The University of Nottingham

Performance Measurement for Reverse and Closed-loop Supply Chains

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ABSTRACT

Supply chains today continue to have shorter life-cycle products as a result of high rates of innovation. The increasing number of electronic retailing and catalogue sales fulfil the requirement of home shopping. More liberal return policies have been introduced to protect customers' buying rights and at the same time generate more sales. A growing number of environmental regulations are created which involve a wide range of products. All of these circumstances contribute to the reverse flow of products which require manufacturing organisations to strategically manage and deal with the return flows. Reverse supply chains or reverse logistics have attracted the attention of many academics and practitioners and one of the important field studies in this area is of Supply Chain Management. To contribute to the field, this research is purposely carried out to study the performance measurement in reverse supply chains. Reverse logistics networks may be classified into several categories depending on the source of the reverse flow. This research will focus on customer and distribution return flows.

The research is significant because there is a gap in the literature and it could help to give companies guidance in managing their reverse supply chains better. Case studies on five companies which include manufacturers and retailers in the UK provide empirical evidence for their practice of performance measurement in reverse supply chains. The research investigates the selection of strategic objectives for reverse supply chains and the impact of product returns' characteristics and the choice of product returns disposition channels. Learning from the performance measurement in a reverse supply chain, the research proposes a three-level performance measurement framework model for reverse and closed-loop supply chains. This framework model provides the decision makers with a formal and systematic approach to select strategic objectives and towards the use of meaningful performance attributes and performance metrics. Subsequently, it offers a practical approach to the decision maker to perform and manage the reverse supply chain more effectively.

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ABBREVIATIONS

RSC	: Reverse Supply Chain
CLSC	: Closed-loop Supply Chain
PM	: Performance Measurement
PMS	: Performance Measurement System

Chapter 1

Introduction

This chapter introduces the research by providing the research background, research objectives, research questions and the scope of the research. Then, the research process is outlined and the chapter concludes with the thesis structure.

1.1 Background

Supply chains today continue to have shorter life-cycle products as a result of high rates of innovation. The increasing number of electronic retailing and catalogue sales fulfils the requirement of home shopping. More liberal return policies have been introduced to protect customers' buying rights and at the same time generate more sales. A growing number of environmental regulations are created which involve a wide range of products. All of these circumstances contribute to the reverse flow of products which require manufacturing organisations to strategically manage and deal with the return flows. Reverse supply chains or reverse logistics have attracted the attention of many academics and practitioners and one of the important field studies in this area is Supply Chain Management. To contribute to the field, this research is purposely carried out to study the performance measurement (PM) for reverse supply chain (RSC) and closed-loop supply chain (CLSC). Reverse logistics networks may be classified into several categories which depend on the source of the reverse flow. The research is significant because there is a gap in the literature and it could help to give companies guidance in managing their reverse supply chains better. Field studies will be carried out to investigate how companies measure and manage performance of their reverse supply chain operations. One of the key questions is whether there are differences between performance measurement in forward supply chains and in reverse supply chains. If yes, what are the differences and should the two supply chains' performance measurement be different. The difficulties in measuring performance will be studied along with the future needs. The key challenges will also be identified. The results from the field studies will be used to gain data on companies' current practice and also will help to construct a framework model to develop performance measurement guidelines for reverse and closed-loop supply chains. The field studies will include semi-structured interviews of five companies and a survey. The selected field studies are very important because there is no data found on how companies measure performance of RSC and CLSC operations. Furthermore, there is little empirical research related to strategic objectives linked to PM. Two main characteristics of product returns and two main characteristics of RSC are identified to assist with the selection of strategic objectives. Overall, the research will provide a better understanding of the relationship between strategic business objectives and performance measurement for RSC and CLSC.

1.2 Research Objectives

The main objectives of this research are:

- to investigate the need of performance measurement or performance management in reverse and closed-loop supply chains.
- to understand the current practice of performance measurement in reverse and closed-loop supply chains.
- to identify the differences between performance measurements of reverse and closed-loop supply chains and performance measurements of a forward supply chain.
- to provide guidelines for selecting an appropriate performance measurement in reverse and closed-loop supply chains.

1.3 Research questions

There are three major research questions in this context; focusing on how companies measure and manage performance of their reverse supply chain operations; to ascertain whether there any differences between performance measurement systems in forward supply chains and performance measurement systems in reverse supply chains; and to decide on an efficient way to set up performance measurement systems for reverse supply chain operations.
The main research questions are as follows:

i) How do companies measure and manage the performance of their reverse supply chain activities?

