has to be decided at that moment. Hereafter attention will be focused on the recovery of used parts generated by the service activities of the service engineers working for WP-NL. No attention is paid to the recovery of parts resulting from the service activities of trade partners, users themselves, or service companies not contracted by WP-NL.

12.2 Business drivers

Parts resulting from warranty repairs are the property of WP-NL. As an appliance manufacturer, WP-NL provides a two-year warranty on its products.. Parts resulting from other repairs by a service engineer belong to the user. At the moment, there is no legislation in the Netherlands that forces companies to take back individual parts of their products, nor is such legislation expected soon, due to the complex control related to such legislation.

Nevertheless, there are several reasons why WP-NL will take back the parts resulting from repair activities by its service engineers:

- To accommodate users who ask that the engineer disposes of these parts,
- To avoid accidents due to unprofessional repair or overhaul of parts like motors and electronic components,
- To provide quality inspection. Parts are sent back to the producers and are used to gain insight into the time-phased behavior of these parts.

Apart from parts that have been replaced, there are also unused parts that are no longer required by the service engineer and which are returned to the DC of WP-NL or to the Central Service Parts Center in Italy in order to be used for other customers.

12.3 Technical aspects

Many parts removed from a product can not be reused as such, even after repair. Other parts can be overhauled, but the economic value does not make it worthwhile. However, the parts can be reused via their materials content.

12.4 Organizational aspects

When a user has a query on a product or if the product malfunctions, the user first has to contact the direct supplier of his product (trade partner). The direct supplier can redirect the user's call or query to WP-NL Customer Services. The objective of WP-NL Customer Services is to provide a world class service to the users of their products and to their trade partners in order to “contribute to the passion for our brands, and to provide quality feedback for new innovative products and services.”

WP-NL coordinates its own service engineers network from its Customer Assistance Center in Breda. Whatever query a user might have, the consultants provide the necessary advice or information. In the case that a consultant cannot provide the necessary advice online, the consultant offers an engineer visit to the user.

When an engineer visits a user at home, he diagnoses the appliance failure and advises the user of the repair conditions. If the user accepts repair, the engineer can make use of the service parts or articles from his service van or make use of pre- or post-ordered service parts.
Once the repair has taken place, the engineer hands over a detailed invoice and survey form.

WP-NL B.V. registers invoices and survey returns such that innovative actions can be taken based upon the feedback of the users.

WP-NL also provides a direct service consultancy to the trade partners, i.e. technical advice and service parts distribution activities.

Roughly speaking, the supply and recovery of service parts is structured as follows. When a repair takes place and a service part is required to replace an existing part, see the left hand side of Figure 12.1, the engineer can make use of the parts in his van or contact the Service department in Breda to order the missing parts. The missing parts will be ordered together with the other van stock replenishment items used that day. These parts will be sent overnight from the Central Service Parts Center, based in Italy, to the engineer’s van. WP-NL contracted two logistics service suppliers, JETservice and TNT innight service, for the distribution of parts from Italy to the vans of the service engineers. JETservice is contracted for the international transport between Italy and the DC of TNT innight service and the DC of WP-NL, whereas TNT innight service is contracted for all other transport activities. Once these parts are in the engineer’s van, the engineer revisits the user.

Next, the different partners involved in the recovery of used parts are briefly described, as well as the roles they play in the recovery process.

From Figure 12.1, it is clear that the recovery network for parts coincides, to a large extent, with the network setup for maintenance and repair activities. The *users* are the initial suppliers of used parts. In this context, a distinction is made between users for whom service activities are done in the context of warranties and those that are made for other reasons. The reason for this distinction is that in the former case WP-NL automatically becomes the owner of the parts that are replaced, whereas in the latter case the user is the owner of these parts and should be willing to let the service engineer take with him the parts that have been replaced.

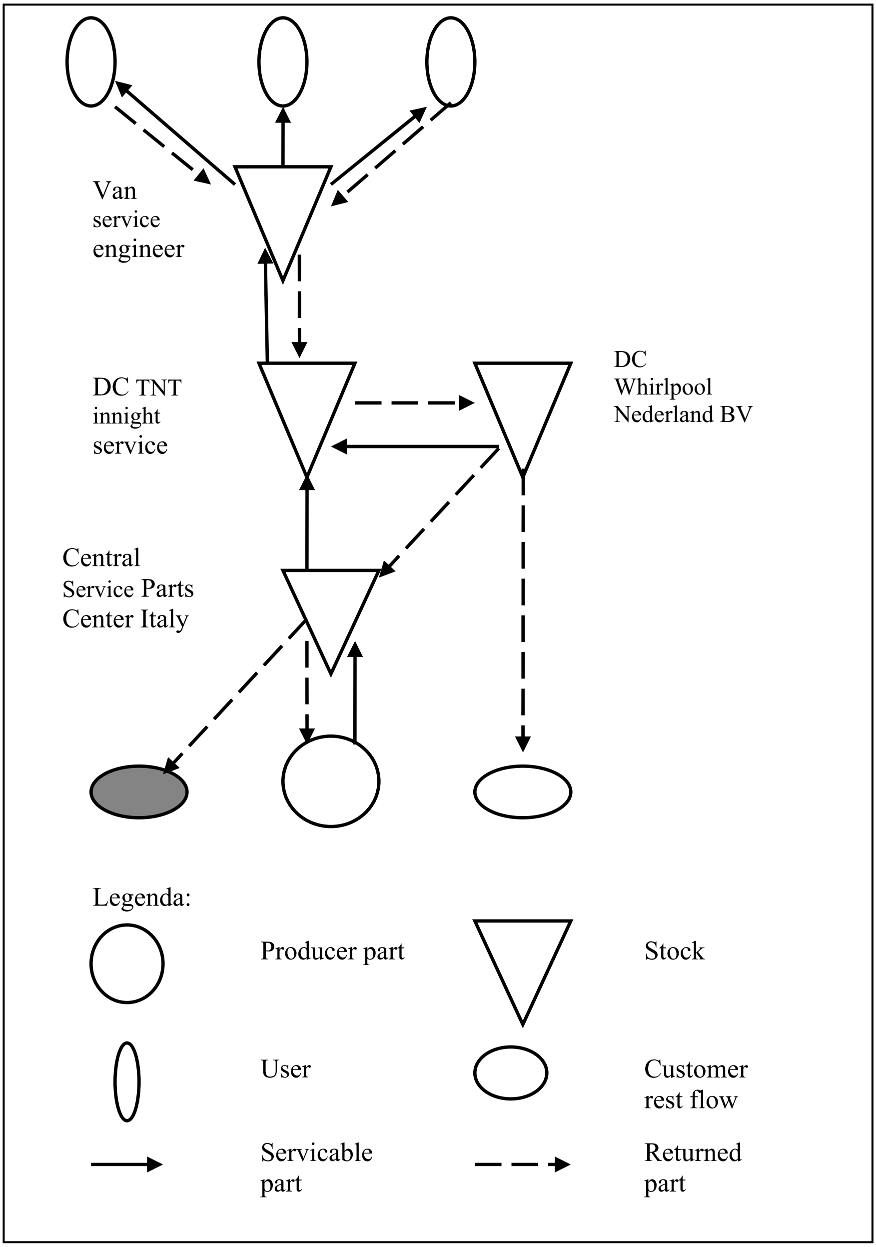

Fig. 12.1. The supply and recovery of service parts via service engineers

The *service engineers* play a central role in the recovery of service parts.

First of all, in the case of no-warranty replacements, the service engineers have to ask the user if he would like the engineer to take care of the parts that he removed. If the user agrees, the service engineer takes the parts with him. In the case of parts that might not be properly repaired, or for parts that are desired by the suppliers of WP-NL, the service engineer tries to persuade the user to give the part to him, in the former case stressing the risk of improper repairs and reuse. About 50% of the parts that are replaced stay with the user and 50% are taken away by the service engineer.

Second, the service engineers have to register the parts that they take back, indicating via stickers with different colors whether or not a certain part can be used. Apart from the parts that have been removed from machines, there are also new parts that turn out not to function well, new parts that are damaged in the van, and obsolete new parts that have to be sent to the DC of WP-NL.

Third, the service engineers have to pack the parts that are to be collected by the third party logistics service provider during the night when new parts are delivered to the van.

Fourth, the service engineers should not mix usable and non-usable parts when replacing or disposing of parts. Note that the return flows reduce the free space in the service engineer's van.

Finally, the service engineers may be asked to properly dispose of the package materials or non-functioning parts themselves.

As mentioned before, at the moment there are two *logistics service providers* involved in the recovery network:

- TNT innight service takes care of the transport of parts from the vans of the service engineers to the DC of WP-NL via the DC of TNT innight service, where the parts that are returned by the different service engineers are combined, and
- JETservice, which is responsible for the transport from the DC of WP-NL to the Central Service Parts Center in Italy.

The service parts that are delivered to the *DC of WP-NL* have to be unpacked and sorted among the others based on the stickers put on parts by the service engineer. Hereafter, the different types of parts are stored separately. At the DC, there is a special storage location for parts returned by service engineers. The parts that are to be returned to Italy are stored on special pallets and are sent to Italy as soon as a full truckload is available. The unused new parts are stored in the DC to wait for a customer in the

Netherlands or Belgium or are sent to the Central Service Parts Center in Italy.

The undesired bad or new parts are put in containers that are emptied in a timely fashion by a *recycler*. There is only one recycler that picks up the undesired parts at the DC of WP-NL.

12.5 Planning and control aspects

As explained, obsolete parts, both used and unused, are collected from the van of the service engineer by the logistics service provider at the same time that new parts are supplied to the engineers. The transport from the DC of WP-NL to the DC of TNT innight service is started when TNT innight service is at the DC of WP-NL to deliver the parts collected from the vans of the service engineers. The transport from the DC of WP-NL to Italy starts when a full truckload is available for return to Italy. Once a recycling container is filled, the recycler receives an order to pick the container up and to take care of its content.

Due to the relatively small number of returned parts that can be used by WP-NL, WP-NL deals reactively with parts returned from service activities, i.e. only when it turns out at the DC of WP-NL that parts can be used are they included in the stock of serviceable parts.

12.6 Information aspects

Which parts might be worthwhile to recover and which parts not is indicated on the parts by the service engineers via stickers with different colors. These stickers do not drop from the part they are put on, but can easily be removed from the part when required.

Most of the used parts that have been removed are not registered. Unused parts to be returned to Italy, and used parts that have to be returned to their producers for examination, are registered by the service engineers in their laptops. In the evening, when the parts are picked up, the service engineer prints a so-called Returned Parts Shipment Note that he adds to the parcels with the parts to be returned. He also sends the shipment note to the DC of WP-NL. In this way, the DC knows what's coming. On each of the parcels with parts to be returned, the service engineer puts a sticker denoting TNT RETOUR DC WP NL. These parcels are put at the end of his van, well visible for TNT innight service.

The logistics service provider TNT innight does not receive data about returns. TNT innight service picks up the parcels during the next visit to the van of the service engineer. In principle, the vans are visited only when parts have to be delivered to the service engineer. However, each Friday all service engineers are visited to pick up parts that are to be returned to the DC of WP-NL. TNT innight only registers the number of parcels that have been picked up at each service engineer. This is done for control, administration, and billing.

The Returned Parts Shipment Note is printed in the DC of WP-NL. This print is used for entrance control.

Only unused parts are registered in the information system at the DC of WP-NL. It is also registered to where these parts are going: on pallets to Italy, to a scrap container (in the case that WP-NL does not want to use them), or to a local stock location in the DC. So, in the available information system, both the stocks of parts that can be used and the stocks of parts that are not used by WP-NL are registered: the former in order to avoid unnecessary supply of new parts from Italy, the latter to inform the customers of these "unusable" parts.

As soon as there are enough pallets to be returned to Italy, a file with data about the returns is sent to the Central Service Parts Center in Italy. The latter indicates which returns are approved and which not. Parts that are not approved have to be removed. Based on the approved return file, the returns are registered by the Central Service Parts Center in Italy.

Jetservice only receives orders to bring pallets with return parts to the Central Service Parts Center in Italy. These returns are removed from the stocks in the DC of WP-NL.

Once a recycling container is filled, the recycler receives an order to pick the container up and to take care of its content. Monthly overviews are generated to give insight into the costs related to the different returns.

12.7 Environmental aspects

There is some extra transport involved in the recovery of service parts because the third party logistics service provider has extra mileage from its DC to the DC of WP-NL to deliver the parts that are returned by the service engineers. There is hardly any extra transport involved in the pickup of parts from the vans of the service engineers nor in the transport from the DC of WP-NL to the Central Service Parts Center in Italy.

The customers for the undesired parts have to guarantee that they deal with these parts in an environmentally conscious way.

12.8 Business-economic aspects

Hereafter, an overview is given of the costs and benefits related to the recovery of parts. In this context, it is important to notice that the part recovery activities do not have consequences for the supply of service parts.

The four main costs drivers are transport, handling, storage space, and registration.

First of all, there are costs related to the initial collection at the user. The collection aspects of the service engineer, as described in detail in the Organizational aspects section, require extra time from the service engineers and therefore result in extra labor costs. Up to now, the extra space required in the engineer's van has not resulted in the requirement for a larger van. TNT innight service to be paid for the collection and transport of parts that are returned by the service engineers. There are also costs related to the DC of WP-NL: handling, unpacking, and sorting parts and storing them in the appropriate containers, pallets, or other storage locations, as well as the costs for registering how much of what has been returned, requiring labor hours plus extra software functionality. The extra space for receiving and processing the parts returned by service engineers; storage space for the pallets used for the transport to the Central Service Parts Center in Italy and the containers that are collected by the recycler; and storage space for the obsolete new parts that are returned do not result in extra costs. Finally, there are costs related to the return transport to Italy. Jetservice has to be paid for the collection and transport of parts that are returned to the Central Service Parts Center in Italy from the DC of WP-NL.

12.9 Conclusions

Based on economic, environmental, and safety elements, Whirlpool Nederland B.V. has a policy for the recovery and scrapping of parts resulting from its service activities. In this chapter, an overview has been given regarding how the parts resulting from service activities are dealt with by WP-NL.

The recovery of parts concerns the recovery of obsolete stocks of new parts from the vans of the service engineers in order to be used by other service engineers, the recovery of new parts that were delivered defective, the recovery of defective parts for product improvement, the recovery of defective parts in order to prevent risky repairs and reuse by others, and the recovery of irreparable parts. The latter two types of parts, as well as unused parts that have become obsolete, are picked up by a recycler in order to recover the materials that the parts contain.

A central role in the recovery process is played by the service engineers, who are required to perform many extra activities. Information systems, as well, play an important role, notably in preventing the unnecessary supply of new parts to WP-NL.

Part 6:
End-of-use closed-loop supply chains

13 End-of-lease asset recovery: the Océ case

Rob A. Zuidwijk, Erwin A. van der Laan and Leon Hoek

13.1 Introduction

Océ enables organizations to manage their document flow and exchange information effectively and efficiently. Océ produces and delivers copiers, printers, plotters, and hybrid systems that integrate various functions like copying, scanning, and printing. Further, Océ delivers consumables and supplies, as well as services and support. Océ tries to have a proactive attitude towards environmental legislation and regulations, and is constantly looking for new information about product safety and environmental issues.

