A Framework for Reverse Logistics — Source link

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A Framework for Reverse Logistics

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Abstract

Reverse Logistics has been stretching out worldwide, involving all the layers of supply chains in various industry sectors. While some actors in the chain have been forced to take products back, others have pro-actively done so, attracted by the value in used products. One way or the other, Reverse Logistics has become a key competence in modern supply chains. In this paper, we present a content analysis of reverse logistics issues. To do so, we propose a content framework focusing on the following questions with respect to reverse logistics: *why*? *what*? *how*?; and, *who*?, i.e. driving forces and return reasons, what type of products are streaming back, how are they being recovered, and who is executing and managing the various operations. These four basic characteristics are interrelated and their combination determines to a large extent the type of issues arising from the resulting reverse logistics system.

Keywords: Reverse logistics, framework, content analysis, theory, supply chain management.

1 Introduction

Twenty-years ago, supply chains were busy fine-tuning the logistics of products from raw material to the end customer. Products are obviously still streaming in the direction of the end customer but an increasing flow of products is coming back. This is happening for a whole range of industries, covering electronic goods, pharmaceuticals, beverages and so on. For instance, the automobile industry is busy changing the physical and virtual supply chain to facilitate end-of-life recovery (Boon et al., 2001; Ferguson and Browne, 2001). Besides this, distant sellers like e-tailers have to handle high return rates and many times at no cost for the customer. It is not surprising that the Reverse Logistics Executive Council has announced that US firms have been loosing billions of dollars on account of being ill-prepared to deal with reverse flows (Rogers and Tibben-Lembke, 1999). The return as a process was recently added to the Supply-Chain Operations Reference (SCOR) model, stressing its importance for supply chain management in the future (Schultz, 2002). Reverse Logistics has been stretching out worldwide, involving all the layers of supply chains in various industry sectors. While some actors in the chain have been forced to take products back, others have pro-actively done so, attracted by the value in used

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products. One way or the other, Reverse Logistics has become a key competence in modern supply chains.

In this paper, we present a content analysis of reverse logistics issues. To do so, we propose the following content framework focusing on the following questions with respect to reverse logistics: *why*? *what*? *how*?; and, *who*?, i.e. driving forces and return reasons, what products, how are they being recovered and who is involved.

The remainder of the paper is organized as follows. First, we go into more detail regarding the scope of Reverse Logistics and we distinguish its domain, relating it with other subjects like green logistics and closed-loop supply chains. Next, we provide a short review of the literature contributing to structure the Reverse Logistics field. After that we characterize Reverse Logistics by looking into it from the four perspectives of the content framework: why are there reverse flows, i.e. the return reasons and the driving forces; what constitutes these reverse flows, i.e. which are the products and materials characteristics; how can they be recovered, i.e. which are the intricate processes; and, who is carrying out these activities, i.e. the supply chain actors. We end up this paper by relating all the issues together.

2 Reverse Logistics: definition and scope

Definition and a brief history

"In the sweat of your face you shall eat bread Till you return to the ground, For out of it you were taken; For dust you are, And to dust you shall return."
Genesis 3:19

Though the conception of Reverse Logistics dates from long time ago (as the aforementioned citation proves), the denomination of the term is difficult to trace with precision. Terms like Reverse Channels or Reverse Flow already appear in the scientific literature of the seventies, but consistently related with recycling (Guiltinan and Nwokoye, 1974; Ginter and Starling, 1978). The Council of Logistics Management (CLM) published the first known definition of Reverse Logistics in the early nineties (Stock, 1992):

"...the term often used to refer to the role of logistics in recycling, waste disposal, and management of hazardous materials; a broader perspective includes all relating to logistics activities carried out in source reduction, recycling, substitution, reuse of materials and disposal."

The previous definition is quite general, as it is evident from the following excerpts "the role of logistics in all relating activities." Besides that, it is originated in a waste management standpoint. In the same year Pohlen and Farris (1992) define Reverse Logistics, guided by marketing principles and by giving it a direction insight, as follows:

"...the movement of goods from a consumer towards a producer in a channel of distribution."

Kopicky et al. (1993) defines Reverse Logistics analogously to Stock (1992) but keeps, as previously introduced by Pohlen and Farris (1992), the sense of direction opposed to traditional distribution flows:

"Reverse Logistics is a broad term referring to the logistics management and disposing of hazardous or non-hazardous waste from packaging and products. It includes reverse distribution

() which causes goods and information to flow in the opposite direction of normal logistics activities."

In the end of the nineties, Rogers and Tibben-Lembke (1999) describe Reverse Logistics stressing the goal and the processes (the logistics) involved:

"The process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal."

The European Working Group on Reverse Logistics, RevLog (1998-), puts forward the following definition Dekker et al., (2003):

"The process of planning, implementing and controlling flows of raw materials, in process inventory, and finished goods, from a manufacturing, distribution or use point, to a point of recovery or point of proper disposal"

This perspective on Reverse Logistics keeps the essence of the definition as put forward by Rogers and Tibben-Lembke (1999), which is logistics. We do not however refer to "point of consumption" nor to "point of origin." In this way we give margin to return flows that were not consumed first (for instance, stock adjustments due to overstocks or spare parts which were not used), or that may go back to other point of recovery than the original (e.g. collected computer chips may enter another chain).

Delineation and scope

Since Reverse Logistics is a relatively new research and empirical area, the reader may encounter in other literature terms, like reversed logistics, return logistics and retro logistics or reverse distribution, sometimes referring roughly to the same. In fact, the diversity of definitions with respect to recovery practices is a well-recognized source of misunderstandings both in research as in practice (Melissen and De Ron, 1999).

We would like to remark that Reverse Logistics is different from waste management as the latter mainly refers to collecting and processing waste (products for which there is no new use) efficiently and effectively. The crux in this matter is the definition of waste. This is a major issue, as the term has severe legal consequences, e.g. it is often forbidden to import waste. Reverse Logistics concentrates on those streams where there is some value to be recovered and the outcome enters a (new) supply chain. Reverse Logistics also differs from green logistics as that considers environmental aspects to all logistics activities and it has been focused specifically on forward logistic, i.e. from producer to customer (see Rodrigue et al., 2001). The prominent environmental issues in logistics are consumption of nonrenewable natural resources, air emissions, congestion and road usage, noise pollution, and both hazardous and non-hazardous waste disposal (see Camm, 2001). Finally, reverse logistics can be seen as part of sustainable development. The latter has been defined by Brundland (1998) in a report to the European Union as "to meet the needs of the present without compromising the ability of future generations to meet their own needs." In fact one could regard reverse logistics as the implementation at the company level by making sure that society uses and re-uses both efficiently and effectively all the value which has been put into the products.