- Are companies having difficulties with measuring the performance of their reverse logistics operations? What are the problems?

- Do they have specific systems or frameworks in place? What is their methodology?
- Is the system/framework working properly in practice?
- What needs to be changed in future? What will be the key challenges?

ii) Are performance measurements in reverse supply chains different from performance measurements systems in forward supply chains?

- If yes, in what aspects?
- Should there be any differences? In what aspects should they be different and why?
- What does the literature say and what is the current situation practised by companies?

iii) What should companies do to ensure that their performance measurement is adequate?

- What should be the appropriate framework/methodology of performance measurement for reverse supply chains be?
- How important are life-cycle aspects?
- Should performance measurement for reverse supply chain be different for different products or sectors?

1.4 Scope of research

The research has the following scope:

- The research is mainly targeted on the RSC and CLSC of customer and distribution returns taking into account the characteristics of types of product returns at every life-cycle stage.
- The PM for RSC is focused at the first phase of PM development, which is identification of key objectives and defining measures.

The major contributions from this research are:

- to provide a better understanding of the relationship between strategic business objectives and program performance measurement in reverse supply chains
- a framework model to aid manufacturing organisations in designing their performance measurement systems in order to manage their reverse

supply chain activities successfully, in-house and for their third party logistics (3PL) providers.

1.5 Research process

The research has been conducted according to three stages. The first stage involves the acquisition and synthesis of knowledge on reverse supply chain management and performance measurement (PM). The second stage presents development of a framework model in designing PM for RSC and CLSC. The third stage marks the start of the empirical work and is composed of case studies involving five UK leading companies. The third stage also includes a survey conducted to complete the theory verification work.

1.6 Thesis outline

This doctoral thesis is structured into eight chapters which are divided into three distinct sections; the research background and overview, the framework development and empirical research, and the research conclusions. This thesis structure is illustrated in Figure 1.1.

Chapter 1 introduces to the reader an understanding of the overall research that includes the objectives, research questions, the scope of research, research process and the thesis outline.

Chapter 2 provides a background of reverse and closed-loop supply chains and reviews the characteristics governing the two types of supply chains. This chapter also highlights the research gaps in the existing literature.

Chapter 3 investigates the literature surrounding performance measurement, and reviews the type of existing conceptual frameworks. This literature is carried out to identify the appropriate methods in developing a PM.

Chapter 4 outlines the research methodology. The chapter justifies the methodology adopted for this research and explains the research design, the selection of case study, data collection methods, data analysis and limitations.

Chapter 5 establishes a three-level model framework which consists of a step-by-step *procedural framework*, a *structural framework* for identifying the right strategic objectives and an extensive list of performance attributes, with suggestion of performance metrics.

Chapter 6 reports the empirical findings from the case studies carried out with five companies. This chapter shows how this learning led to further understanding of the characteristics of product returns and RSC, and the practice of selecting strategic objectives for RSC and CLSC through segmentation of product returns. The results from a questionnaire survey are also discussed which contribute to the learning of performance measurement in RSC and CLSC. The chapter concludes with the discussion of key findings from the overall empirical works.

Chapter 7 summarises the knowledge gained from this research and reviews whether the research questions have been answered. This chapter includes: the research background and the research approach, and describes the research contributions to academia and industry. This chapter also describes the research limitations and directions for further research.