At the beginning of the 1980s, Océ started to remanufacture machines. Machines that came back to the organization were cleaned and sold to its Operating Companies (OpCos) that operate local markets worldwide.

At the beginning of the 1990s, Océ started recovery activities for parts of machines within an assembly department. Parts of machines were taken out and installed in other machines, after the parts were thoroughly cleaned. In December 1995, a separate unit was formed within Océ in Venlo, the Netherlands, called Asset Recovery (AR).

13.2 Business drivers

The most important reason for Océ to engage in product recovery is that in the long run it is economically profitable to collect used machines and either remanufacture them or reuse their parts (Interview Hermans, 2003). Purchasing costs are saved, because it is cheaper to install a used part in a new machine than to order and install a new part. Service costs can be lower because extracted used parts can be fixed and used again in follow-up service visits. The recovery strategy also serves marketing purposes. Environmental awareness among customers creates a preference for products that are produced in an environmentally friendly way. At the end of the nineties, the European Union in the so-called Waste Electrical and Electronic Equipment (WEEE) directive and the Dutch government introduced producer responsibility, meaning that all producers are responsible for the whole life cycle of their product.

13.3 Technical aspects

Machines that arrive at AR are either dismantled (85%) or remanufactured (15%). Within Océ, dismantling means cannibalization of machines for production or service purposes and removal of environmentally hazardous components. Remanufacturing at Océ can roughly be divided into three operations:

- *Dust-off*: machines are cleaned and checked thoroughly and then resold in the market,
- *Factory Produced New Model (FPNM):* a remanufacturing operation in which some extra features are added. One example of an FPNM is a high-volume copier that is adjusted for a lower-volume copier market. Another example is a copier that after adjustment can handle more paper. An FPNM is targeted for new markets,
- *Standard Revision Projects* include the removal of parts during repair and maintenance and the cleaning and testing of components, after which the machines are returned to the market. This activity is more elaborate than Dust-off.

The intrinsic quality of the product is not the only determinant of the allocation to a recovery option such as remanufacturing. Expected market demand also determines whether it is useful to remanufacture a machine.

At the moment, R&D focuses on End-of-life handling. R&D is more concentrated on the added value for Asset Recovery processes and mainly focuses on the most appropriate parts for reuse. In the future, R&D will be focused on the following issues (Interview Geujen, 2003):

- Parts that are appropriate for reuse must be identified earlier in the engineering phase and discussed with the designer in order to obtain reuse specifications,
- Hazardous materials must be identified in the R&D phase,
- The removal of appropriate parts and hazardous materials should be made easier,
- Finally, AR would like to see a safe and damage-free return of machines.

There are a few trends in the reuse of components in the Océ product design. The life cycle of new machines is getting shorter. Technology changes like the shift from analog to digital and the increase of color printing and higher volume printing will become more important. For AR this means that they have to concentrate more on service returnables, which are parts that the service technicians have to replace in the field.

Moreover, the returns will switch from simple components to complex components with more value. For the reuse of these complex components, AR will need to contact the original supplier, who has more knowledge about this. AR will be handling fewer simple parts and will do more management of the complex parts flow.

All customers expect high quality copiers and printers that meet all environmental and energy standards. In order to have a competitive advantage, Océ aims at constant improvement, going for the newest and best technologies. Within Océ, each organizational unit must live up to these high standards in order to maintain customer satisfaction.

13.4 Organizational aspects

AR is the department within Océ that is responsible for recovering value from products and parts that are returned from the markets. AR resides within the Manufacturing and Logistics department (M&L).

The main function of AR is to execute the reverse logistics policy. Groups Logistics defines the logistic policy, in collaboration with AR. This implies several functions:

- Taking back machines and service parts from OpCos from all over the world,
- Remanufacturing, refurbishing, and cannibalizing machines,
- Remanufacturing and repairing service parts, and
- Balancing the demand of used machines and parts with returned machines and parts.

AR decides worldwide whether machines are remanufactured (and henceforth starting a new life cycle) or dismantled for (spare) parts that can be reused in old or new machines.

The main goal of AR is to reduce external orders by OpCos by delivering used products that are functionally as new. Reuse of recovered parts and machines is enforced by the fact that new parts and products can only be ordered by the OpCos and the departments M&L Machines and Logistics Service Parts (LSP) when AR can not supply recovered versions of these parts that satisfy the appropriate quality conditions (Interview Gommans, 2003).

We now explain the physical flows as depicted in Figure 13.1. Parts and machines are returned to and collected via OpCos at the local markets. Return rates of Océ products are quite high, partly due to the fact that machines are sent out through lease contracts in the Business-to-Business market. Parts are released from the market e.g. as a result of maintenance services by service engineers, while machines are returned e.g. at the end of a lease contract. AR located in Venlo, the Netherlands, is the international collection point. As said before, machines that arrive at AR are either dismantled (85%) or remanufactured (15%). Apart from Dust-off, done by the OpCos themselves, remanufacturing is done either in Venlo, the Netherlands, or Prague, Czech Republic. The facility in Prague specializes in processing standardized recovery operations in large batches. The OpCos more and more outsource recovery operations to the central facilities.

All machines suitable for remanufacturing that come from the OpCos undergo visual inspection resulting in an A, B, or C quality certificate. “A” quality denotes that a machine is in good condition and can be remanufactured. “B” quality machines can either be remanufactured or dismantled, depending on demand for particular machines or components. “C” quality machines are to be dismantled.

The logistics service provider Cabooter in Venlo stocks repairable parts, to be forwarded to internal repair or external repair at the suppliers. Repaired parts are further assembled and forwarded to Logistics Service Parts (LSP). Remanufactured machines are forwarded to the units Digital Document Systems (DDS) and Wide Format Printing Systems (WFPS).

When managing the collection of returns, one needs to take into account that transport of garbage waste across countries is, in a lot of cases, prohibited. It is therefore necessary that returned machines that are transported across country borders are labeled as “recyclable, reusable equipment” so that it is legal to transport them (Interview Van Knippenberg, 2003).

Because Océ has OpCos in many countries and legislation on end-of-life handling varies considerably from country to country, every local OpCo takes care of the removal of goods according to national legislation. In the Netherlands, products are transported to and handled at AR in Venlo. The remaining material is offered to recyclers or handled/disposed of in accordance with Dutch legislation.

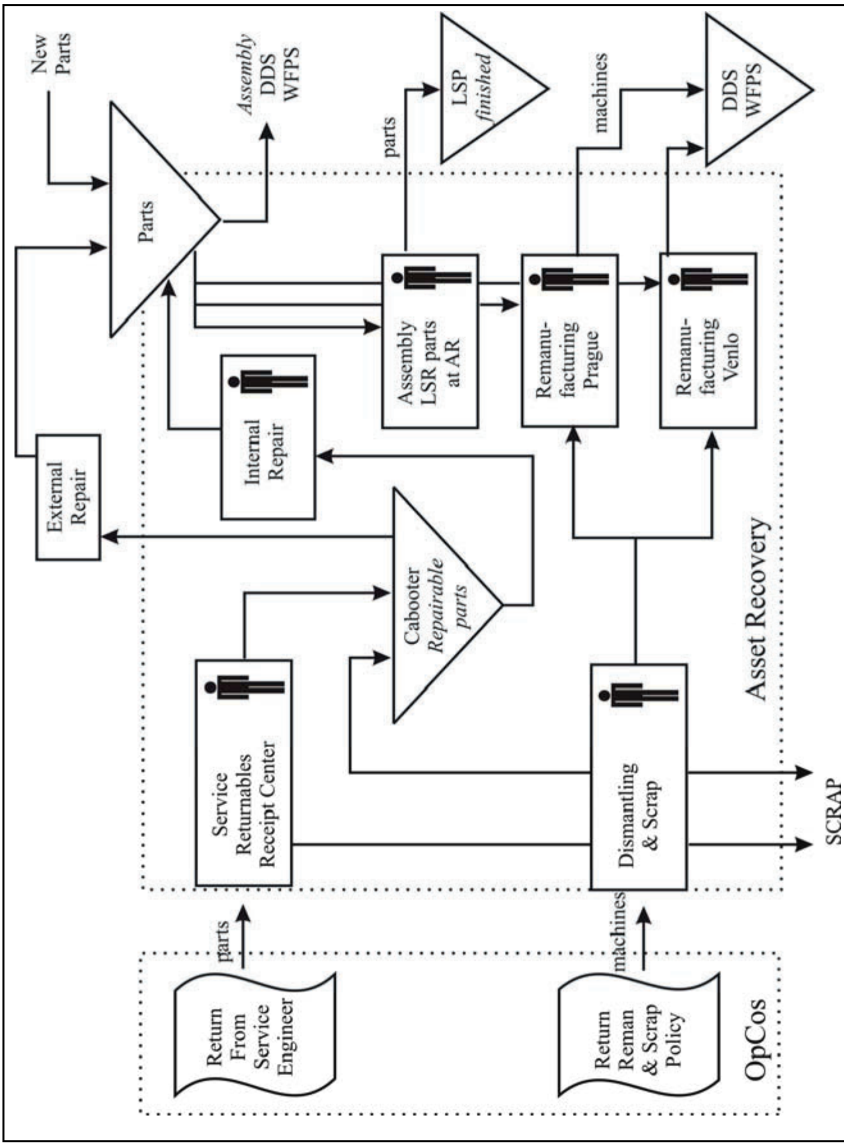

Fig. 13.1. Physical flows through Asset Recovery

Due to digitisation, machines will contain more complex components, which will take more effort to remove efficiently. In this process, costs play the most important role and will determine whether activities take place at AR or are outsourced to the suppliers. This implies that the focus of AR will be on organizing value recovery rather than on performing all operations in-house.

The organizational units AR and R&D are getting more connected. The transport and scrap manual, for example, will help in educating R&D engineers. There are also some initiatives to connect the information systems of AR and R&D. In this manner, the R&D engineer is able to mark important reuse specifications.

13.5 Planning and control aspects

One should keep in mind that returns are characterized by uncertainty in timing, quantity, and quality. Updates of lease contracts by sales are quite often motivated through commercial incentives, so even in this case return forecasts are difficult to make from the standpoint of AR. In the end, recovered components can be used in the forward production process, so that the production process utilizes both recovered and new items. Currently, AR uses a conservative approach towards estimating future replenishment stock, which comes down to keeping high stock levels. In order to reduce stocks, more advanced supply strategies are under consideration.

Besides keeping safety stock and thereby mitigating the effects of uncertainty, one can also opt for reducing uncertainty by influencing the return stream. One of the instruments used by AR is pricing of returned products and parts. A new project called Trading Desk aims at enabling transactions of returns between the OpCos and AR.

The logistics department within AR is responsible for the forecasts of spare parts for all machines. With the latest switch from analog to digital machines, many more spare parts must be available and this will put more pressure on this department in the near future. After a transition period, the market will mainly consist of digital machines and a new equilibrium in inventory will be established (Interview Schoonwater, 2003).

A somewhat related issue is that whenever a product is taken out of the market earlier than anticipated, the spare parts reserve built up by AR becomes partly obsolete. AR must monitor developments and processes within the whole company in order to proactively manage this issue properly.

13.6 Information aspects

Also for the processes at AR, information plays an important role. The information flows between AR and the OpCos consist of regular updates of policy, pricing documents, return forms, and remanufacturing announcements (Interview Faassen, 2003). Meetings take place on a regular basis and further communication is done via email and telephone. Océ is entering a phase in which every OpCo is adopting the same information system. The information system that is going to support the information flow is SAP R3.

The number and quality of machines that AR gets back is uncertain. At this moment, OpCos provide forecast information of expected returns of printers and copiers for disassembly and remanufacturing, but only for a small horizon. OpCos know, for example, which lease contracts will expire and which contracts will be continued. The actual installed base data and history data are also available to AR. AR would like to make its own forecasts via a central database with the information from the OpCos. However, for the actual returns, AR is still dependent on the OpCos and does not have enough influence to control this process yet.

The Trading Desk project has been started to improve the machine flows within Océ between the OpCos and AR. Trading Desk is an information network for the trade of machines. The supply and demand of machines is very important and the network operates via a price mechanism. The availability of machines is more important than the price. At this moment, three parties are involved in this project: the marketing business units at the OpCos, the logistics department from AR, and the direct export department. The involved parties contact the Trading Desk with specific demands or overstocks. The Trading Desk operates as an intermediate and tries to match supply and demand.

In order to manage product data, recent product types contain a chip that records service history. The service technicians save all repair and usage history information in a central database. This information is attached to machines, rather than to components. AR can use this information when needed, but it is not yet used to the full extent.

Some products of Océ contain hazardous materials. Every product has a safety information card. This document reports which hazardous materials are contained in the product. When OpCos locally handle the end-of-life products, they have access to this information. Additional information can always be acquired in Venlo and OpCos can always choose to send back their end-of-life products to Venlo for end-of-life handling.

An important marketing issue is communication towards the customer. The products that Océ produces often contain used components or are remanufactured. In some markets, legislation requires explicit labeling of machines that contain recovered parts. In any case, both new and used components must meet the highest quality levels (Interview Philips, 2003).

13.7 Business-economic aspects

From an economics point of view, a number of issues are important. AR sets a price towards the OpCos each year for returned machines and twice a year for returned parts. This credit-price is determined on a non-profit basis, see Table 13.1. Machines also have a book value on the balance sheet of the OpCo. In some cases, the credit-price of a machine may be lower than its book value. This automatically means that such a machine will remain at the OpCo, because OpCos are autonomous business units and are accounted for their financial results. So both the price set by AR and the book value set at the OpCo determine the incentive to return machines to Venlo. This results in situations where the policy of AR is disturbed by financial considerations. The lack of a truly dynamic pricing system is also a factor that contributes to this.

Table 13.1. Credit-price calculations

Standard price new component	€500
Repair costs	-€200
Failures (accounted for 5% price new)	-€ 25
Standard price repairable	€275
Reservation market risk 12.5%	-€ 34
Commission for Service Returnables Receipt Center	-€ 25
Credit price (Return Inter Company Price)	€216

One market characteristic that is of high importance to the recovery process is the fact that Océ doesn't target consumer markets but mainly focuses on the Business-to-Business segment. The number of machines set out in the market is therefore limited compared to consumer markets, but each machine corresponds to high value. As Océ has created one central reverse logistics operation in Venlo, economies of scale can be achieved. Transportation costs are not considered a bottleneck for the centralised approach.

13.8 Conclusions

Océ has developed into a recovery operation that adds value to its organization. In order to make the operation even more profitable, management wants to develop AR into a lean and responsive operation, given certain developments. The important market developments are focused further on Business-to-Business segments involving high-value machines, e.g. high-volume and wide-format printers, while the technical innovations relate to color copying and printing, and digitalization. As a consequence, returned machines contain a lot of recoverable value. It is very important to create the right incentives for OpCos to forward such returns to the proper recovery options. Initiatives such as Trading Desk may create a market that enables this through dynamic pricing.

The creation of a second recovery facility in Prague, Czech Republic, enabled specialization and cost savings. A proper understanding of recovery costs enables make-or-buy decisions. For example, value recovery from complex digital parts may be outsourced to the original supplier. When outsourcing will take place on a larger scale, AR becomes an organizer of value recovery instead of a mere recovery operating-unit.