The border between forward logistics (from raw materials to end user) and reverse logistics (from end user to recovery or to a new user) is not strictly defined as one can wonder about what 'raw materials' are, or who the 'end user' is, in modern supply chains. For instance, used/recovered glass is a substantial input for new production of glass. A holistic view on supply chains combining both forward and reverse logistics is embraced by the closed-loop supply chain concept (Guide and van Wassenhove, 2003). Recovery practices are framed within the supply chain, and the encircling aspect of the process as a whole is therefore stressed: having either 1) a physical (closed-loop): to the original user (see Fleischmann et al., 1997); or 2) a functional (closed-loop): to the original functionality. Thinking in term of closed-loop supply chains emphasizes the importance of coordinating the forward with the reverse streams. Actually, whenever both forward and reverse flows are involved, co-ordination has to be minded (see Debo et al., 2003). This happens, either in closed- or open-loops (the latter refers to when neither the original user or original functionality are in the reverse logistics process).

3 Reverse Logistics: a review of literature on theoretical developments

In the literature dealing with reverse logistics one can essentially find quantitative modelling, case studies and theory building. For a review on the state-of-affairs on quantitative modelling before the RevLog project, we refer to Fleischmann et al. (1997). For a compilation of reverse logistics case studies we suggest De Brito et al. (2003) and Flapper, et al. (2004) . In addition, for more overviews on reverse logistics, we suggest the following references: Stock, 1992; Kopicky, 1993; Kostecki (1998); Stock (1998); Rogers and Tibben-Lembke, 1999; Guide and van Wassenhove, 2003.

In this review we focus on contributions for the construction of reverse logistics theory. Since there are no established references on Reverse Logistics theory, we sometimes depart from literature on related fields that secondarily add to the theoretical growth of Reverse Logistics. In addition we briefly point out how the content framework presented in this paper relates to this literature on the one hand and how it deviates from it on the other.

In the mid nineties, Thierry et al. (1995) shaped product recovery management by detailedly going over the recovery options, distinguishing: 1) direct re-use (and re-sale); 2) product recovery management (repair; refurbishing; remanufacturing; cannibalization; recycling); and, 3) waste management (incineration and land filling). The authors characterize the recovery options according to the level of disassembly, and the quality required as well as the resulting product. Besides this, the paper uses three case studies (BMW, IBM, and an anonymous copy remanufacturer) to illustrate changes in operations when companies get engaged in recovery. In the *How* section of this paper, we employ a similar recovery option typology, introducing however the term re-distribution as another form of direct recovery, and using (parts) retrieval instead of the term cannibalization. Besides outlining how products can be recovered, we also put forward the *who* perspective and we add two dimensions that help to understand Reverse Logistics: *why* and *what*. Fleischmann et al. (1997) have actually touched upon these perspectives, except for the characterization of the return reasons. The following characteristics are used to show the diversity of reverse logistics systems: 1) motivation (economical and ecological); 2) the type of items (spare parts, packages, and consumer goods; 3) the form of reuse (reused directly, repair, recycling, and remanufacturing) and, processes (collection, testing, sorting, transportation and processing); 4) the involved actors (members of the forward channel or specialized parties). These issues partially come back in the subsequent sections with further elaboration on their characterization. In addition, we sum up the return reasons to the *why* dimension. The authors concluded that the research up to then was rather narrowed to single questions and accordingly they suggested dedicating more research effort to the impact of return flows on supply chain management.

Fuller and Allen (1997) used the recycling of post-consumer goods as the inspiration for the following typology of reverse channels: 1) manufacturer-integrated; 2) waste-hauler; 3) specialized reverse dealer-processor; 4) forward retailer-wholesaler; and 5) temporary/facilitator. In this paper we consider a broad range of recovery options, besides recycling, and a broader list of actors besides the ones involved in a pure recycling system. Yet, what we can learn from Fuller and Allen (1997) is that in reverse logistics are likely to appear three types of players: 1) typical forward chain players (manufacturer, wholesaler, retailer); 2) specialized reverse players; and 3) opportunistic players. We come back to this in the *Who* section.

Late nineties, Carter and Ellram (1998) put together a model of stimulating and restraining forces for Reverse Logistics. They identify four environmental forces: 1) from the government (in terms of regulations); 2) from suppliers; 3) from buyers; and 4) from competitors. In the *Why* section we discuss as well driving forces for Reverse Logistics, where the aforementioned items are part of the discussion. One important matter not emphasized by Carter and Ellram (1998) is the direct economic benefit. Another ignored aspect is the company inner-responsibility, denominated as corporate citizenship during our discussion.
Gungor and Gupta (1999) present an extensive review of the literature (more than 300 articles or books) on environmentally conscious manufacturing and product recovery. They subdivide the literature in categories, outlining a framework. This paper looks upon product recovery from the point of view of environmentally conscious manufacturing. Both the regulatory and opinion pressure respectively by government and customers are mentioned. We contemplate a tri-fold driving force for Reverse Logistics: corporate citizenship (where the environmental accountability is included), economics and legislation (see *Why* section). Gungor and Gupta (1999) go over environmental design, stressing the relevance that the constitution of the product has for recovery. They mention e.g. the number of components, the number of materials and the easiness of material separation. We come back to this on the *What* section.

Goggin and Browne (2000) have recently suggested a taxonomy of resource recovery specifically for end-of-life products with the focus on electronic and electrical equipment. Their classification is based in three dimensions, as follows: 1) public vs. private sector; 2) commercial vs. domestic market segments; and 3) large vs. small products. These issues come into the framework presented here, specifically in the *What* and *Who* sections. Essentially, what we retain from them is that a relevant characteristic of a reverse logistics system is the nature of those behind the network, i.e. private vs. public (for more on this, we refer to Fleischmann et al, 2003). Furthermore, other relevant traits are the size of the product, and the market segment. With respect to resource recovery, Goggin and Browne (2000) delineate three types: material reclamation, component reclamation, and remanufacturing. The authors feature these groups according to input and output product complexity. In fact, this was earlier brought by Thierry et al. (1995), who presented a lengthy list of recovery options, which we generally follow (see

How section).

In contrast with most of the previous contributions, we are not going to go into details for one or other form of reverse logistics. Instead, we bring forward a content framework on reverse logistics as a whole by bringing structure to the fundamental contents of the topic and their interrelations. As mentioned before, we do this by answering four basic questions on reverse logistics: *Why*? *What*? *How*? *Who*? In this way the reader can generally understand what reverse logistics issues are about and at the same time capture the vast assortment of matters involved.