In order to manage returns on a European scale, logistics processes need to be supported by information. An integrated information system between the OpCos and central facilities such as AR enables coordination of logistics processes and may result in cost savings and enhanced performance. These benefits should be large enough to justify the required investments. Product returns that contain a lot of value may provide these benefits.

A company such as Océ that is able to profit from product recovery needs not see environmental legislation as a burden. As economical life cycles of products become shorter, product development should consider product recovery at an early stage. At Océ, the interaction between R&D and AR, on product recovery during product development is certainly on the agenda. The aforementioned developments bring new opportunities to the management of AR and it is clear that more than one perspective is required to exploit those opportunities to the full extent.

Acknowledgements

This case description reports on a case study at Océ N.V. in Venlo, The Netherlands. The authors thank Paul Wouters, Toon Hermans, Frank de Beijer, Wil Gommans, Leo Geujen, Robert Schoonwater, Hay van Knippenberg, Barry Phillips and Hans Faasen from Océ N.V. for their cooperation. The case study has been conducted by the authors and by colleagues from the Erasmus University, namely Jacqueline Bloemhof, Moritz Fleischmann, Jo van Nunen, and student Diana van Eijk. The responsibility of this case description resides with the authors.

14 Cellular telephone reuse: the ReCellular Inc. case

V. Daniel R. Guide Jr., Kumar Neeraj, Charles Newman and
Luk N. Van Wassenhove

14.1 Introduction

Founded in 1991 in Ann Arbor, Michigan, by Charles Newman, ReCellular Inc., further denoted by ReCellular, is one of the leading traders of used and remanufactured cellular telephones, further denoted as cell phones. In the initial days of inception, when cell phones were an expensive consumer product (average prices were $3000), Newman leased cell phones as an alternative to buying. In the following years, it became increasingly clear that there was a distinct market for used and remanufactured cell phones, provided the product had an acceptable level of quality. Charles Newman sensed an opportunity in this emerging trend and decided to enter the remanufactured cell phones market. The company's wide range of remanufactured product offerings at high levels of quality and at attractive prices soon created a huge market. By 2000, ReCellular had remanufactured over 1.3 million cell phones of all makes and technologies and had operations around the globe including South America, the Far East, Western Europe, Africa, the Middle East, and North America. The company had ambitious plans of increasing its geographic reach. As Newman put it, "We want to be the 'first in the second' wireless exchange business." Specific data on the efficiency of the reuse systems (i.e. how much of the new cellular telephones sold were reused in one form or another) was not readily available. However, industry experts believe that remanufactured and reused as-is cellular phones made up at least 5-8% of the total worldwide market.

14.2 Technical aspects

There were three main technology related factors that created complexities in ReCellular's supply chain.

First, the lack of a worldwide standard technology limited the potential market for remanufactured phones. For example, a used phone acquired in the U.S. could not be sold in Europe. Europe used Global System for Mobile Communications (GSM) operating with a bandwidth of 900MHz while the United States used GSM operated with a bandwidth of 1900MHz. The two systems were not compatible.

Second, the short product and technology life cycle resulted in a rapid decline in price of a new model, necessitating fast acquisition, remanufacturing, and sale of a used phone. For example, if a major carrier stopped using a phone model, the local market for that product could be dramatically affected. In order to operate profitably, ReCellular had to ensure that the used phones were put up for sale as soon as they were acquired lest they become obsolete.

Finally, cellular airtime providers limited the number of cell phone technologies supported by their system, limiting the scope of the potential market for some used telephones.

14.3 Organizational aspects

Figure 14.1 shows the ReCellular Inc. network, including the flows of new cell phones.

The forward flow of cell phones consisted of the flows from manufacturers to retailers, and airtime providers to the users of cell phones.

The flows for reuse were more complex. ReCellular did not directly collect used cellular phones from end users. Instead it procured used cellular phones in bulk from airtime providers, third-party collectors, and a variety of other sources. In order to ensure a steady and reliable supply, ReCellular's procurement staff devoted substantial effort to identifying suppliers, establishing relationships with them, and transferring sorting and grading expertise to them. Cellular airtime providers acted as consolidators by collecting used phones from users who had returned the phones at the end of service agreements or users who had upgraded to a newer technology. Airtime providers, having received the phones, then brokered them to ReCellular in an effort to recover whatever residual value they could obtain.

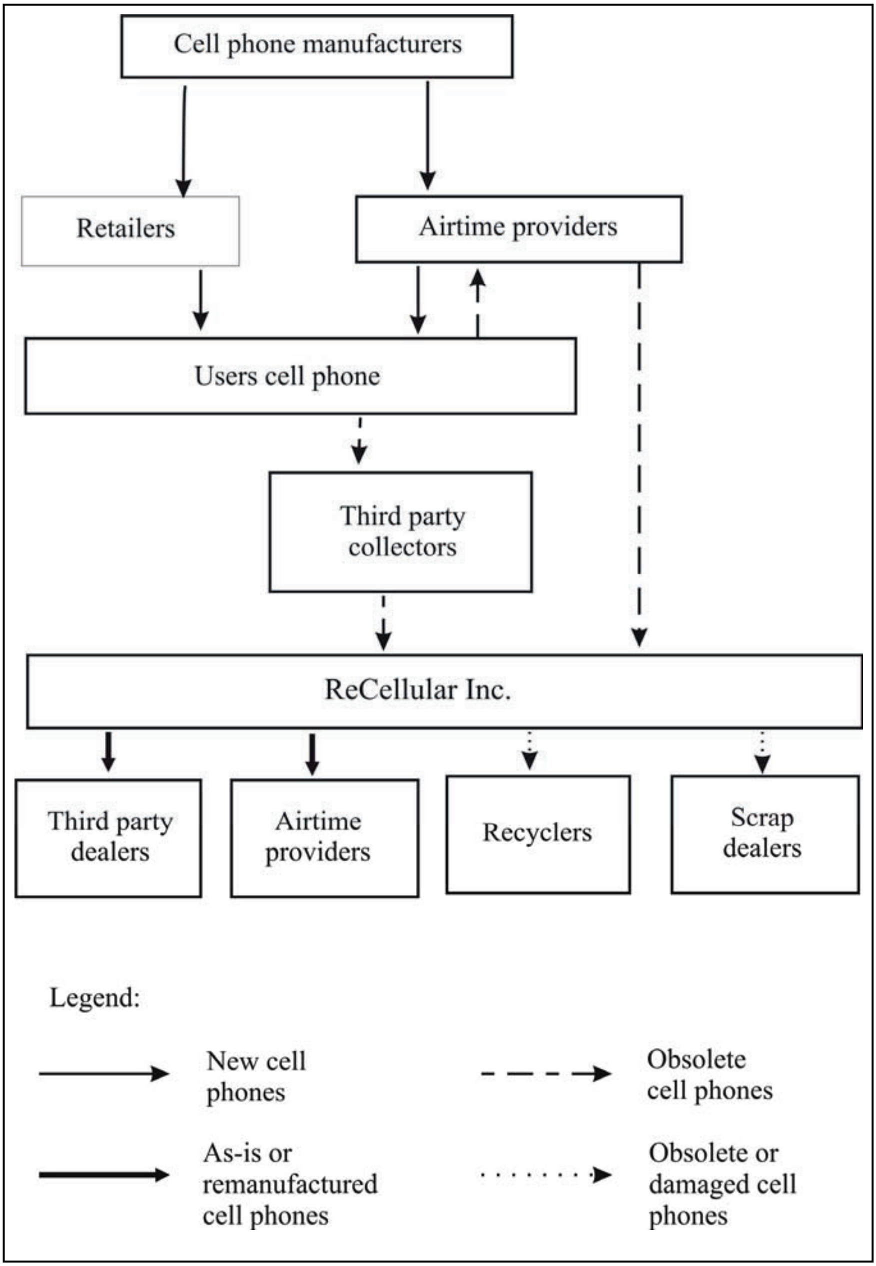

Fig. 14.1. The ReCellular Inc. network, including the flows of new cell phones

Third-party collectors were often charitable foundations, (e.g. the Wireless Foundation (http://www.wirelessfoundation.org) that played the role of a consolidator by collecting used cell phones and accessories from individuals. The Wireless Foundation, a not-for-profit organization, described the objectives of its "Donate a Phone" program as follows: "DONATE A PHONE program recycles used wireless phones to help the environment and raise funds for a variety of charities. Most phones are resold as economical alternatives to new phones. The rest are safely recycled in accordance with all applicable U.S. environmental regulations."

ReCellular then sorted and graded the cell phones by quality, and sold them as-is or remanufactured to airtime providers and third-party dealers working with airtime providers. Cell phones that were obsolete or damaged beyond higher-order recovery were sold to recyclers and scrap dealers. Recyclers recovered polymers, other materials in the cell phone assemblies, and base materials in batteries. Scrap dealers separated the cell phones into materials and resold individual parts for reuse in other applications and offered the other sorted materials to recyclers. In order to deal with the earlier mentioned technical difficulties and to leverage geographic complementarities, ReCellular operated on a global basis. For example, it could acquire phone models dropped by a carrier in one geographic market and remanufacture and sell them in another area where such phones were still supported by major carriers.

14.4 Planning and control aspects

ReCellular's prime motivation was to exploit opportunities for earning a profit from obsolete cell phones. Therefore, the key drivers of the acquisition process at ReCellular were the potential demand for a particular model of cellular phone, the quality of the phones available, and the prices that they could fetch in the refurbished products market. The demand for remanufactured cell phones and the availability of used phones were influenced by a number of factors, including: introduction of new technology (e.g. digital and analog), changes in prices of cellular airtime and cellular phones, promotional campaigns, opening of new markets, churn (i.e. users changing airtime providers), and the number of new cellular telephones manufactured. As a result, the flow volumes through the reverse supply chain were very volatile.

14.5 Environmental aspects

ReCellular was a leader in the secondary wireless industry in environmental practice and followed a policy of minimizing the impact of electronic waste on the environment. Through tighter procurement practices, it sought to reduce procuring cellular phones that needed to be scrapped and tried to recycle most of the components. Nevertheless certain components of the cellular phones such as batteries, chargers, leather casing, etc., could not be sold and therefore were scrapped. ReCellular sent such material to certified recyclers and scrap dealers who dealt with them appropriately. ReCellular's intention was to ensure that none of the scrap from its process entered either a landfill or developing countries.

14.6 Business-economic aspects

The profitability of ReCellular's operations was critically dependent on its acquisition process. The price paid for acquiring used phones was the single most important cost element in its value chain. Variability of quality levels, timing, and prices of used phones could dramatically affect ReCellular's bottom line. For example, different levels of quality of used phones required different types of testing and remanufacturing. In order to deal with this problem, ReCellular had established a fixed six-point nominal quality scale with linked prices at which it procured used phones from its suppliers. This limited the uncertainty in its supply chain in terms of the quality of incoming flows, reduced the need to sort and grade phones in-house, and minimized the number of phones scrapped. For example, in 2000, the prices of used phones for different quality grades were as given in Table 14.1 below.

Table 14.1. Quality dependent prices for some cellular phones in 2000

Make / Quality	**1**	**2**	**3**	**4**	**5**	**6**
Ericsson DH336/338	$33	$31	$29	$25	$20	$15
Nokia	$110	$105	$100	$90	$80	$60
Motorola Startac 3000	$85	$75	$65	$55	$35	$25

In addition to the acquisition prices, ReCellular also incurred logistics costs such as collection, transportation, storage, and remanufacturing costs including sorting, grading, testing, and repair costs and the cost of replacement materials. Due to the low cost of bulk air transportation of phones (it was estimated that transporting cellular phones by bulk air cost as little as $0.50 per phone), using a worldwide network of suppliers of used phones was practical and cost-efficient.

On the sales revenue side, the value of a used cell phone was dependent on future market demand for that particular model, either in remanufactured or as-is form. Although demand for a graded as-is used cellular phone or a remanufactured phone was known for that instant in time, prices were not stable due to the highly dynamic nature of the industry. The selling prices for remanufactured phones tended to drop over time much like a perishable product. In addition, there was stiff competition among remanufacturers.

14.7 Conclusions

With the supply of used cell phones volatile and prices in a constant state of flux, identifying and taking actions to reduce the uncertainties in the reverse flows as early as possible was an important issue in the cell phone remanufacturing business. ReCellular leveraged its global presence to establish a better match between the supply and demand of used phones. By the end of 2001, it had introduced e-commerce operations on its website to increase the visibility of its requirements and inventory and the velocity of product flows in its supply chain.

ReCellular managed to control some of the adverse effects of the supply uncertainty by adopting an intelligent procurement process which included active supplier development activities such as training on testing and grading procedures, a system of the grading of used phones by their quality levels, and a pricing system connected to the quality of the used phones.

15 Recovery of car engines: the Mercedes-Benz case

Hans-Martin Driesch, Hans E. van Oyen and Simme Douwe P. Flapper

15.1 Introduction

The following describes the situation in 1997. Although many changes occurred since then, these changes do not concern the issues that play a role, but how they are dealt with.

In 1997, Mercedes-Benz (MB) belonged to the Daimler-Chrysler-Corporation with headquarters in Stuttgart, Germany. MB is, among others, active in the marketing, production, distribution, and after-sales activities for cars, vans, and trucks.

MB offers the owners of an MB car, van, or truck the option of replacing their present engine with a remanufactured engine, of the same or different type, with the same quality as a new engine, but for a price 20-30% lower than the price of a similar new engine. This offer holds for at least 20 years after a new car, van, or truck has been purchased. MB offers similar options for waterpumps, crank cases, crank shafts, and other parts produced by MB itself.

In this chapter, we focus on the recovery network for engines for cars and vans, further denoted by the MB-MTR network, based on the MB-MTR plant in Berlin, Germany, where the actual remanufacturing takes place.

In 1996 MB-MTR remanufactured about 60 of the above engines a day, selling 14,250 remanufactured engines in total, about 40% of the total world-wide market for remanufactured MB engines for cars and vans.

15.2 Business drivers

There are a number of issues that play a role in MB's decision to have a network for the recovery of engines for cars and vans, almost all of them being business-economic.

The engine replacement offer allows people to use their MB for a long time against reasonable costs, making it more compelling to buy an MB car or van. Several other car manufacturers, including BMW and Volkswagen, also offer remanufactured engines and other parts as service parts.

MB cars and vans can be used for a long time. Due to this, there was and still is a lively trade in used MB engines and other parts. Moreover, not all third parties that are active in the used engine market work according to high quality standards. In the case of problems due to this, people may relate their negative experiences to the quality of MB parts which could harm the reputation of MB.

MB has to be able to provide service parts for over 20 years. This requirement can be fulfilled by maintaining production facilities for the components for all older types of engines as well as assembly facilities for these engines. Another option would be to build high enough stock of new engines and components to fulfill the requirements for service parts for so many years. It also is possible to fulfill at least part of the service requirement by remanufacturing used engines and other parts, which is often cheaper.

Finally, DaimlerChrysler expected that producers would eventually become responsible for their products at the end of their active life. MB decided to anticipate this, in order to have an advantage over competitors when such legislation became active.

15.3 Technical aspects

In order to be able to give the high-level warranty, and due to the uncertainty in the configuration i.e. which components are in a given used part, and the condition of the used engines, the latter have to be disassembled completely. This usually has to be done manually, partly due to the above uncertainties. Note that a typical engine contains several hundreds components.

There exist restrictions with respect to the technical possibilities for recovery: not all parts or components in these parts can be recovered up to the desired level and have to be replaced. There also exist restrictions on combining new and used components in remanufactured engines. Parts and components get worn out with use. Due to this, some used components or parts can only be reused together with other used parts or components. This we call the gear-chain problem: If the chain of your bike needs to be replaced, this often requires that the gear also be changed because the replaced chain and the old gear might not fit well, resulting in a non-optimal functioning of the total system.

Due to the long life-cycle of MB cars and parts such as engines, there are hundreds of different engine variants in the field. This number is rapidly increasing due to mass customization.

15.4 Organizational aspects

Figure 15.1 shows the MB-MTR network for collecting, processing and distributing used engines from cars and vans.

The starting point for the flows in the network are the owners of an MB car or van who go to an MB dealer in order to have the engine repaired. If an MB dealer (1) is not able to repair a defective MB engine or if the owner for some other reason wants to replace the present engine in her/his car by a remanufactured engine, the MB dealer can order this engine from MB's central service parts distribution center (DC) in Germersheim, Germany (4).The engine is delivered to the dealer via a regional DC (2).

Within Europe this delivery takes 24 hours. The dealer removes the present engine from the car or van, and assembles the remanufactured engine in the customer's car.

The engine that is removed from the customer's car by the dealer is collected at this dealer and transported to a regional collection center. From here, the engines are sent in full-truck loads to MB-MTR in Berlin, Germany (3).

Based on actual or forcasted demand, MB-MTR completely disassembles supplied engines. The components obtained in this way, are cleaned, tested, and, as much as required and possible, reconditioned, after which they are assembled together with new parts into reusable engines.

Parts of the actual recovery processes are outsourced to third parties (5). Parts or components that can not be reused, or that are always replaced by new, have to be ordered from outside (6).

Remanufactured engines are transported to the central service parts DC of MB in Germersheim, Germany from which new service parts are also distributed to dealer organizations all over the world. Here they are stored, waiting for a customer.

Apart from delivering remanufactured engines to this central DC, MB-MTR also supplies remanufactured engines to third parties (8). This concerns the engines or components of the engines that MB-MTR is not interested in. These third parties do not have to supply engines in order to receive remanufactured engines. Engines or components of engines that cannot or are not expected to be reused, are sold to recyclers for materials recovery (7).

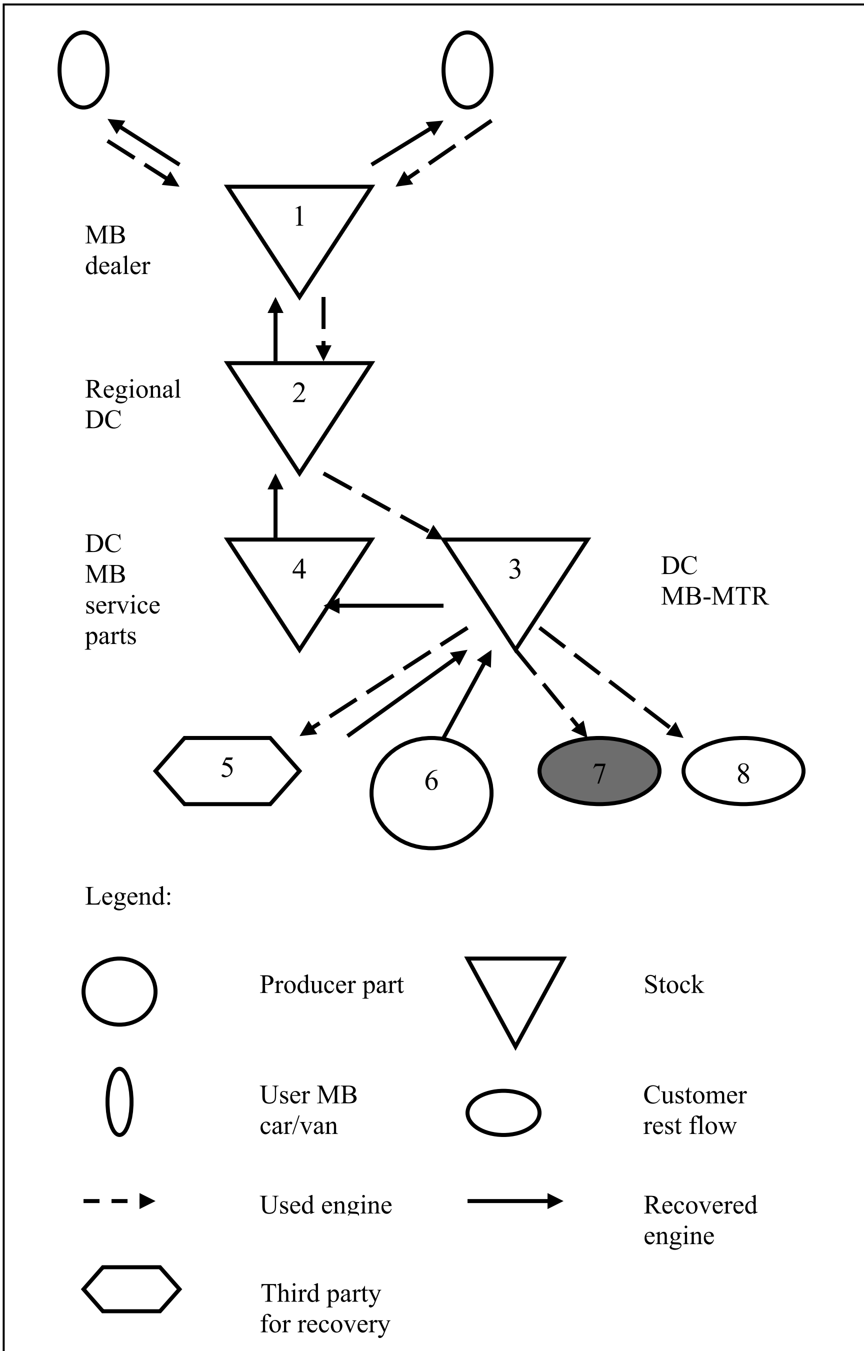

Fig. 15.1. The MB-MTR network for engine recovery

In this way, in 1996 about 99% of the received engines was reused, and about 70% of the components in these engines were reused as a component.

In order to stimulate the supply of engines, MB-MTR offers the suppliers of an engine, usually MB dealers, a relatively high price depending on the state of the engine, the demand for a certain type of engine, and the price that other parties offer for the engine. As said before, the customer has to pay for the recovered engine 70-80% of the price of a new engine, and the recovered engine has the same warranty that is given as for new engines.

15.5 Planning and control aspects

Hereafter we shall distinguish between the planning and control of the network as a whole and the planning and control of parts of this network: the collection of used engines at dealers; and the processing of collected engines within MB-MTR.

The planning and control of the network as a whole is based on the expected demand for remanufactured engines and the expected supply of used engines.

Both the time that engines are supplied and the time that remanufactured engines are demanded can hardly be influenced by MB.

Due to the relatively short delivery times for most types of engines (e.g. 24 hours inclusive transport within Europe), it is not possible to start remanufacturing activities right when a dealer orders. Consequently, it is not possible to use the engine that is supplied by a customer as the starting point for a remanufactured engine for this customer. Moreover, the customer does not always want a remanufactured engine of the same type as delivered by him/her. Thus, MB has a stock of remanufactured engines in its central service parts DC from which these engines are delivered to MB dealers.

Hereafter follows an overview of the main processes within MB-MTR as well as the most important decisions related to them.

Directly after receipt, MB-MTR inspects the used engines and allocates them to one of the limited groups of engines that MB-MTR distinguishes based on a number of components that can directly be identified. Based on the expected differences between supply and demand, MB-MTR decides which of the received engines can be immediately sold to others. The same holds for badly damaged engines. The other engines are stored for further processing.

Apart from engines that are sold immediately after receipt, all engines are completely disassembled by MB-MTR. This is due to the very high quality standards of MB, as at the moment there is no other way to determine the exact configuration and condition of the received engines.

The trigger for starting the disassembly of a number of engines of a certain type is the assembly of remanufactured engines of the same type. The actual number of engines that is disassembled, where all engines belong to the same engine group, corresponds with the above mentioned number of remanufactured engines that is assembled, multiplied by factors via which the technical reusability of the most important components of that type of engine is taken into account. Thereby it is assumed that the factor related to the worst component holds for all components in an engine.

The disassembly activities, usually done manually, are always done for a small number of engines. The components that are disassembled are not kept together but are stored separately in bins per component. From then on, it is no longer known from which engine each component is derived. Before another type of engine is disassembled, the bins with disassembled components are removed and replaced by empty bins. When necessary, tools are changed. The latter two activities explain the use of lot sizes in the context of disassembly.

The types and quantities of resources required for the disassembly activities can be forecasted well based on historical data. There is some uncertainty with respect to the duration of the disassembly process due to the uncertain composition with respect to the types and number of components and the condition of the engines.

There are a number of components that are always replaced by new components for technical or business-economic reasons. For a small number of the hundreds of components that are disassembled from one engine, it is immediately clear whether or not they can be reused. However, most components first need to be cleaned and tested before a decision about their reusability can be made. About 20% of the components from used engines do not fulfill the high standards set by MB-MTR.

The cleaning and testing activities are done in lots, taking into account the expected yield via yield factors based on past experience. The reuseable components are stored, waiting for their revision. If there are too many good copies of a component, the excess number are sold.

The required quantity of resources for cleaning and testing can be forecasted well based on historical data, but less well with respect to the moment they are required.

Certain components are always directly reconditioned after having been disassembled, cleaned, and tested. The reconditioning of all other components is started as soon as a certain number of each of these components are available for reconditioning.

There exists uncertainty with respect to the result of the reconditioning activities. In order to cope with this uncertainty, MB-MTR uses yield factors. Related to the above uncertainty, there exist uncertainties with respect to which activities are to be done and the duration of these activities. All of these uncertainties are due to yet another uncertainty, with respect to the exact state of the components that are to be reconditioned.

When forecasting the time-phased resource requirements for the different reconditioning activities, probability factors are used. The values of these factors are based on past experience.

The starting point for the assembly of engines from reconditioned and new components is the long-term forecasts from the central service parts DC. As mentioned before, it is not possible to postpone assembly till an actual order for a certain reconditioned engine arrives due to the short delivery times to dealers.

The assembly starts when all required components are available. Figure 15.2 shows the assembly list of a remanufactured engine RE, where the numbers along the connection lines denote the number of a component in the subassembly at the next higher level. For example, there are one copy of component C1 and one copy of component C2 required for producing one copy of engine RE. The dashed lines in Figure 15.2 denote an OR relation, i.e. one copy of RE may contain either one copy of component C11, or one copy of component C12. So when there are not enough reusable copies of component C11, component C11 may be replaced by component C12. However, replacing C11 by C12 may require that C211 is replaced by C212, which makes using the potential flexibility difficult.

Note that usually only AND relations occur in assembly lists, as indicated by the non-dashed lines in Figure 15.2, where all components related to eachother by the non-dashed line are required in order to have one remanufactured engine ER.

Usually, the physical stock of a component that also is obtained via recovery contains copies of this component with different engineering dates. MB-MTR uses copies with the oldest engineering date first.

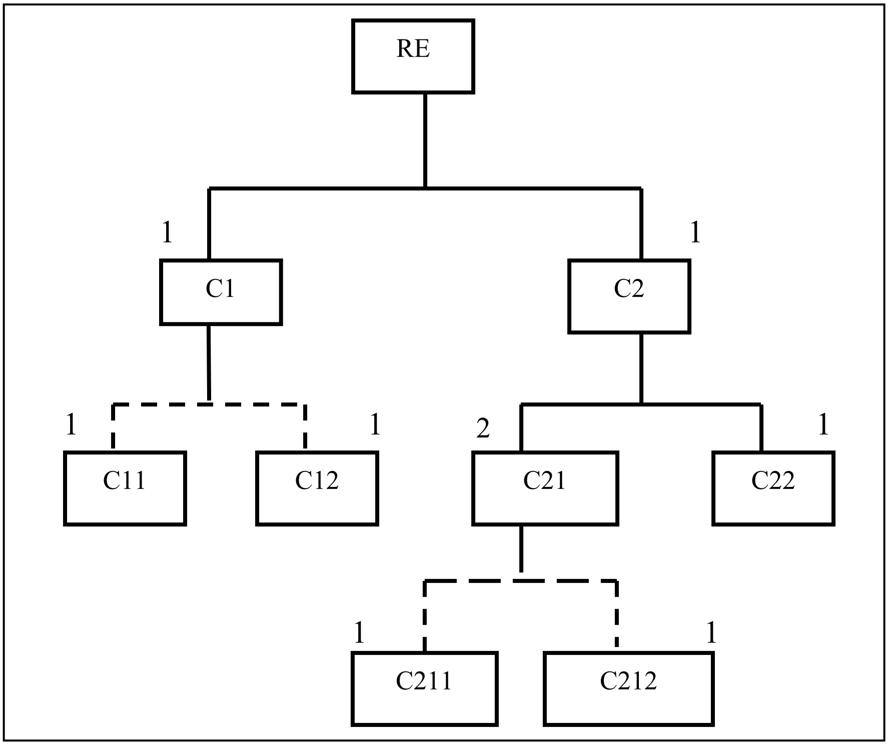

Fig. 15.2. Example of an assembly list for a remanufactured engine RE, allowing alternative components

15.6 Information aspects

All kinds of extra functionalities had to be implemented in the standard ERP package that MB used, in order to be able to

- Distinguish between copies of a part with different quality levels,
- Support maximum stocks,
- Support alternative parts (, i.e. to support OR relations, see Figure 15.2),
- Support the allocation of alternatives based on the engineering date of copies of a part,
- Support the tolerance problem (, i.e. the combining of components that have been used more or less), and

- Define standard routings, which processes can easily be activated or deactivated based on the state of what has to be recovered or based on the results of foregoing processes.

There is an increasing use of chips via which all kinds of data are collected that can be used when executing the actual processes and during the planning and control of these processes.

Moreover, via these data it becomes easier to estimate the price that should be paid to a dealer for the engine that is removed in order to be replaced by a remanufactured engine.

15.7 Environmental aspects

DaimlerChrysler pays a lot of attention to the natural environment in general. In the context of the part recovery network, special attention is paid to the environmental behavior of the customers for parts or components other than the owners of an MB car or van, such as recyclers.

15.8 Business-economic aspects

From the above, it will have become clear that all kinds of expenses and revenues play a role, including the price that is paid for engines that are replaced; the expenses for collection, storage, processing, and disposal; and the income obtained via the remanufactured engines and other parts, as well as the income by selling obsolete stocks, parts, and materials to third parties, such as recyclers. In order to encourage dealers to send the engines removed from the cars of their clients, the price that they have to pay for a remanufactured engine is inclusive of a fee which is refunded to a dealer once the removed engine is received by MB-MTR.