4 Reverse Logistics: why? what? how? and, who?

After having briefly introduced the topic of Reverse Logistics, we now go into the fundamentals of Reverse Logistics by analyzing the topic from four essential viewpoints: *why*, *what*, *how* and *who*. Former studies have argued that these types of characteristics are relevant to characterize reverse logistics (see e.g. Thierry, 1995; Fleischmann et al., 1997; Zhiquiang, 2003). In this paper, we consider the following details:

- *Why* are things returned: we go over the driving forces behind companies and institutions to become active in Reverse Logistics, *Why-drivers* (receiver), and the reasons for reverse flows (return reasons), i.e. *Why- reasons* (sender);
- *What* is being returned: we describe product characteristics which makes recovery attractive or compulsory and give examples based on real cases (products and materials);
- *How* Reverse Logistics works in practice: we give a list of processes carried out in reverse logistic systems and we focus on how value is recovered in the reverse chain (recovery options);
- *Who* is executing reverse logistic activities: we go over the actors and their role in implementing reverse logistics (reverse chain actors);

Why-drivers (receiver): Driving forces behind Reverse Logistics
In the literature of reverse logistics, many authors have pointed out driving factors like economics, environmental laws and the environmental consciousness of consumers (see e.g. RevLog, online). Generally, one can say that companies do get involved with Reverse Logistics either 1) because they can profit from it; or/and 2) because they have to; or/and 3) because they "feel" socially motivated to do it; Accordingly, we categorize the driving forces under three main headings, viz.

- Economics (direct and indirect);
- Legislation;
- Corporate citizenship;

Economics:
A reverse logistics program can bring direct gains to companies from dwindling on the use of raw materials, from adding value with recovery, or from reducing disposal costs. Independents have also gone into the area because of the financial opportunities offered in the dispersed market of superfluous or discarded goods and materials. Metal scrap brokers have made fortunes by collecting metal scrap and offering it to steel works, which could reduce their production costs by mingling metal scrap with virgin materials in their process. In the electronic industry, many products arrive at the end of useful life in a short period, but still with its components having intrinsic economic value. ReCellular is a U.S. firm that has showed to know how to take economic advantage from this as of the beginning of the nineties by trading in refurbished cell phones (see Guide and Van Wassenhove, 2003).

Even with no clear or immediate expected profit, an organization can get (more) involved with Reverse Logistics because of marketing, competition and/or strategic issues, from which are expected indirect gains. For instance, companies may get involved with recovery as a strategic step to get prepared for future legislation (see Louwers et al., 1999) or even to prevent legislation. In face of competition, a company may engage in recovery to prevent other companies from getting their technology, or from preventing them to enter the market. As reported by Dijkhuizen (1997), one of the motives of IBM in getting involved in (parts) recovery was to avoid that brokers would do that. Recovery can also be part of an image build-up operation. For instance, Canon has linked the copier recycling and cartridge recycling programs to the "kyo-sei" philosophy, i.e. cooperative growth, proclaiming that Canon is for "living and working together for the common good" (see Meijer, 1998; and, www.canon.com). Recovery can also be used to improve customer's or supplier' relations An example is a tyre producer who also offers customers rethreading options in order to reduce customer's costs. In sum, the economic driver embraces among others, the following direct and indirect gains:

- Direct gains:
  - input materials;
  - cost
  - reduction;
  - value added recovery;
- Indirect gains:
  - anticipating/impeding legislation
  - market protection;
  - green image;
  - improved customer/supplier relations;

Legislation:
Legislation refers here to any jurisdiction indicating that a company should recover its products or accept them back. As mentioned before, in many countries home-shoppers are legally entitled of returning the ordered merchandize (e.g. in the UK, consult the Office for Fair Trading,

online). Furthermore, and especially in Europe there has been an increase of environmentally-related legislation, like on recycling quotas, packaging regulation and manufacturing take-back responsibility. The automobile industry and industries of electrical and electronic equipment are under special legal pressure (see Bloemhof et al., 2003). Sometimes companies participate "voluntarily" in covenants, either to deal with (or get prepared for) legislation.

Corporate citizenship:
Corporate citizenship concerns a set of values or principles that in this case impel a company or an organization to become responsibly engaged with reverse logistics. For instance, the concern of Paul Farrow, the founder of Walden Paddlers, Inc., with "the velocity at which consumer products travel through the market to the landfill", pushed him to an innovative project of a 100-percent-recyclable kayak (see, Farrow and Jonhson, 2000). Nowadays indeed many firms, like Shell (www.shell.com), have extensive programs on responsible corporate citizenship where both social and environmental issues become the priorities.
Figure 1 depicts the, previously described, driving triangle for Reverse Logistics.

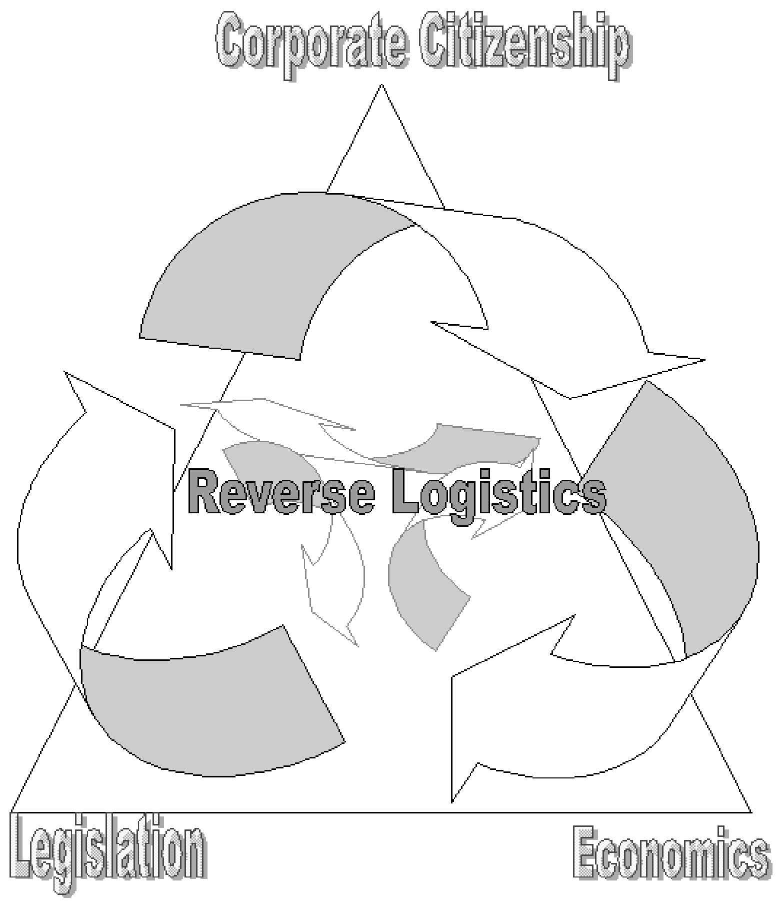

Figure 1: Driving triangle for reverse logistics

One should notice that these are not mutually exclusive motivations and in reality it is sometimes hard to set the boundary. In many countries, customers have the right to return products purchased via a distant seller as mail-order-companies or e-tailers. Thus, these companies are legally obliged to give the customer the opportunity to send back merchandize. At the same time, this opportunity is also perceived as a form to attract customers, bringing potential benefits to the company.