It is not completely clear how the sales of remanufactured engines and other parts influence the sales of new copies. The same holds with respect to whether or not offering the option results in extra sales of new cars.

15.9 Conclusions

In this chapter, insight has been given in MB's network for the recovery of engines and other parts from cars and vans, as it was in 1997. The chapter shows the consequences of the uncertainties with respect to time, quantity, and the state and configuration of the supplied engines for the functioning of the system, especially with respect to planning and control, the information system that is required, and the related business-economics aspects.

There are a number of things that put the profitability of the network under pressure. First, the prices of new engines are decreasing, making the difference in price between a new and a remanufactured engine less. Secondly, due to an increase in electronics, fewer parts can be repaired, resulting in higher disposal costs and less income from selling undesired parts.

Finally, the ever increasing number of engine variants combined with very short delivery times requires processing in small lots as well as stocks with a high risk of obsolescence, making the recovery of car engines even less attractive. Fortunately(?), there is increasing demand for the few basic elements of engines, such as long and short blocks, partly undoing the problem just mentioned.

Part 7:
End-of-life closed-loop supply chains

16 Recovering end-of-life large white goods: the Dutch initiative

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16.1 Introduction

Discarded white and brown goods make up an ever-growing waste flow. Examples of white goods are refrigerators, coolers, freezers and washing machines, whereas TVs and loudspeakers are examples of brown goods. In the Netherlands alone, yearly about 130 million kilograms of white and brown goods are discarded: 90 million kilos of large white goods, 20 million kilos of large brown goods and 20 million kilos of small consumer appliances such as hair dryers, razors and walkmans (VROM, 2002). Within the European Union (EU), the total volume of discarded consumer electronics is estimated to be 6 million tons per year (EUR_Op, 2000). Since the early nineties, the EU has been working on drafts for a directive on Waste of Electrical and Electronic Equipment (WEEE) and a directive on restricting the use of certain hazardous components within electrical equipment. The EU directive on WEEE has been ratified by the European Parliament in October 2002 and contains the following guidelines for the member states (www.itri.co.uk/WEEE2.htm, 2002):

- Producers should take the responsibility for the end-of-life phase of their products, encode new products for identification, and provide information to the processors for adequate recycling,
- Appropriate systems for the separate collection of WEEE should be put in place, where private households can return for free,
- Producers have to set up and finance appropriate systems in order to ensure accurate processing and reuse of WEEE and are responsible at the latest from the point of collection at municipalities,
- A collection target has been set of 4 kg per head of population yearly. Retailers (trade-ins) and municipalities must offer collection services. WEEE must be collected separately and pre-processed such that optimal recovery is possible,
- Depending on the product category, recovery quotas are set between 70-90% of the weight of the goods collected. Hazardous contents

must be removed and processed according to strict prescriptions. Reuse in the original supply chain is encouraged, but only for plastics targets are set: 5% of the weight of newly produced consumer electronics,

- WEEE from OEMs that do not exist anymore will be processed by collective systems,
- For future products, producers are primarily individually responsible and have to set up their own individual system or form an alliance.

Now that the directive is in force, EU member states must implement legislation on producer responsibility within 18 months. The precise formulation of legislation is left to the individual member states, which may lead to different practical implementations (Boks, 2002). Some member states, like the Netherlands and Italy, already have implemented systems based on producer responsibility; some other members, like Germany and Belgium, are on the way, and others are lagging behind or reluctant to replace well-functioning municipal systems. Outside the EU, Norway and Switzerland and some Asian countries, like South Korea, Japan, and Taiwan, adopted or are considering adopting producer responsibility.

The purpose of this chapter is to give detailed insight into the structure and the functioning of the Dutch network for collecting and processing end-of-life large white goods. The reason for focusing on the Netherlands is that the EU has decided to implement the Dutch network for collecting and processing end-of-life white and brown goods EU-wide (Anonymous, 2002). As indicated before, many different types of white and brown goods exist. This chapter will focus on large white goods, which make up more than 50% of the total weight of the total WEEE flow in the Netherlands (NVMP, 2002).

16.2 Business drivers

The main driver for the producers and importers of white and brown goods for setting up a network for end-of-life product recovery was legislation in the Netherlands forcing them to take care of their products at the end of their active life in an environmentally sound way. In this context, it is important to distinguish between freezers, coolers, refrigerators containing (H)CFC, and other large white goods, mainly laundry machines and dishwashers. The main reason for this subdivision is that it is forbidden to trade refrigerators, coolers, and freezers containing (H)CFC within the Netherlands or to export these goods from the Netherlands.

16.3 Technical aspects

The network that has been set up has to take care of products at the end of their active life. Due to this, the primary focus is on materials reuse with forced removal of certain hazardous substances like (H)CFC and parts like batteries.

The processor that makes up part of the Dutch WEEE network, realizes a recycling percentage of 95% of the weight of the disposed (H)CFC-containing white goods that are received by the processor. This percentage is much higher than the percentage of 75% required by the Dutch government and the EU directive on WEEE.

The weight recycling percentages realized by the selected processor for the (H)CFC-free large white goods is 85%, also higher than the 75% presently required by the Dutch government.

16.4 Organizational aspects

Already in 1992, the Dutch government announced that producers and importers of brown and white goods would be made responsible for their products once these products are disposed of by their last user (Langenbach, 1998). The Dutch government offered these producers and importers the possibility of coming up with a proposal with respect to how they would take care of the above responsibility. When by June 1, 1998, the different parties still had not presented a strategy, the Dutch government announced that producers and importers of white and brown goods would be legally forced to take back the products they sold on the Dutch market at the end of their active life and to take care that these products are processed in an environmentally sustainable way, such that a certain preset minimum weight percentage of these products is reused. All producers and importers of large brown and white goods were forced to fulfill the above requirement by January 1999, whereas for the producers and importers of small appliances the same requirement holds as of April 2000.

The Dutch government requires that producers and importers of large white goods indicate in advance

- How they will take care of the collection of white goods disposed of at retailers and municipalities,
- Which percentage of the collected goods will be reused,
- Which percentage will be disposed of in another environmentally friendly way,

- How they will finance their system,
- How they guarantee the take-back and processing of their products in case they would stop selling on the Dutch market, and finally
- How they will monitor the required activities.

Companies can fulfill their responsibilities by setting up a collection-processing system of their own or by setting up such a system together with other companies. Many producers and importers of white goods in the Netherlands are a member of the sector organization of suppliers of household appliances in the Netherlands (VLEHAN), whereas many producers and importers of brown goods are a member of the Dutch sector organization of producers, importers, and distributors of electronics (FIAR).

Taking into account that for both white and brown goods a system had to be set up, the fact that many producers and importers of white goods are also producing or importing brown goods, and that many retailers are selling both goods, it is not surprising that the two sector organizations mentioned above decided to set up a joint system. Although the members of these organizations may be competitors with respect to new products, they are not competitors when having to take care of the take-back and processing of their products at the end of their lives. By combining efforts, cost reductions could be realized. Good experiences had been obtained by the collective system for car wrecks collection and recycling in the Netherlands (Groenewegen and Den Hond, 1993). Moreover, by setting up a joint system, the Dutch government was willing to force all producers and importers to ask the same fee for the take-back and processing.

In the context of the above system, VLEHAN established the White Good Foundation, whereas FIAR established the Brown Good Foundation. Most producers and importers of white and brown goods who were not a member of VLEHAN or FIAR decided to join these foundations. All members together sell 80% of all white and brown goods in the Netherlands. The two foundations together established the Dutch organization for removing metal-electro products (NVMP) (Langenbach, 1999). This organization takes care of the combined collection and processing of discarded white and brown goods, where the actual collection from the user/owner is a joint responsibility of retailers and municipalities forced by law. The latter two groups are supposed to transfer collected products to the NVMP.

Initially, the system was approved for three years: 1999, 2000 and 2001. The following targets were set:

- Collection targets. In principle, all consumer products discarded in the Netherlands should be collected by the system, except for a number of products of some Original Equipment Manufacturers, (OEMs) / importers who set up their own system for these products,
- Recycling targets. The system only deals with material recycling. For white goods, a minimum of 75% material recycling, based on weight, must be realized.

The realization of the above targets is supported by bans on landfilling and bans on trading (H)CFC-containing products such as freezers and refrigerators.

Figure 16.1 shows the overall structure of the collection-processing network for WEEE goods in the Netherlands, where the bold printed box and lines represent the part for which the producers/importers and hence NVMP is responsible and pays.

The network consists of a collection part - the retailers, municipalities and Regional Transhipment Stations (RTSs) - and a processing part, consisting of processors, connected to each other via transport taken care of by carriers. It is a combined bring-pick-up system. Hereafter, the main parties, their responsibilities, and their rewards are discussed.

The owners of large white goods form the starting point of the collection-processing network. These owners can be households, individuals as well as companies and organizations. The owners determine whether, when, and where a product enters the network. In the Netherlands, there are several possibilities for large-white-goods owners to discard such products.

When buying a new product, an owner can ask the retailer to take back the product that is replaced. The retailer is legally forced to do this for free. Especially for the larger products like washing machines and dishwashers, the retailer usually collects the old product when delivering the new one. An owner can also deliver white goods for free to a municipality depot or an RTS, e.g. in case the owner does not buy a new white good. Some municipalities offer to collect end-of-life white goods at the owner for which the latter normally has to pay. Apart from the above options, owners can also sell or give away for free their end-of-life (H)CFC-free white goods to third parties not related to the network.

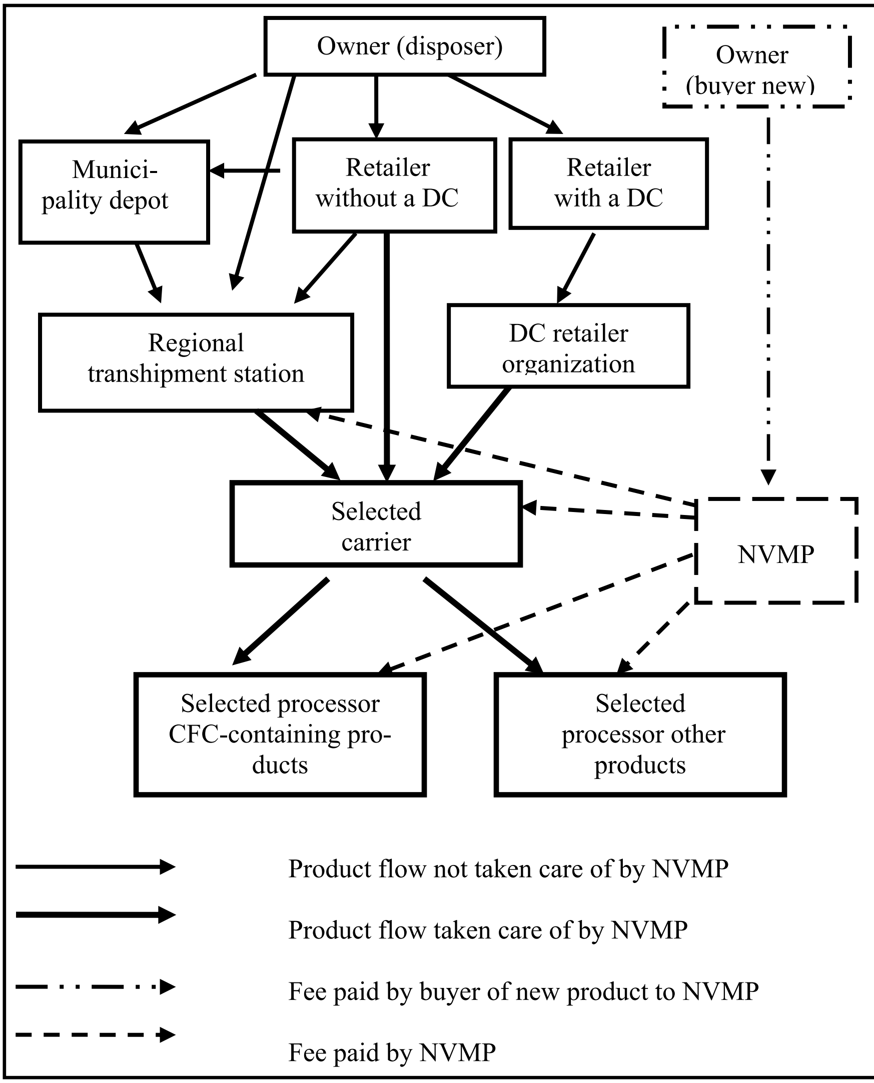

Fig. 16.1. Structure of the Dutch network for collecting and processing of end-of-life large white goods

Note that owners, apart from being a supplier, play another important role in the functioning of the network: as a buyer of (parts of) end-of-life white goods or as a buyer of products partly containing recycled materials from disposed large white goods.

Before producers and importers were forced to take care of their products at the end of their lives, it was possible to dispose of white goods at the *municipality depots* for a certain fee. The more than 400 municipalities were responsible for the further processing of these discarded white goods. The fees received were sufficient to cover the costs related to the above.

Since the actual start of the WEEE network in January 1999, owners do not have to pay for the disposal of their white goods at the municipality depots. Due to this, combined with the ban on selling or exporting (H)CFC-containing refrigerators, coolers and freezers, the flow of end-of-life white goods to the municipality depots has increased considerably. Only if this causes a lack of space at a municipality depot, the depot can refuse the white goods supplied by retailers.

The municipalities collect, handle, and store large white goods and regularly bring them to an RTS. However, the municipalities do not get paid for these activities.

There are 62 *Regional Transhipment Stations* (RTSs) in the Netherlands, founded and managed by the Dutch Association for Waste and Cleaning Management (NVRD). The RTSs are located such that each retailer is located within 20 km distance from an RTS. Sometimes an RTS coincides with a municipality depot. Every municipality depot belongs to one RTS, whereas one RTS can be related to several municipality depots.

At the RTSs, the end-of-life white goods supplied by retailers, municipalities, and owners are sorted and stored in containers. From the RTSs, full containers are transported to one of the two processors selected by NVMP by one of the third party logistics service providers selected by NVMP. In order to have full containers collected, the RTSs have to contact NVMP. The selected third party logistics service provider replaces full containers with empty ones. For their activities, the RTSs receive a partial reimbursement from NVMP.

Since January 1999, *retailers* are legally forced to accept for free end-of-life goods from owners/disposers buying similar new goods. In the case of large white goods, which need installation at the customer's home, the retailer collects the old product upon delivery of the new one.

In the Netherlands, there are about 2,500 retail outlets where new large white goods are sold. Many of these outlets, about 1,500, belong to one of the 15 retail chains in the Netherlands. Each of these chains operates one or more distribution centers (DCs) for stock keeping and distribution to the stores.

If a retailer is a member of a retail chain, in most cases the disposed goods collected by the retailer are picked up by the chain and brought to one of the DCs of this organization, where they are sorted and temporarily stored, see also (De Koster et al., 2002). One of the two selected third party logistics service providers collects full containers ("bulk transport") with discarded white goods at these DCs and brings these containers to the predetermined processor.