Why -reasons (sender): return reasons for Reverse Logistics
Roughly speaking, products are returned or discarded because either they do not function (anymore) properly or because they or their function are no longer needed. Let us next elaborate these return or discard reasons in more detail. We can list them according to the usual supply chain hierarchy: starting with manufacturing, going to distribution until the products reach the customer. Therefore, we differentiate between manufacturing returns, distribution returns and customer returns.

<u>Manufacturing returns</u>
We define manufacturing returns as all those cases where components or products have to be recovered in the production phase. This occurs for a variety of reasons. Raw materials may be left over, intermediate or final products may fail quality checks and have to be reworked and products may be left over during production, or by-products may result from production. Raw material surplus and production leftovers represent the product not-needed category, while quality-control returns fit in the "faulty" category. In sum, manufacturing returns include:

- raw material surplus;
- quality-control returns;
- production leftovers/by-products;

<u>Distribution returns</u>
Distribution returns refers to all those returns that are initiated during the distribution phase. It refers to product recalls, commercial returns, stock adjustments and functional returns. Product recalls are products recollected because of safety or health problems with the products, and the manufacturer or a supplier usually initiates them. B2B commercial returns are all those returns where a retailer has a contractual option to return products to the supplier. This can refer to wrong/damaged deliveries, to products with a too short remaining shelf life or to unsold products that retailers or distributors return to e.g. the wholesaler or manufacturer. The latter include outdated products, i.e.those products whose shelf life has been too long (e.g. pharmaceuticals and food) and may no longer be sold. Stock adjustments take place when an actor in the chain re-distributes stocks, for instance between warehouses or shops, e.g. in case of seasonal products (see De Koster et al., 2002). Finally, functional returns concern all the products which inherent function makes them going back and forward in the chain. An obvious example is the one of distribution carriers as pallets: their function is to carry other products and they can serve this purpose several times. Other examples are crates, containers and packaging. Summarizing, distribution returns comprehend:

- product recalls;
- B2B commercial returns (e.g. unsold products, wrong/damaged deliveries);
- stock adjustments;

- functional returns (distribution items/carriers/packaging);

Customer Returns
The third group consists of customer returns, i.e. those returns initiated once the product has at least reached the final customer. Again there is a variety of reasons to return the products, viz.

- B2C commercial returns (reimbursement guarantees);
- warranty returns;
- service returns (repairs, spare-parts...);
- end-of-use returns;
- end-of-life returns;

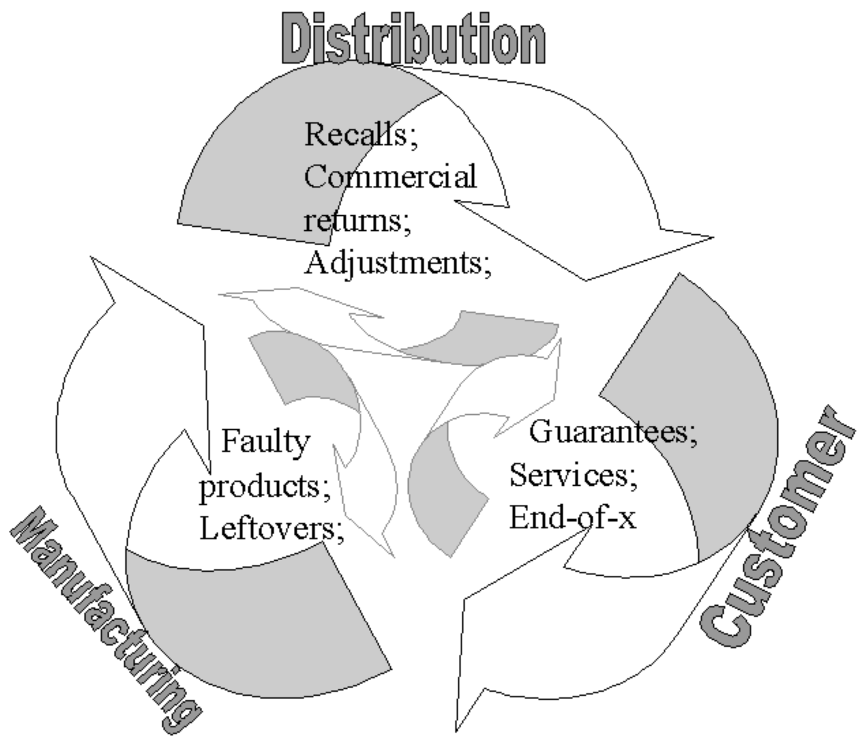

Figure 2: Return reasons for reverse logistics

The reasons have been listed more or less according to the life cycle of a product. Reimbursement guarantees give customers the opportunity to change their minds about purchasing (commonly shortly after having received/acquired the product) when their needs or expectations are not met. The list of underlining causes is long, e.g. with respect to clothes dissatisfaction may be due to size, color, fabric's properties and so forth. Independent of the underlining causes, when a customer returns a new product benefiting from a money-back-guarantee or an equivalent, we are in the presence of B2C commercial returns. The next two reasons, warranty and service returns, refer mostly to an incorrect functioning of the product during use, or to a service that is associated with the product and from which the customer can benefit.

Initially, customers benefiting from a warranty can return products that do not (seem to) meet the promised quality standards. Sometimes these returns can be repaired or a customer gets a new product or his / her money back upon which the returned product needs recovery. After the warranty period has expired, customers can still benefit from maintenance or repair services, but they no longer have a right to get a substitute product for free. Products can be repaired at customer's site or sent back for repair. In the former case there are many returns in the form of spare-parts in the service supply chain, since in advance it is hard to know precisely which parts are needed for the repair.

End-of-use returns refer to those situations where the user has a return opportunity at a certain life stage of the product. This refers to leasing cases and returnable containers like bottles, but also returns to second-hand markets as the one of bibliofind, a division of amazon.com for used books.

Finally, end-of-life returns refer to those returns where the product is at the end of their economic or physical life, as it is. They are either returned to the OEM because of legal product-take-back obligations or other companies like brokers take them for value-added recovery (see *How* section).

Figure 2 summarizes the return reasons for Reverse Logistics in the three stages of a supply chain: manufacturing, distribution and customer.

How: Reverse logistics processes

The *how* viewpoint is meant to aboard how Reverse Logistics works in practice: how is value recovered from products.

Recovery is actually only one of the activities involved in the whole reverse logistics process. First there is collection, next there is the combined inspection / selection /sorting process, thirdly there is recovery (which may be direct or it may involve a form of re-processing), and finally there is redistribution (see Figure 3). Collection refers to bringing the products from the customer to a point of recovery. At this point the products are inspected, i.e. their quality is assessed and a decision is made on the type of recovery. Products can then be sorted and routed according to the recovery that follows. If the quality is (close to) "as-good-as-new," products can be fed in the market almost immediately through re-use, re-sale and re-distribution. If not, another type of recovery may be involved but now demanding more action, i.e. a form of re-processing.

Re-processing can occur at different levels: product level (repair), module level (refurbishing), component level (remanufacturing), selective part level (retrieval), material level (recycling), energy level (incineration). We refer to Thierry et al. (1995) for complete definitions. For other points of view on recovery/re-processing levels, see Fleischmann et al. (1997), and Goggin and Browne, (2000). At module level, the product, e.g. a large installation, building or other civil object gets upgraded (refurbishment). In case of component recovery, products are dismantled and used and new parts can be used either in the manufacturing of the same products or

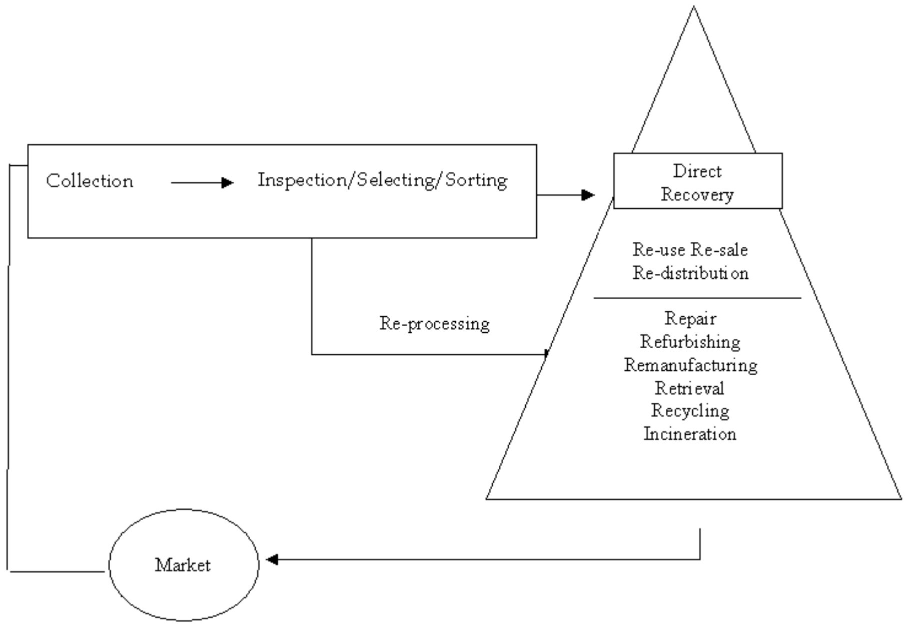

Figure 3: Reverse logistics processes

of different products (remanufacturing). In material recovery, products are grinded and their materials are sorted out and grouped according to a quality wish, so recycled materials can be input raw material, such as paper pulp and glass. Finally, in energy recovery products are burned and the released energy is captured (incineration). If none of these recovery processes occur, products are likely to go to landfill.

Figure 4 represents recovery options ordered as for the level of re-process required, in a form of an inverted pyramid. At the top of the pyramid, we have the global levels, such as product and module, and at the bottom more specific levels like materials and energy. Please note that returns in any stage of the supply chain (manufacturing, distribution and customer) can be recovered according to options both from the top and from the bottom of the pyramid.

One can find overall similarities between the inverted pyramid above and the Lansink's waste hierarchy introduced in 1979 by this Dutch member of parliament as being: prevention, re-use, recycling and proper disposal (see www.vvav.nl). At first, one may think that recovery options at the top of the pyramid are of high value and more environmentally friendly than options close to the bottom, which recover less value from the products. We would like to stress that both thoughts are not necessarily true. Originally, the Lansink's hierarchy was put together regarding the environmental friendliness of the recovery option. Yet, the hierarchy is disputable even there. In the case of paper recycling versus land filling, one may go against recycling by arguing that paper is biodegradable and requires less energy than the de-inking and bleaching processes necessary for recycling. With respect to the economic value of each recovery option, that depends for instance on the existence of a matching market. Thus, it is possible that a used product has essentially no market value as such, but is very valuable as a collection of spare parts.

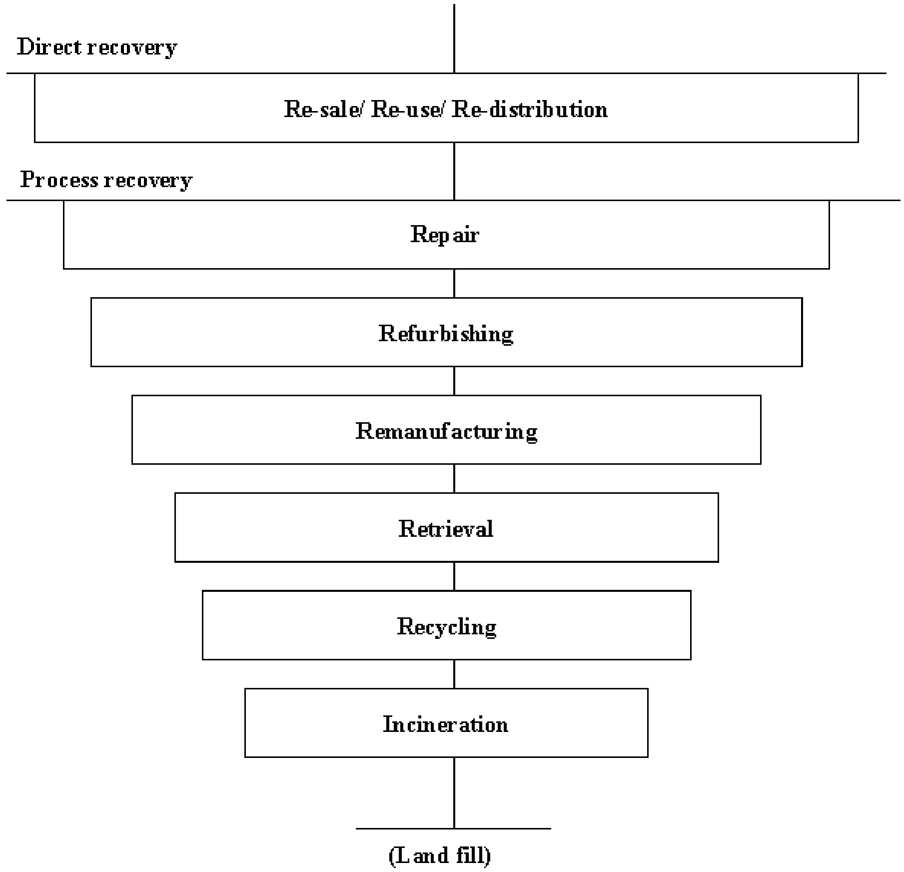

Figure 4: Recovery option inverted pyramid

What: Types and characteristics of returned products
A third viewpoint on Reverse Logistics can be obtained by considering what is actually being discarded or returned. Three product characteristics seem to be relevant , viz.