About 1,000 outlets belonging to independent retailers are joined in purchasing organizations, which procure the products that associated retailers sell, assist in the design of shops, and take care of advertising. Independent retailers usually do not have much space for storing end-of-life white goods. In the case that a retailer is not a member of a retail chain, (s)he has to bring these goods to a municipality depot or an RTS. These retailers can also contact the NVMP organization to have the collected end-of-life white goods picked up by one of the two selected third party logistics service providers responsible for the "fine collection". This pick-up takes place within 48 hours after the retailer has contacted NVMP. This option only holds when a certain minimum quantity is available for transport. By the end of 2000, this minimum quantity was 8 units. Retailers can also bring end-of-life white goods to an RTS themselves. It turns out that relatively few retailers use this option.

To summarize: retailers collect, handle, and store discarded large white goods and have to take care of their transport to an RTS or a DC of the retail organization of which they are a member.

Until June 2001, both retail organizations and independent retailers did not get paid for their contribution to the Dutch WEEE network. Since then, they have received some money for this.

Via a public tender, two carriers/*logistics service providers* (LSPs), Vonk and Hoogers, were selected by NVMP to take care of the transport of end-of-life white goods from independent retailers, retailer group DCs and RTSs to the two selected processors. Hoogers is responsible for the bulk transport to the selected processors, whereas both Hoogers and Vonk take care of the fine collection, but for different parts of the Netherlands. Both LSPs bring the goods obtained via fine collection to their depot, where they temporarily store the collected white goods in containers till full container loads are formed. Hereafter the containers are further transported by Hoogers to one of the two selected processors. Both LSPs are paid by NVMP.

Via a public tender, two *processors*, CoolRec and HKS Metals, have been selected for the processing of large white goods, CoolRec takes care of coolers, freezers, and refrigerators and HKS Metals takes care of all other large white goods. The main activities of the processors are the removal of harmful substances, the disassembly and separation of parts and materials, and the sale of the disassembled parts and materials to specialized processors. On behalf of the producers and importers, the processors have to realize a recycling percentage of 75% of the total weight of the collected discarded large white goods for reuse as a material. Both processors are paid by NVMP.

16.5 Planning and control aspects

With respect to planning and control, at least two levels have to be distinguished: the level of the network as a whole and the level of the individual parties involved in the network.

Essentially, the network as a whole is a push network: the inputs are delivered more or less autonomously with respect to time and quantity. There is no planning and control at this level, apart from planning the required resources for timely executing the different collection and processing activities. The transport between the different parties is planned by the carriers based on the agreements with respect to the minimum or maximum quantities that may be collected during a visit and the response time for pickup requests. The individual processors plan the further processing.

16.6 Information aspects

In order to run the network, track must be kept at the following data:

- When and which quantities of what are transferred to NVMP by the different collectors,
- When and which quantities of what are transported from where to where by the two selected third party logistics service providers,
- When and which quantities of what are processed by the processors. Which quantities are sold to whom and actually disposed.

All this information is primarily used for paying the selected carriers and processors for what they do for the network and for getting insight into the different flows delivered by the different parties. Apart from the above, data is required concerning the disposal fees paid by the buyers of new products and data for the actual planning of the collection and processing by the selected carriers and processors.

16.7 Environmental aspects

As indicated in section 16.3, from the products that are received by the two selected processors, a very high weight percentage can be reused as material.

16.8 Business-economic aspects

The activities taken care of by NVMP, see Figure 16.1, are paid via a fee that buyers of new white goods have to pay at the moment of purchase. The reason for charging a disposal fee on new products instead of discarded products is to avoid owners illegally dumping the products that they want to discard. Table 16.1 shows the fees that had to be paid initially for different types of white goods.

Table 16.1. Initial disposal fees on large white goods (NVMP, 2002)

Product	**Disposal fee**
Refrigerator, cooler, or freezer	€18
Other large white goods	€9

The other sources of income, as well as the expenses related to the network, have been discussed before in section 16.4.

16.9 Functioning of the network

Table 16.2 shows the numbers of (H)CFC-containing and (H)CFC-free large white goods that were expected to be disposed of via the NVMP network, and the numbers that have actually been disposed of via the NVMP network during 1999, 2000 and 2001.

Table 16.2. Expected and actual flows of large white goods to the processors in the NVMP network (NVMP, 2002)

Year	Expected number of discarded refrigerators, coolers, and freezers	Actual number of discarded refrigerators, coolers, and freezers	Expected number of discarded other large white goods	Actual number of discarded other large white goods
1999	460,000	460,000	640,000	136,000
2000	550,000	575,000	770,000	285,000
2001	630,000	609,000	910,000	345,000

In 1999, a total of 596,000 large white goods, notably refrigerators, coolers, and freezers, were received and recycled by the NVMP network. In

2000 and 2001, we see a steady increase in the number of (H)CFC-containing large white goods, close to the forecasted number. For (H)CFC-free large white goods, the actual numbers are still much lower than expected. There are a number of possible explanations for this difference, including incorrect forecasts for the discarded quantities and system leaks.

Forecasts are based on past sales data as well as on estimates for the expected period of use, which on the one hand should take into account purely technical aspects and on the other hand macro- and micro-economic aspects like the general economic situation, costs for replacements of parts, costs for energy, water during use, etc., see also (Boks, 2002), pp. 103-110.

Based on our interviews, system leaks seem to be a plausible major reason. There is insufficient incentive for the initial collecting parties, retailers, municipalities, and RTSs to transfer collected goods to the NVMP processors due to no or little financial compensation for their activities. For (H)CFC-containing white goods, a trade ban prohibits that flows leave the network before being processed. But for the (H)CFC-free large white goods no bans exist and a certain percentage of these products leave the system after having been collected by the retailers and municipalities. There are many companies, including brokers and processors not involved in the network, willing to collect these white goods for free or even pay for the discarded white goods, because, among other reasons, they would otherwise lose some of their supply sources. The problem is that these companies may remove the materials, parts for which they can get money, and dump the rest. So the above leak flows are good for NVMP and the collecting parties from an economic point of view, but from an environmental point of view this is unclear, since it is not known to where the products are going and what happens to non-profitable material fractions.

As a result, the actual number of (H)CFC-free white goods transferred to and processed under the control of NVMP differs from the expected number.

The above was one of the reasons that in 2001 it was decided to pay 10% of the disposal fee to the partners involved in the initial collection (retailers, municipality depots and RTSs) to cover at least part of their cost. Comparing this with the costs made by the above partners makes clear that this should provide an incentive for some of the above parties not to sell collected (H)CFC-free large white goods. But taking into account the costs for the different collectors, especially the large differences in costs for the different collectors and the prices that parties outside the NVMP network are willing to pay for some collected large white goods, this may not be enough. We can see a slight improvement in the collection rates for the (H)CFC-free large white goods in 2001. However, it seems that for

(H)CFC-free large white goods a full trade ban might also be necessary to realize the goals set for the NVMP network.

Economies of scale are essential for keeping the costs for the network and thereby the disposal fee, low. The processing of (H)CFC-containing products requires investments in specialized equipment.

For each main activity for which NVMP is responsible, only one partner has been contracted for a number of years. During these years, these partners become experienced, making them the ideal partners beyond this period. Working with a small number of processors and LSPs for a longer period of time may be beneficial from an efficiency point of view, but it increases the risk of monopolization which may result in rising costs for NVMP in the future. According to the website of NVMP (NVMP, 2002), contracts with the present processors were extended because "there are no other processors available that can meet NVMP's high demands."

The system presently in use in the Netherlands is not stimulating producers of large white goods to put effort into designing products that can be disassembled easily or that do not contain many different materials, a point also raised by Dillon (1994). This shortcoming might be overcome by relating the disposal fee to be paid to the above-mentioned characteristics of products. A number of studies have started to explore these possibilities. In this context, the NVMP initiated the Design For Recycling award for OEMs in 2001. As discussed in the introduction, the EU has explicitly addressed this issue in the final version of the EU directive.

The income of NVMP resulting from the disposal fees mentioned in Table 16.1 outweighed the reimbursements paid by NVMP to the processors and carrriers. This was due to the gap between the number of new products sold and the number of products collected by the NVMP network, leaks to parties not related to NVMP, and because part of the collection costs did not have to be covered by the fee. In response to these findings, in July 2001 the disposal fee per unit was lowered to €17 for (H)CFC-containing products and €5 for (H)CFC-free large white goods respectively.

16.10 Conclusions

In this chapter, attention was paid to the Dutch nationwide network for the collection and processing of discarded white and brown goods. The focus was on large white goods, which represent in weight over 50% of the total flow of discarded consumer electronics products. The network clearly has its merits, but also some drawbacks were indicated.

It enhances economies of scale, is clear to the buyers/owners of the products as well as the other partners, and it is relatively easy to control by the authorities. Since fees are charged on new products, and collection is free for owners and compulsory for retailers and municipalities, owners are stimulated to return their end-of-life goods to the proper channels. Because the network has been built on existing infrastructures, it could be implemented relatively quickly. Since national legislation on producer responsibility for various EU member states is quite different at an operational level, see e.g. (Boks, 2002), it might be convenient to OEMs/importers to have collective national networks instead of individual international networks.

On the other hand, the Dutch WEEE network appears to have some major flaws. Not every party receives a fair share of the disposal fee, resulting in network leaks. There is a risk for a monopoly position for third party logistics service providers and processors once they are selected for the network, which may result in higher costs in the long run. There are no incentives for OEMs to design for recycling. To some extent, these flaws can be seen as start-up problems and in fact NVMP has made efforts to cope with these flaws. The future will tell whether the measures taken prove to be successful or whether innovations are necessary.

In December 2001, it was decided to continue the network in 2003 and 2004 with the same partners.

Acknowledgements

The authors wish to thank the organizations and companies interviewed in the context of this chapter for their cooperation.

17 End-of-life tire recovery: the Thessaloniki initiative

Sophia Panagiotidou and George Tagaras

17.1 Introduction

The necessity for effective management of the vast volumes of used car tires worldwide has led to the development and utilization of several methods for recovering some of the added value in those products, reducing at the same time the negative environmental effects of uncontrollable disposal or landfilling. Such methods include energy recovery, recycling, retreading, and direct reuse in secondary markets or applications. However, according to the European Tire Recycling Association (ETRA), an unfortunately large percentage of the total used tires, estimated at 40-50% in the European Union, is still landfilled.

Greece is one of the EU member states that have made little progress in used tires management. It is estimated that approximately 50,000-60,000 tons of used tires are accumulated each year and more than 80% of those tires are discarded, either controllably or even uncontrollably. This case study describes an initiative by the Association of Local Authorities of the Greater Thessaloniki area that aims at reducing landfilling and promoting other, more environmentally friendly uses for car tires at the end of their lives.

The pilot program for used tires collection

The greater Thessaloniki area, in the North of Greece, has a population of about 1,000,000 and substantial economic and industrial activity. Administratively, it belongs to the region of Kentriki Makedonia (Central Macedonia) and, at a lower level, to the Prefecture of Thessaloniki. At a third level, the area is divided into 21 municipalities, the largest of which is the Municipality of Thessaloniki.

The Association of Local Authorities of Greater Thessaloniki (ALAGT for brevity) is a public environmental protection and development agency, established in 1971 and having as members the 21 municipalities of the Prefecture of Thessaloniki. It is responsible for the management of the main landfill site of the prefecture (which receives about 440,000 tons of waste per year), the restoration of old sites, and the planning and construction of new landfills, as well as for the application of recycling programs and for promoting public awareness about the environment and its protection. In particular, since 1988 ALAGT has been running recycling programs aiming at the recovery of paper, glass, and aluminum. It is estimated that it currently collects about 5,000 tons of paper per year and much lower quantities of glass and aluminum cans. It must be noted that ALAGT is not responsible for the collection of urban waste; this is the responsibility of the municipalities. ALAGT has 135 employees and is funded by the Greek government and the Cohesion Fund of the European Commission.

In 1998, ALAGT considered including rubber from used tires in its target materials for recovery. It is estimated that approximately 6,000 tons of used tires are produced each year in the greater Thessaloniki area. In 1998, about 80% of those tires were landfilled, while the remaining 20% went to retreading. At that time, a total of 179 tire retailers and 6 retreading companies operated in the Thessaloniki area.

The flow of used tires differentiates between passenger car tires and truck or bus tires. In the case of passenger car tires, retreading is not an option; the end-user either leaves the used tires at the retailer after replacement or, rather rarely, may discard them on his/her own. In the case of truck/bus tires, when there is a need to replace the tires, the end-user (driver, company) may either address the truck tire retailers or the retreading companies directly. Provided the end-user wishes so and the condition of used tires permits, the tires are retreaded and returned to their owner. Otherwise, the end-user can buy another set of tires, retreaded or new, while his own used tires are left at the retailer and can either be retreaded and resold or considered "useless" and discarded.

In an effort to reduce the proportion of used tires ending up at landfills, ALAGT decided to undertake a pilot program for collecting used tires from tire retailers and retreading companies, with the purpose of using them in a more environmentally conscious way. More specifically, ALAGT informed the tire retailers and the retreading companies that they would be able to dispose of their useless tires free of charge, by loading them onto an ALAGT truck that would circulate to collect the tires upon request. Thus, these companies could forego the cost of discarding the useless tires themselves. At the same time, ALAGT would supply the tires to companies that would use them for energy recovery. The original plan was to use the tires as fuel in the cement kilns of two major Greek cement companies.

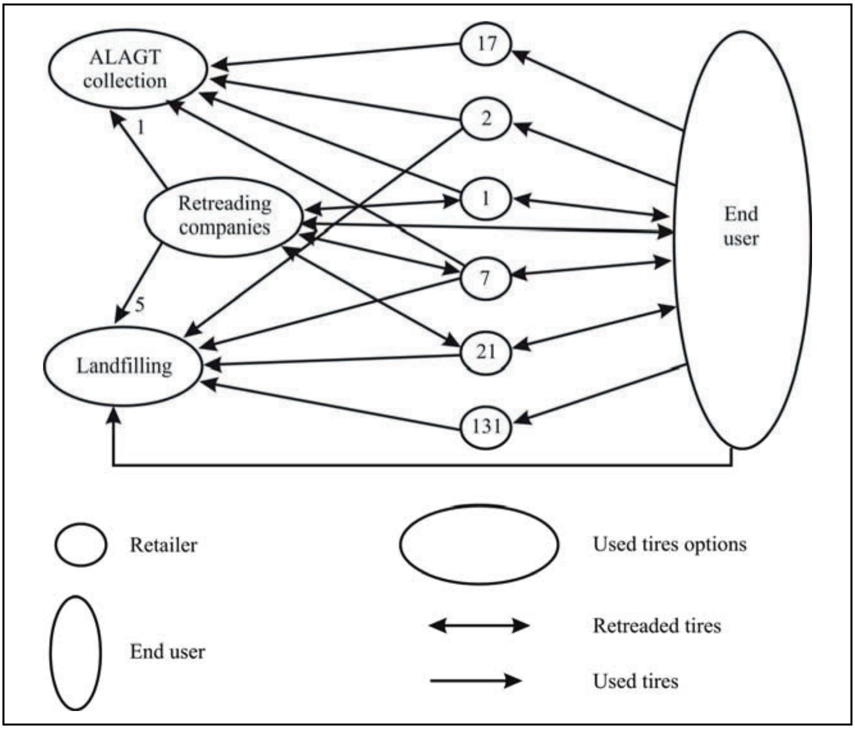

Fig. 17.1. The overall network of used tires flows in Thessaloniki

The program was initiated in December 1998 and the information presented here was collected during the period from April 1999 to January 2000. Figure 17.1 shows the overall Thessaloniki network and the directions of flows of used tires as of December 1999. The tire retailers (circles) are separated in categories depending on the type of flows they are involved in, with the numbers inside the circles indicating how many retailers belonged to each category. For example, 17 retailers participated fully in the program, giving all their useless tires to the collecting truck. At the other end, 131 retailers did not participate at all and continued to landfill all the used tires.