- composition;
- deterioration;
- use-pattern;

Composition
As highlighted by Gungor and Gupta (1999), product composition in terms of the number of components and of materials is one of the many aspects to keep in mind while designing products for recovery. Not only the number, but also how the materials and components are put together, will affect the easiness of re-processing them and therefore the economics of reverse logistics activities (Goggin and Browne, 2000 discuss product complexity). The presence of hazardous materials is also of prime relevance, as it demands special treatment. The material heterogeneity of the product can play a role in recovery, where one tries to obtain separate streams of different materials, which are as pure as possible (a problem in case of plastics). The

size of the product has also been pointed out as a significant factor for recovery systems (see Goggin and Browne, 2000). One can mind e.g. the impact of this aspect on transportation and handling. Summing up, the intrinsic characteristics of a product are decisive for the recovery, since they effect e.g. the economics of the whole process.

Deterioration
Next there are the deterioration characteristics, which eventually cause a non-functioning of the product, but also determine whether there is enough functionality left to make a further use of the product, either as a whole or as parts. This strongly effects the recovery option. Several questions have to be asked in order to evaluate the recovery potential of a product: does the product age during use? (intrinsic deterioration); do all parts age equally, or not? (homogeneity of deterioration); does the value of the product decline fast? (economic deterioration). In fact, products may become obsolete because their functionality becomes outdated due to the introduction of new products in the market, as happens with computers. This will restrict the recovery options that are viable. The same can be said for the intrinsic deterioration and whether, or not, it is homogeneous. If a product is consumed totally during use, such as gasoline, or if it ages fast, like a battery, or if some parts are very sensitive to deterioration, reuse of the product as such is out of the question. If however, only a part of the product deteriorates, then other recovery options like repair or part replacement or retrieval may be considered.

Use-pattern
The product use pattern, with respect to location, intensity, and duration of use, is an important group of characteristics as it affects for instance the collection phase (see How section). It will make a difference whether the end-user is an individual or an institution (bulk-use), demanding different locations for collection or different degrees of effort from the end-user (e.g. bring to a collection-point). The use can also be less or more intensive. Let us consider the case of leased medical equipment, which is commonly used for a small time period, and it is likely to be leased again (after proper operations like sterilization). Time is not the only component describing intensity of use, but also the degree of consumption during of use. Consider for instance the example of reading a book. Quite often one reads a book only once after the purchase and keeps it, but does not do anything with it later on. This has stimulated Amazon to start her successful second-hand trading of books.

The characteristics of the product are related with the type of product in question. Product type in fact gives the first global impression on the potential states of the product when it reaches recovery. The product's type has been used by Zhiquiang (2003) to sketch the planning of reverse logistics activities. Fleischmann et al. (1997) distinguish the following types: spare parts; packages; and consumer goods. A natural addition is the class of industrial goods, which in general are more complex and of a different use pattern than consumer goods. Furthermore, by looking at the United Nations (UN) classification of products (see UN, online), and at the relevant characteristics for reverse logistics (as described previously) we find it important to discriminate a few more classes of products as: ores, oils and chemicals; civil objects, and other transportable products. It is common knowledge that civil objects have a long useful life. Besides this, recovery has mostly to be in-site as objects like bridges and roads are not easily removed and transported as such. Ores, oils and chemicals are a special category due to their common hazardous composition needing specialized handling during any recovery process. Finally, we attribute a separate category for other materials, such as pulp, glass and scraps. In sum, the following main product categories are discriminated:

- consumer goods (apparel, furniture, and a vast variety of goods)
- industrial goods (e.g. military and professional equipment);
- spare-parts;
- packaging and distribution items;
- civil objects (buildings, dikes, bridges, roads, etc.);
- ores, oils and chemicals;
- other materials (like pulp, glass and scraps);

Who is who in Reverse Logistics
There are several viewpoints on actors in reverse logistics. We can make a distinction between (see also Fuller and Allen, 1997):

- forward supply chain actors, (as supplier, manufacturer, wholesaler and retailer);
- specialized reverse chain players(such as jobbers, recycling specialists, etc.);
- opportunistic players (such as charity organization);

Some of the players are responsible for or they organize the reverse chain while other players simple execute tasks in the chain. The final player role we have to add to this is the accommodator role, performed by both the sender/giver and the future client, without whom recovery would not make much sense. Any party can be a sender/giver, including customers. The group of actors involved in reverse logistic activities, such as collection and processing, are independent intermediaries, specific recovery companies (e.g. jobbers), reverse logistic service providers, municipalities taking care of waste collection, public-private foundations created to take care of recovery. Each actor has different objectives, e.g. a manufacturer may do recycling in order to prevent jobbers reselling his products at a lower price. The various parties may compete with each other.

This viewpoint is made clear in Figure 5. The parties at the top of the picture are either responsible or made responsible by legislation. They are from the forward chain, like the OEM. Next we also have parties organizing the reverse chain, which can be the same parties, or foundations in case companies work together or even the state itself. Below these parties we have the two main reverse logistic activities, collecting and processing, which again can be done by different parties.

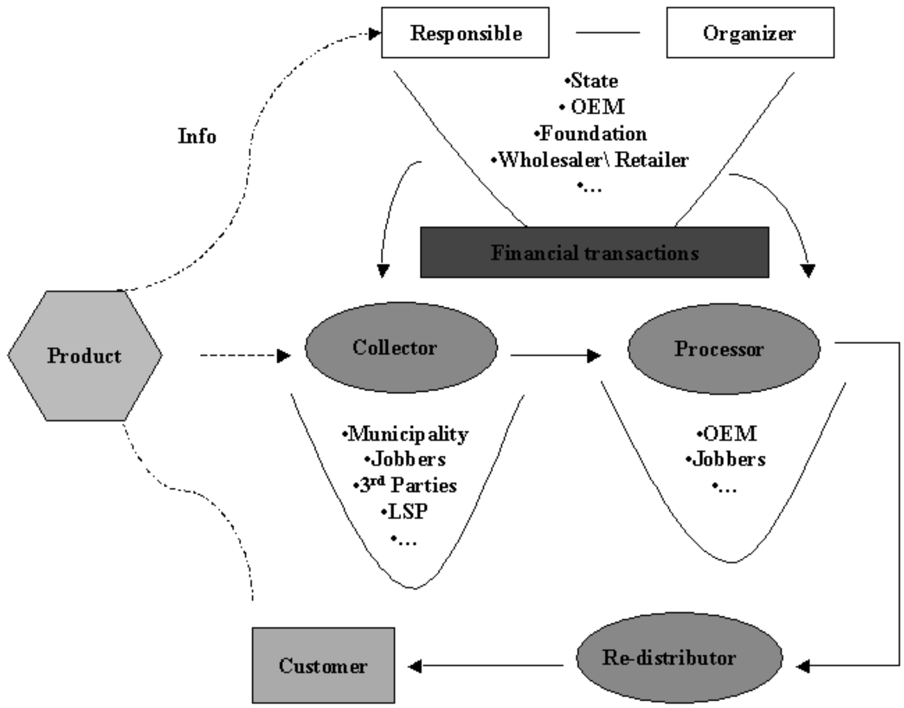

Figure 5: Who is who in reverse logistics

5 Why, what, how, who and reverse logistics issues

In principle every man-made product or system is returned or discarded at some point of its life. It is the paradigm of product recovery management that some kind of recovery and reverse logistics activities should have been planned for that moment. In many producer responsibility laws, the original manufacturer is made responsible in this respect. In the previous sections we gave context to Reverse Logistics by presenting brief typologies for the return reasons and driving forces (*why*), for the type of products (*what*), for the recovery processes (*how*) and for the actors involved (*who*). These four basic characteristics are interrelated and their combination determines to a large extent the type of issues arising from the resulting reverse logistics system (see illustration of Figure 6).

Table 1 encapsulates several case studies that serve to start the discussion on the type of issues arising from the resulting reverse logistics system.

Toktay et al. (2003) deal with forecasting issues and use the Kodak's remanufacturing of single-use cameras as an illustration. When the single-use camera is returned, some parts have not deteriorated at all during use (like the circuit boards) and they can feed again production of remanufactured cameras. Forecasting of the quantity and timing of returns is crucial when Kodak has to decide e.g. 1) the moment to introduce new products in the market (which will make previous circuit board obsolete); 2) the collection policy; 3) the procurement of new circuit boards; 4) the inventory management of new circuit boards.

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

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

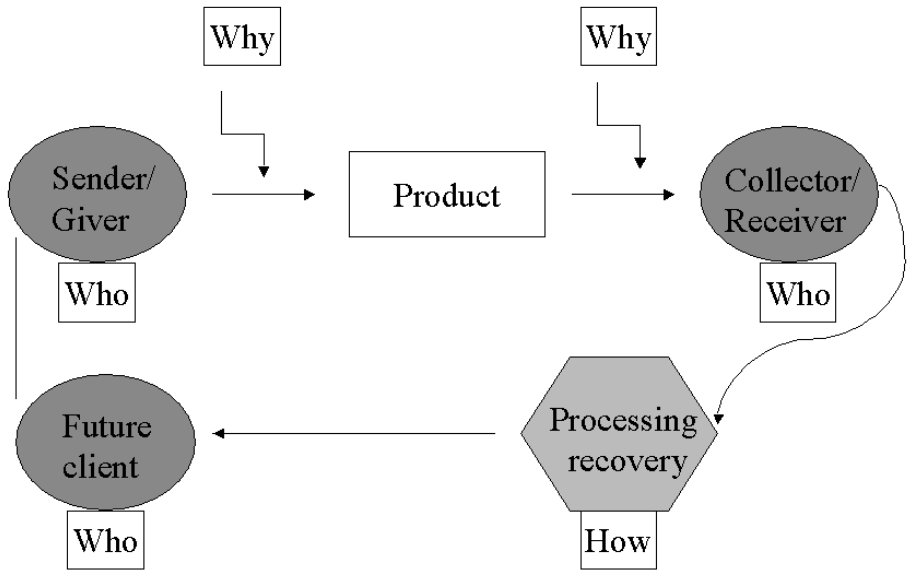

Figure 6: Why, how, what and who: basic interrelations

Fleischmann et al. (2003) discuss network decision-making by introducing the IBM case. In many countries IBM has a take-back program allowing business customers to return used products on top of the take-back responsibility that IBM has for the consumer market. IBM has set a business unit dedicated to the management of recovery with 25 facilities steering repair, remanufacturing and recycling (also with the involvement of third parties). IBM has to decide on how to organize the collection of product returns, and which parties involve depending on the processes required (see Who section). Reverse logistics networks have different aspects of forward logistic networks, as stressed by the authors and IBM has opted for different solutions depending on the region.

Beullens et al. (2003) present several examples of vehicle routing, among which is the case of a specialist recycler in the UK. This recycler collects products car repair centers, such as car batteries. The collection is organized by sectors. For some specific hazardous content, the collection (and transportation to destination) should not exceed 12 hours. One of the issues confronting this recycler is precisely the delineation of the sectors and the timing of collection. Besides this, different product streams correspond to different containers, complicating loading and unloading of vehicles, and vehicle routing as well.

De Brito and De Koster (2003) treat warehousing issues in reverse logistics, illustrated by the operations in the warehouse of a mail-order-company in the Netherlands, Wehkamp. The assortment consists mainly of fashion products and hardware, which can be returned at no cost for the customer. Wehkamp has to decide whether to combine, or not, forward flows with return flows in the warehouse. This decision can be taken for each operation stage, i.e. 1) transportation from and to the warehouse; 2) receipt at the warehouse; and 3) storage. Furthermore, Wehkamp has to invest in an information system because returns have to be tracked back, so the customer is not billed.

Van der Laan et al. (2003) consider the management of recoverable inventories giving the example of Volkswagen remanufacturing of car parts, which are subsequently sold as spare-parts. Demand does not always match supply of spare parts, requiring the production of new parts by Volkswagen. To decide are the moments of production and respective quantities. Extra complexity is added to the lack of control over returned parts, which actually can even not be remanufacturable if deterioration is large (see What section).

Kiesm*ü*ller et al. (2003) give attention to dynamic inventory control, with another example in the automobile industry, i.e. Daimler-Chrysler. This company remanufactures Mercedes Benz engines in a facility near by Berlin, in Germany. The authors go over the dynamic issues resulting from seasonal and life cycle effects. The engine life cycle is describes has having mainly two phases, i.e. a phase of increasing on sales followed by declining sales. In the first phase, the demand for remanufactured engines is higher than the supply of returned ones (as failures are scarce), and the other way around in the second phase. On top of this, the corporate policy does not allow reusable engines to be disposed, so they have to be (expensively) kept in inventory (see also the How section and the importance of future market for recovery economical feasibility).

As we described in the *How* section, reprocessing may involve several processes among which disassembly. Inderfurth et al. (2003) go into the details of scheduling of operations introducing the case of copier's remanufacturing by Xerox. The assembly of new and reassembly of refurbished parts is done in the same assembling line. This involves careful coordination of production and remanufacturing orders. Besides this, Xerox has to decide in which extent starts with disassembly of returned copiers, before having an order for refurbished parts. The authors present another case, Schering, a pharmaceutical company in Germany. During the manufacturing processes, some chemical by-products are relieved. These by-products contain valuable substances that after being regained can be used again in the production process. Both production and retrieval of substances is processed in batches, which share the same operators and the same multi-purpose containers. Again, coordination is essential here (with respect to production and retrieval operations). A complicating factor comes from the fast deterioration of some of the retrieved substances.