An overview of the situation at the end of the year 1999 indicated that only 27 of the 179 tire retailers and 1 of the 6 retreading companies were participating in the pilot program. Seven additional shops initially took part in the program but they soon discontinued their participation for several reasons that are discussed in the following paragraphs. The majority of the participating retailers were exclusively passenger car tire retailers; the difficulties posed by loading and unloading the big, heavy truck tires prevented most truck tire retailers and retreading companies from participating in the program.

The amount of tires collected by ALAGT during the period April 1999 – December 1999, around 400 tons, represents approximately 13% of the total volume of used tires produced in the same period. The percentage of retreaded tires remained almost constant at around 20% during the same period and the percentage of tires landfilled dropped from 80% to about 67%. In what follows, we provide a more detailed discussion of the business drivers, technical and organizational aspects, planning and control aspects and information, environmental and business-economic aspects of this case as they were perceived in the beginning of the year 2000.

17.2 Business drivers

The primary driver for the collection of used tires on the part of ALAGT was the realization of the negative environmental consequences of uncontrollable disposal and landfilling. Tires, as waste, take up considerable space in landfilling sites and if disposed of in large volumes may lead to fires and toxic emissions. Although there is currently no relevant legislation in Greece, it is increasingly understood that the state must take measures to prevent further degradation of the environment. Thus, the initiative of ALAGT was received very positively by the environmentally conscious citizens of Thessaloniki.

17.3 Technical aspects

From a technical point of view, used tires, if not landfilled, can in principle be used in four alternative ways: direct reuse, retreading, recycling, and energy recovery. These options are now described briefly and discussed from the point of view of ALAGT.

Direct reuse

At the end of their useful life, tires may be resold in secondary markets (typically in developing countries) or may be directly put to a variety of secondary uses, including noise barriers on motorways and construction of artificial reefs. As such activities and applications are not widespread in Greece, ALAGT did not consider direct reuse a viable option for the collected tires.

Retreading

When the condition of a used tire is relatively good, retreading can be applied, usually more than once. Retreading is the only method that reuses tires for their original purpose. Most of the tire's value is recovered, which means that retreading results in considerable energy and materials savings. Moreover, the quality of retreaded tires is comparable to that of new ones while their price is much more attractive; the price of a retreaded truck tire is about 40% lower than the price of a new one. However, retreading in Greece is limited to truck and bus tires, because the passenger car owners have the impression that retreaded tires are of significantly lower quality.

The retreading business is economically profitable, as the successful operation of the 6 retreading companies proves. Since ALAGT has no intention of competing with the private sector in this field, the collected tires should follow one of the following two alternative routes.

Recycling

Tire recycling means material recovery in the form of shredded tires or granulate. The tire granulate is produced either by mechanically grinding whole tires or by cooling fragments of tires using liquid nitrogen. There are hundreds of products and applications for tire granulate, such as in road paving, sports fields, roofing materials, footwear, automobile parts, etc. The tires collected by ALAGT could be recycled, provided that a tire recycling plant operated in the vicinity. However, since that was not the case, recycling was not considered an implementable option.

Energy recovery

Energy may be recovered from used tires through various forms of incineration. The main forms of energy reclaim are electricity generation by incineration, direct use as fuel in cement kilns, and pyrolysis (thermal degradation in the absence of oxygen). Tires have a high energy content compared to other types of solid waste and fossil fuel, while their size and shape make them easy to handle.

ALAGT considered the direct use of the collected tires in the cement kilns of major cement plants located not too far from Thessaloniki as the preferred option for the utilization of the tires.

17.4 Organizational aspects

The different partners involved in the pilot collection program were:

End-users

The owners of passenger cars address the tire retailers in order to replace their tires. The new tires are usually installed on the spot and the tire retailer retains the used ones. The case where the car owner buys the new tires and installs them on his/her own is a rather infrequent one and results in uncontrollable disposal of the used tires.

The truck/bus owners, on the other hand, address either a tire retailer or a retreading company to replace or retread the tires and they never discard the used tires themselves.

In all cases, the used and non-retreadable tires are useless to their owners and consequently the end-users have no reason to prevent the tires' further utilization.

Tire retailers

The tire retailers are of primary importance for the collection program because of their key role in the network. They are the ones that collect most of the useless tires and consequently should be the ones convinced about the advantages of participating in the program. By having the useless tires collected on site at no charge they can experience significant savings in transportation costs. On the other hand, if the tires are not collected on a regular basis they occupy valuable storage space. As a matter of fact, when the retailers participating in the program were faced with storage problems due to long inter-arrival times of the collection truck, they were obliged to discard the tires on their own to free up their storage space.

Retreading companies

Although the retreading companies handle a relatively small volume of tires, they are profitable. Their installed capacity suffices to handle larger quantities of truck tires and even to move into retreading passenger car tires.

An important activity of the retreading companies is the sorting of used tires to determine whether their condition is good enough to allow retreading. These companies end up with large quantities of waste truck tires, which are the most difficult to manage (store and transport) due to their size. In addition, the fact that the companies in question are usually situated outside of the city makes participation in the recycling program even more difficult (only one of them actually participated in the program).

Association of local authorities of greater Thessaloniki

The Association of Local Authorities of the Greater Thessaloniki area was the leader, initiator, and managing agent of the pilot program for the collection, storage, and subsequent utilization of end-of-life tires. ALAGT has a certain experience with recycling of paper, glass, and aluminum cans. However, the collection of those materials differs substantially from the collection of used tires, as the former is carried out mainly through special bins where the users deposit the respective materials. In addition, the resources that the association could allocate to the tire recovery program were limited, resulting often in late response to the collection requests of the tire retailers.

Customers for useless tires

The most likely customer for the tires collected by ALAGT is the cement industry, which could use the tires directly as fuel in the cement kilns. Two major cement companies have already expressed an interest in the program. There are no technological drawbacks in the use of waste tires as fuel but the technical experts of the cement plants claim that the existing kilns are not suitable for the incineration of used tires. Thus, the cement plants have to construct new kilns and the management of the cement companies argues that the construction cost of these specially designed kilns should be subsidized by the state, as is the practice in many countries. In addition, the proper operation of these kilns requires a steady flow of a sufficient volume of used tires that has to be guaranteed by ALAGT (if constructed, the kilns can absorb all the used tires of the greater Thessaloniki area).

Another important problem to be settled is the cost of transporting the tires to the plants. Since two of the candidate plants are located more than 200 kilometers away from Thessaloniki, the transportation cost is not negligible.

17.5 Planning and control aspects

The collection process

ALAGT allocated a single truck and three employees to the collection process. The employees have the truck under their full command and are responsible for loading, transporting, and unloading the tires at the storage area.

The overall procedure is as follows: retailers that participate in the program contact the collection team by phone, informing them that a quantity of used tires is available for collection. The time period between successive collections from a retailer varies between one week and two months, depending on the size of each retailer's shop. The transportation itinerary is set by the collection team. The main criterion in preparing the schedule is the minimization of transportation costs, while ensuring that priority is given to the retailers that placed the earliest requests. However, scheduling is done empirically, without using any formal mathematical models.

In practice, the limited capacity of the collection truck resulted in substantial delays and disputes with the retailers. In cases of significant delays and the accumulation of large volumes of tires taking up all the available storage space, the retailers had to discard the tires on their own, without waiting for the next visit of the collection truck. A survey conducted by the case writers revealed that the long delays (up to two weeks from the day of the phone call) and the limited capacity of the collection truck were the main impediments to the broader participation of the tire retailers in the pilot program. As a matter of fact,

- Only 15 of the 35 retailers or retreading companies that participated in the program stated that they were fully satisfied,
- 12 shop owners complained about the delays, and
- 14 of the 35 retailers complained about the fact that only part and not all of their useless tires were collected most of the time.

In the context of the same survey, a questionnaire was addressed to a random sample of 30 of the 150 retailers or retreading companies that never participated in the program. The reasons cited for not participating were:

- The shop owners never took the initiative to contact ALAGT (16 responses),
- The shop owners did not even know about the program (9 responses), and

- The shop owners contacted ALAGT but there was no response on the part of the collection team (5 responses), mainly because their location was considered inconvenient.

Storage and delivery to customers

The collected tires are stored in a public storage area close to the main landfill site of the prefecture. By the beginning of the year 2000, about 400 tons of used tires had already been accumulated in the storage area. No tires had yet been delivered to the potential customers, as the negotiations with the cement companies were still under-way.

17.6 Information aspects

In the management of used tires, the most important information aspect is the condition of the tire and its retreading history (whether and how many times the tire has already been retreaded), which determine its suitability for retreading. This information is typically kept by the owners of trucks and buses.

As far as the collection program is concerned, the collection team keeps records of the retailers that have contacted the team to arrange for tire removal. Other relevant information that could be useful in planning, such as actual itineraries and volume by retailer, was not kept or processed in a systematic way.

17.7 Environemntal aspects

The management of used tires in a way that eliminates or at least minimizes the quantities landfilled has obvious benefits for the environment. First of all, it reduces the amount of a type of waste that is difficult to handle, extremely flammable, and capable of releasing various hazardous substances into the environment when it disintegrates. In addition, the systematic and organized collection of used tires by an agency such as ALAGT, simultaneously serving multiple retailers, exhibits economies of scale and consequently reduces the environmental cost due to the transportation of the used tires.

If the collected tires are used by the cement industry as fuel, experience shows that there is either no change in the concentration of the pollutants produced or even a decrease in some of them, provided of course that the guidelines for replacing only 10 to 30% of the fuel normally used are strictly followed. An additional side benefit is that no residual ash is produced from the process. Thus, from an environmental point of view, using waste tires as fuel in the cement industry is highly recommended, especially in cases of short distances between the tire storage area and the cement plant.

17.8 Business-economic aspects

The costs and benefits to the participating tire retailers have already been mentioned in previous paragraphs. This section presents the economic aspects of the program from the point of view of ALAGT. The main cost drivers are related to the collection and transportation activities, while the storage cost is rather negligible.

Costs of initial collection and transportation

The direct marginal cost of the initial collection of the used tires from the retailers and their transportation to the storage area includes the salaries of the three employees and the operational cost of the collection truck (gas and maintenance). During the first six-month period of the pilot program, this cost has been calculated at 88€/ton. However it was estimated that this cost would be reduced with the gradual expansion of the program and the acquisition and utilization of a second truck specially equipped for loading and unloading the tires, to the point that the direct marginal cost could eventually become as low as 47€/ton.

Storage costs

The cost of storing the collected tires is not considered significant, as the storage area is owned by ALAGT, it is used free of charge, and would not be utilized otherwise. However, the future availability and capacity of that storage area was questionable, because it is close to the landfill site, which would need to be extended sooner or later.

Costs of transportation to the customers

The extra transportation cost from the storage area to the cement plants that will use the waste tires is estimated at around 20€/ton on average, with the exact figures depending very much on the actual distance of each plant from the storage area. At that time it was unclear whether this cost would be undertaken by the plants, either in part or in its totality. It was agreed, however, that plant personnel would be responsible for unloading the truck at the plant.

17.9 Conclusions

Although the effort to collect waste tires and use them for energy recovery constituted an important initiative for the improvement of the present situation regarding used tires management in Greece, it unfortunately encountered major difficulties in its implementation right from the beginning.

One important problem was the complete lack of external sources of funding for the financial support of the collection process. ALAGT had to rely exclusively on its limited resources and thus could only allocate a single truck with one driver and two workers to the program. This has caused significant problems regarding the cooperation with the few tire retailers that decided to participate, to the extent that 20% of them (7 out of 35) decided to terminate their participation.

However, the most serious obstacle to the successful continuation of the program was the failure to negotiate a mutually acceptable agreement with the cement companies regarding the coverage of the construction cost of new kilns and the transportation cost from the tire storage area to the cement plants. In fact, the main issue of subsidizing the cost of new kilns was outside the responsibility of ALAGT; it is more a matter of negotiations and agreement between the cement companies and the state (Ministry of Development and/or Ministry of Environment, Planning, and Public Works).

The end result of the above difficulties is that the pilot program was brought to a halt in the first few months of the year 2000, less than a year after its launch. The collection of used tires was discontinued and the quantities already collected, namely around 500 tons of tires, remained in the storage area, waiting for a customer.

ALAGT is currently investigating alternative financial resources or solutions that would render the resumption of the program economically viable. One of the measures that it has been proposed to the Greek government is to impose a fee on the tire manufacturer or on the end-user (the passenger car, bus or truck owner), in order to help finance tire recycling procedures following the completion of the product life cycle.

Part 8:
Conclusions on closed-loop supply chains

18 Future developments in managing closed-loop supply chains

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18.1 Introduction

This final chapter allows us to look ahead a number of years and to speculate about likely future developments. Our predictions are based on insights obtained from close collaboration with companies and organizations mentioned in this book as well as with many others. They also incorporate findings from our more theoretical research and views expressed in the literature. Our starting point will be the frameworks presented in chapter 1.

18.2 Business drivers

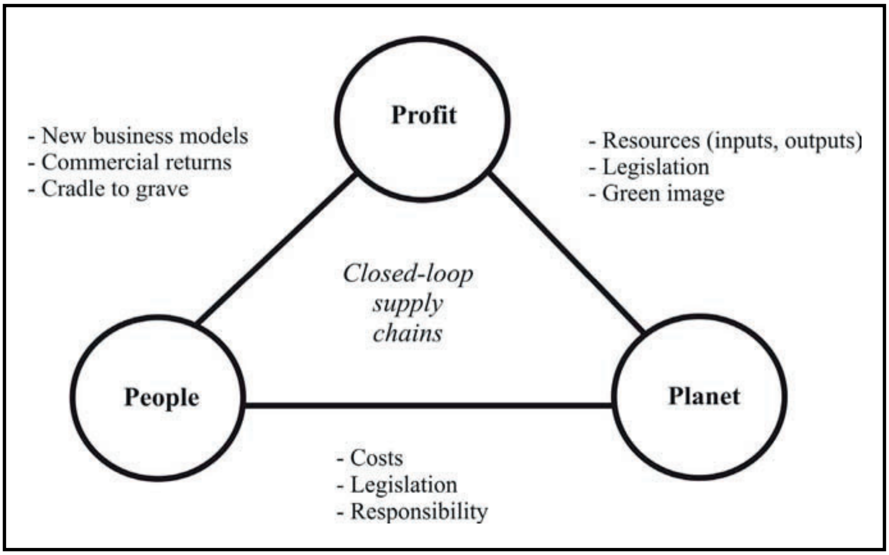

Fig. 18.1. Profit, People, Planet and their relations in the context of closed-loop supply chains

Profit

We expect the direct and indirect economic benefits of closing supply chains to remain the main driver for both OEMs and third parties in the next decade.