One of the key-actors in a reverse logistics system is the sender/giver of returned products, usually a customer (See Figure 6). Yet, customers can be more or less active concerning the returns. The following three examples illustrate differences in customer involvement: 1) to return bottles to the supermarket; 2) to send back a toner cartridge via mail (Bartel, 1995); and 3) to have a refrigerator collected at home (Nagel and Meyer, 1999). Some companies more or less obvious incentives to get products back, like deposit fees or charity's donations (see De Brito et al, 2003). Teunter and Van der Laan (2003) discuss one implicit incentive, i.e. the valuation of inventories in case of in-house returns. They illustrate some of the issues with a copier producer/remanufacturer that has a single European plant but several National sales organizations. The latter, purchase and return copiers to the plant, which uses internal "prices" to control the product flows. During the last years the plant has tried several price mechanisms in order to optimize profit.

As mentioned in the *What* section, products with hazardous content need special handling during recovery. Not only this, but one may be interested in the best way to handle it, so that the environmental impact is minimized. One of the techniques to assess environmental impact is Life-Cycle Analysis (LCA). E.g. Pappis et al. (2003) measure the environmental performance of associated with the recycling or disposal activities of a Greek lead recycler. In addition, Bloemhof-Ruwaard et al. (2003) take into account both economic and ecological impact. Two cases are considered by the authors. The first one is on the composition of the product, more specifically on design decisions for the recovery of refrigerators by a Japanese manufacturer. The second is on the network design for the of the pulp and paper industry in Europe.

Above we indicated some of the issues arising from reverse logistic systems, by citing twelve real-life situations. The exact influence of the four dimensions of the framework presented here (*why*, *how*, *what* and *who*) is still an open question that requires more investigation. Goggin and Browne (2000) try to predict the recovery type (in their case, remanufacturing, component recovery and material recovery) from product characteristics, like input product complexity and output product complexity, together with some other factors. The product complexity is defined after the number of levels and constituents in the Bill of Materials describing the product. Although the paper is an interesting contribution, we feel that more research should be done to validate the hypotheses, especially since more recovery options exist (such as reuse and refurbishing) and more types of products and systems should be considered (the authors restrict themselves to electronic products). De Brito, Dekker and Flapper (2003) provide an overview of some 60 cases on Reverse Logistics in which they also give an overview of the products handled. Half of their cases deal with metal products, machinery and equipment. Some 30% of the products processed are transportable goods like wood, paper and plastic products. Around 20% concern food, beverages, tobaccos, textiles and apparel. The authors derive several propositions related with the framework put forward here. Furthermore, Dekker et al., 2003 and De Brito et al. (2003)shed more light on the interrelations of the *why*, *how*, *what* and *who*.

6 Summary and conclusions

In this chapter we have provided a framework for the basic understanding of Reverse Logistics according to four perspectives: 1) *Why* are things returned? The answer included the forces driving companies to become active in Reverse Logistics, i.e. *Why-drivers*; and, the reasons for products going back in the supply chain i.e. *Why- reasons*; 2) *How* returns are processed? In this respect we described the overall activities in a reverse logistics process, and we gave special attention to recovery options; 3) *What* is being returned? The analysis comprised, on the one hand crucial product characteristics for reverse logistics, and on the other a classification of products types; 4) *Who* are is executing reverse logistic activities? Here, the inquiry was on the actors and their role in implementing reverse logistics;

More specifically, we have differentiated three driven forces for reverse logistics: 1) *Economics*; 2) *Legislation*; and 3) *Corporate citizenship*. In summary, companies become active in reverse logistics 1) because they can profit from it; or/and 2) because they have to; or/and 3) because they "feel" socially motivated to do it. We have also stressed that the economic gains can either be direct or indirect. For instance, a company may directly benefit from having reused materials as raw materials, but it may also be a strategy to improve its relations with customers. The three drivers are also interlinked and boundaries are sometimes blurred, and reverse logistics is often carried out for a mix of motives. The return reasons were organized according to three supply chain stages: 1) *manufacturing returns*, which embrace raw material surplus, quality-control returns, and production leftovers or by-products; 2) *distribution returns*, which include product recalls, returns coming back due to commercial agreements (B2B commercial returns), internal stock adjustments and functional returns; 3) *customer returns*, which comprise reimbursement guarantees, warranty returns, service returns, end-of-use and end-of-life returns.

The overall reverse logistics activities were confined to 1) collection, followed by 2) inspection / selection /sorting process; 3) re-processing, and finally 4) redistribution. The re-processing can be more or less light. We discriminated two groups: The first is of *direct recovery*, where returned products are in an as-good-as-new condition and so one can directly re-use, re-sale, and proceed to re-distribution. The second group, *process recovery*, is where more elaborated re-processing occurs. When zooming into reprocessing, we distinguished recovery options by occurrence levels (in great concordance with Thierry et al, 1995), that is 1) product level (*repair*); 2) module level (*refurbishing*); 3) component level (*remanufacturing*); selective part level (*retrieval*); material level (*recycling*); and, energy level (*incineration*).

On product characteristics, we qualified three as the main product features affecting reverse logistics: 1) the composition of the product; 2) the deterioration process; and 3) the use-pattern. On product types, we were inspired by the work of Fleischmann et al. (1997) and the UN product's classification, and the following types were differentiated: 1) civil objects; 2) consumer goods; 3) industrial goods; 4) ores, oils and chemicals; 5) packaging and distribution items; 6) spare-parts; and finally 7) other materials (like pulp, glass and scraps).

Regarding actors in reverse logistic systems, we divided them in three groups: 1) typical *forward supply chain actors* (manufacturers, wholesalers, retailers); 2) *specialized reverse chain players* (jobbers, remanufacturers, ...); and 3) *opportunistic players* (such as charities). With respect to their roles, one finds 1) that are actors that are actually *responsible* for operations in the reverse logistics chain; 2) others, that set up or combine operations, they have a role of an *organizer*; 3) many parties are busy carrying out the processes, like the collectors, so they play an *executer*; 4) there are the sender/giver that facilitates the product for recovery and the future client that will acquire recovered products, without which recovery would not make practical sense, so they have an *accommodator* role.

Finally, we have pointed out that the four perspectives of the reverse logistics framework not only give context to reverse logistics systems but their combination determines to a large extent the kind of issues that arise in implementing, monitoring and managing such a system. The precise influence of the four dimensions of the framework presented here (*why*, *how*, *what* and *who*) is still an open question that requires more investigation.

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