The clearly discernable trend to service based economies will continue. Offering a reliable service or functionality gradually becomes more important than selling the product delivering the function. For instance, tire manufacturers offer fleet owners insight into the consequences of poorly inflated tires, uneven loading of their trucks, and road conditions (Debo, 2002). They also increasingly offer tire management guaranteeing quality service while charging only a cost per mile travelled as opposed to selling their tires. There is a growing demand for leasing or renting products, not only by companies but also by households. In the Netherlands, all car companies are now also leasing whereas until recently most were only selling. See also (Sterman, 2000).

In such an economy companies will increasingly be confronted with returns since they provide the hardware that carries the desired service for the client. For example, air time providers offer cellular telephones and take them back when the customer switches to another model or at the end of the contract. See the ReCellular Inc. case in this book.

From a cash flow perspective the expected transition from sales to leasing is not so big since many sellers already allow their customers to spread payments over time. Moreover, leasing and renting often allow companies to reuse items when the present contract ends, either as entire products or as parts.

In case products are sold, closing the loop of a supply chain often means offering an extra service to customers. See the cases on Whirlpool, L'Oréal, HP, Wehkamp, and Mercedes-Benz in this book. A questionnaire by Rockwool, a big Danish producer, revealed that the collection system for their end-of-use products played an important role in their customers' buying decision (Wijshof, 1997).

Market and brand protection will also remain an important reason for closing supply chains. This concerns protection of new product markets like in the case of toner cartridges and markets for service parts. By preempting other companies from remanufacturing, companies also protect their brand name and reputation from being tarnished by poor quality remanufactured products. This was an important driver for Whirlpool when they decided to close part of their supply chain. See the Whirlpool case in this book.

Entering new markets, see the Mercedes-Benz and ReCellular Inc. cases in this book, and keeping production, distribution and servicing costs under control, see the Schering, NEC-CI, Océ and OMRON cases in this book, will most probably only grow in importance as reasons for companies to close their supply chains.

Scarcity of raw materials, although not yet considered a major issue by many companies, may quickly become an important driver for closing supply chains as it was immediately after World War II. At this very moment Chinese companies are buying metal scrap on the global markets in order to secure enough input material for their immense requirements. Of course, increasing scarcity of input materials will make closed-loop recovery more profitable.

Planet

The world will be confronted with a growing number of people with increasing requirements for natural resources and space due to higher standards of living. The mind-boggling development of China is a good case in point. Increasingly global markets will force more countries to enact laws stimulating or forcing companies to close their supply chains. A global economy in which the rich simply shove their waste on the poor is simply not sustainable (and certainly unethical). Legislation can force producers to take responsibility for their products after their useful life and to organize for proper disposal. It can also impose minimum recycling percentages and encourage reuse. Companies failing to comply may face severe fines, lose their license to operate or be punished by customers or investors.

People

In addition to legislation we expect growing pressure from environmental groups, customer organizations, investors and other stakeholders. People will increasingly want to associate themselves with companies that are good corporate citizens and take their corporate social responsibility seriously. An increasingly large component of this corporate social responsibility will be directly or indirectly related to environmental concerns and sustainable environments. This book shows that profitable closed-loop supply chains are an important building block for sustainable future operations.

18.3 Enablers

Technical developments will further facilitate profitable closing of a growing of supply chains. Companies increasingly design for reusability, even across platforms and generations. The drop in prices will also considerably increase the use of all sorts of smart sensors keeping track of every individual product's history allowing more reliable and faster estimation of the quality, configuration, and condition of potential product returns, thereby obviously facilitating the design of profitable reuse systems. For instance, by using radio frequency techniques (Simon et al, 2001), or by building chips into products as done by Robert Bosch in their power tools (Klausner et al, 1998), more detailed information about these products is available, avoiding time losses in disassembly and extensive quality testing.

Although at the moment many of these tools are or can only be used locally, more sophisticated tools are quickly becoming available. These tools should allow a view from a distance and encourage continuous remote monitoring, like the tracking and tracing facilities currently used for the planning and control of distribution items like pallets and for parcels distributed by companies like DHL, UPS and TNT. It is not hard to imagine a not too distant future in which the product will permanently broadcast its position and state, allowing the producer to proactively and opportunistically collect it and reroute it (after eventual repair or remanufacturing) to a more suitable and more profitable location. This installed base management opens fascinating opportunities for sustainable closed-loop supply chains as defined by our profit, people and planet triangle.

Quality of recovered products will no longer be an issue. This will allow companies to sell used items with the same quality guarantees as new items. Already today, some refurbished products like large servers, although sold at lower prices than new products, are more reliable than the latter.

We expect a growing collaboration between companies on issues related to end of life products. This way the necessary economies of scale can be realized and a better negotiation and lobbying position can be created when it comes down to new rules and regulations from governments. For instance in the Netherlands, nationwide collaboration can be found for brown and white goods, see the case on large white goods in this book, and batteries. These initiatives build on the successful consortium of car manufacturers and importers dealing with end-of-life vehicles.

A growing set of planning and control techniques and software are being developed for closed-loop supply chain management, see (Dekker et al., 2004). We expect those tools to soon be integrated in standard ERP software and to be routinely used in business. These tools should provide transparency on a routine basis and therefore allow much better analysis and control of closed-loop supply chain profitability. Better and earlier information on products about to return as well as the condition they are in will also allow for improved planning and control. Web-based systems will be widely used for global acquisition and sales of used items, thereby providing both better access to returned items and improved remarketing of recovered products.

In the past, used or recovered products were often sold on secondary markets to customers who could not afford to buy new ones. Although buying the newest product may still provide some customers with perceived status, in the foreseeable future we expect that for a growing number of products and markets status will become less important. Indeed, today the market for used tires is much smaller for cars than for commercial vehicles, see the RetreadCo case in this book, partially because of these status issues. However, we expect that for a growing number of products "used" will no longer mean poorer quality or lower status. At the contrary, used may gain status since a larger part of the population may only care for the function or service provided by the product and may prefer a product that is environmentally friendly. After all, the current fashion for antiques, old timers and second hand cloths may be an early signal of these emerging trends. Insurance companies are now offering policies where used parts replace stolen or damaged ones. Beijenkorf, a high-end department store in the Netherlands sells "unique" fashion clothing supplied by the Salvation Army. The latter uses collected old clothes as input materials for designers creating the fashion items. Of course, one can look at these examples as interesting faits divers, but they can also be seen as precursors of emerging trends of more sustainable closed-loop supply chains of the future.

Improved designs and better technologies will make it possible to deliver good quality used products for relatively low prices. Together with increased legislation and changing consumer perception, this will make closing the loop more profitable for an increasing number of products. Given the low labor costs in a number of big emerging economies it is likely that the labor intensive activities associated with product recovery like disassembly and repair will be moved there. Since the new products are already increasingly produced there, new and remanufacturing activities will become co-located making their integration easier. In addition these emerging economies are also ideal markets for recovered products. This trend is already visible today. Examples are Kodak moving its single use cameras to Eastern Europe and China and Canon doing the same with its toner cartridges.

Finally, we expect that one of the most important business economic enablers for reuse will be increased scarcity in raw materials. Although this trend has been noticeable for some time, we believe that the curve has now reached its tipping point and that the effects of increased input prices will be strongly magnified in the near future. One obvious consequence will be increased acceptance of reuse and more closed-loop supply chains.

18.4 Problems to be solved

There are also many potential roadblocks to the successful closing of supply chains. A number of them are mentioned below.

Technical developments, while often being enablers, may also endanger profitable closing of a supply chain. Pressures to decrease the weight of cars in order to reduce fuel consumption may push producers to use lighter materials like plastics. This in turn may lead to more costly processing of end-of-use products. In this example the environmental burden caused by the product's use is decreased but from a materials reuse perspective the net effect is negative.

Increased global competition and rapid technological innovation are still pushing towards shorter life-cycles thereby reducing the options for reuse. This also applies to the machines and tools used for producing, distributing and servicing products. Note that this trend may already be slowing down. Big computer users like banks and insurance companies are increasingly worried about their growing cost of ownership. Many of them are seriously considering less frequent and more coordinated replacement and upgrading of their computer equipment.

Miniaturisation, and many other technical developments partly undo efforts to design products that can easily be disassembled. More electronics, as well as an increasing use of embedded software may decrease the technical possibilities for repair.

Companies may use the effects mentioned above to make it harder on others to reuse their products. This may make closing the supply chain harder especially if the OEM is not interested in it for commercial reasons and if there is no legislation forcing the company to either close the loop itself or make it easier for others to do so. There has been an interesting set of court cases in this respect rather recently (e.g., on toner cartridges).

We expect a growing number of countries or even local governments to restrict or ban the supply of used items. In the Netherlands there are already restrictions on some products crossing borders between provinces. Similarly, former Eastern Germany has closed its borders to the disposal of batteries. International pressure groups like Greenpeace will continue to influence the world opinion to restrict movement of used products to less developed countries as long as special provisions are not taken and enforced. Of course, many of these actions are justified as exemplified by the case of shipwreck disassembly in Bangladesh. However, the above trend will persist and make closing the loop in supply chains more difficult until a suitable international legal framework is established and properly enforced.

Limited use of software to support integrated planning and control of forward and backward flows in closed-loop supply chains also makes profitable operation of the latter more difficult. Typical examples are packages for pallet pools, rental cars, and railcars. Often the software used by companies to support their closed-loop supply chain planning is tailor-made. This obviously makes it harder to integrate with standard ERP packages and more painful when the latter are being upgraded.

Finally, technological evolution and globalization still lead to the flooding of many markets with cheap new products that may be hard to reuse because of low durability and quality. These products are often substitutes for products that could be profitably reused or for remanufactured products. A good case in point is the collapse of the re-treaded car tire market in Europe due to the success of cheap tires from the Far East. These cheap new tires are sold at about the same price of a re-treaded tire. From a customer perspective buying a high quality expensive new tire may be the best option from a total cost-of-ownership perspective, but the initial cash outlay is obviously larger than that for a cheap tire. In addition, from an environmental impact perspective, re-treading of car tires may be a valuable option since the core of the tire is usually quite durable and can be reused by applying a new tread.

18.5 Trends with respect to the different types of return flows

We now discuss how the trends in closed-loop supply chains described above will influence the different types of flows considered in this book.

Shorter life-cycles lead to increased pressure on designers as well as on the supply chain that needs to introduce the new product and ramp it up successfully faster. Despite improved design techniques and better understanding of supply chain management and product rollovers, it is very likely that shorter product life-cycles, rapidly changing technology and mass customisation will increase supply chain hiccups, be they in production or distribution. There will be increased scrap and rework, more obsoletes, growing defects and more frequent recalls. This trend is already quite noticeable as well as extremely painful for some companies.

Short delivery times, high disposal costs and an increasing concern for keeping a green image will force companies to focus more clearly on closing their production loop in the near future. This concerns more specifically decisions on what to produce where and care for obtaining and keeping the required license to operate, which may become increasingly difficult and expensive in some countries.

Increased Internet sales and more lenient sales conditions in general will boost the number of commercial returns in many countries and sectors. Since these products are often unused and may lose value quickly (e.g., PCs currently lose about 1% of their value per week), it will be crucial to design quick turnaround closed-loop systems capable of putting these commercial returns back on the appropriate markets fast.

Customers no longer wish to be burdened by distribution and packaging items accompanying products they buy. Legislators increasingly want producers to take care of these items as part of the sales and delivery process. It follows that return flows of distribution and packaging materials are on the rise.

Although return flows due to repairs will increase because of faster introduction of new products one could also argue that production techniques have improved considerable and poor quality products are less present than before. However, it is likely that flows related to replacements will increase since a growing number of functional components can no longer be repaired at the customer site. They are simply too complex and require sophisticated equipment. In addition, customers no longer want to be deprived of the use of their products for a long time because of large repair lead times. They want their product replaced or its functionality restored pronto.

Increased buying of functionality or service instead of physical products (e.g., through leasing contracts) will augment end-of-use flows since customers will find it necessary or convenient to switch functionalities quickly. An extreme but telling example would be to lease a car but to have the option to change the model frequently over time, e.g., a SUV for the week but a little sports car for the weekend and a camper for the holidays. This would obviously lead to increased flows in this closed-loop supply chain.

Finally, it is obvious that companies will be confronted with increased end-of-life flows caused by shorter lifecycles, increased legislation and concern for sustainability. Global supply chains snaking through many companies and countries are also forcing companies to become much more careful about selecting and managing their suppliers and channel partners. Extended producer responsibility makes the OEM accountable for hiccups no matter where in the supply chain they arise and companies can take a serious blow if suppliers fail to act properly. In a sense, this is also about closing the loop in the system. In any case, increased concern for proper tracking and tracing and strict application of standard procedures will also make closed-loop supply chains easier to justify and implement.

18.6 Conclusions

In this chapter we presented our perspective on the future of closed-loop supply chains. As usual with extrapolations some trends clearly support closing the loop, like design for disassembly, cheap sensor technology, and the Internet, whereas others appear to hinder closing of the loop, like short life-cycles and mass customisation. Whatever the outcome may be, smart companies take advantage of periods of transition characterised by greater uncertainty. They take calculated risks and benefit from temporary competitive advantages through pioneering innovative solutions. This book has presented plenty of cases of companies doing exactly this in the context of closed-loop supply chains.

Some cases taught us about new business models, e.g., the ones based on a new concept of customer service (e.g., the OMRON and Whirlpool cases). Other cases revealed innovative ways of monitoring product use and taking business advantage of this information (e.g., the Océ and NEC-CI cases). Still other cases focused on smart use of tracking and tracing technology and integrated information systems in managing flows of products or distribution items (e.g., the Heineken and Wehkamp cases). Some chapters dealt with collaboration initiatives (e.g., the Port of Rotterdam case) and personnel incentive schemes (e.g., the L'Oréal case) to induce appropriate behaviours in the closed-loop supply chains. In short, the industrial cases gave a rich overview of how business drivers, technical aspects, organizational issues, planning and control requirements, information systems, environmental concerns and, most importantly, pure business economics shape successful closed-loop supply chains in practice today.

This book took a business perspective. We discussed opportunities and challenges of profitably closing the loop in supply chains from the point of view of the OEM. Of course, other perspectives are equally relevant, e.g., those of the government or policy maker, the consumer, society at large, and other partners in the supply chain including banks and investors. In short, one could take the perspectives of all stakeholders of the firm. We indirectly included other stakeholders by taking a profit, people, and planet perspective but always from the company's viewpoint. There is obviously room for other books taking a different perspective. For example, closed-loop supply chains may have macro-economic impacts on the global economy (Van Beukering, 2001).

As stated at the outset, closed-loop supply chains are a growing but still relatively new phenomenon in business. Very little is known about the realities of industrial practice for the simple reason that smart firms practicing closing the loop are not too keen on transferring their know-how to others. In addition, busy executives have more urgent things to do than to write about their business for the benefit of others. It is therefore even more surprising that we were able to find so many of our industrial friends willing to contribute to this book. It makes this book unique and therefore we are extremely grateful for their contribution.

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