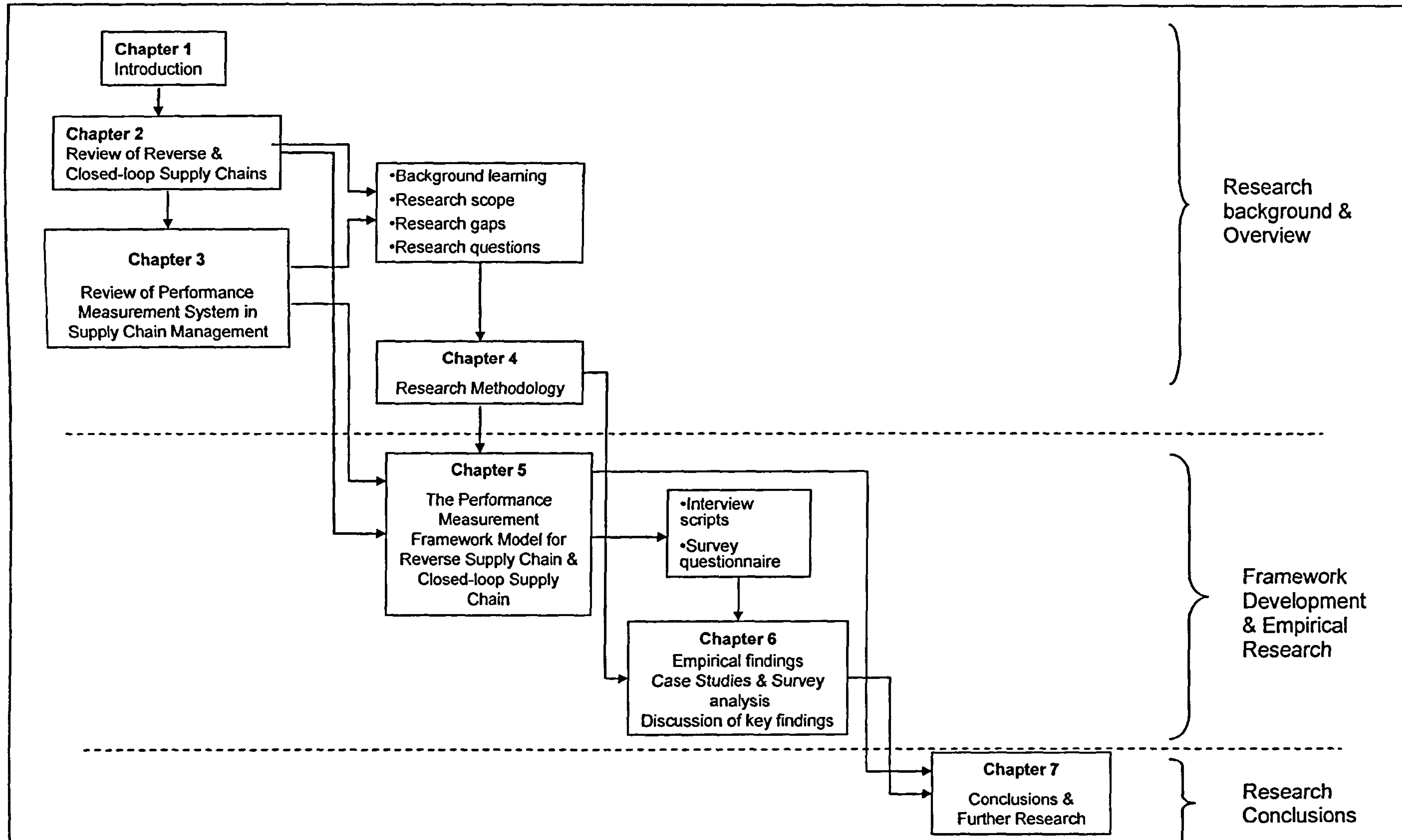

Figure 1.1: Thesis structure

Chapter 2

A review of reverse and closed-loop supply chains

In this chapter, the research questions listed in Chapter 1 are used as the contexts to understand the theoretical aspects of subjects discussed and to review the existing literature to support and analyse each subject. Basically, this thesis deals with two major areas; reverse and closed loop supply chains and supply chains' performance measurement. The latter will be discussed in the next chapter which will include the need of performance measures in reverse and closed-loop supply chains, and this chapter will focus on the first subject. The chapter starts with the definitions of reverse and closed-loop supply chains, linking to the activities and the players involved. Then, drivers of product returns and the types of product returns are studied. It is followed by the identification of collection and distribution methods and also the types of channel partners involved. It will then go on to the types of returns processing and disposition method and also types of secondary markets. Finally, facilitating factors in achieving effective CLSC are examined and the major constraints in management issues are identified.

2.1 Introduction

2.1.1 Reverse supply chain model

The forward supply chain can be viewed as the flow of materials, products and information from suppliers through production and distribution for final users (Schary, 2001). Reverse supply chain deals with the backward flows of product recovered from the users. This trend is happening for many reasons – the rise of electronic retailing, the increase in catalogue purchases, more self-service stores, a lower tolerance among buyers for imperfection - but few companies are dealing with it properly (Stock et al., 2002). A reverse supply chain is required when an additional supply of products come from the opposite direction of the main business. If there is a return stream interfering with the original product flow, there will be additional activities that need specific attention. This opens up a new dimension for managing the reverse flow of products. A reverse supply chain is a series of activities required to retrieve a used or unused product from a customer and either dispose of it, reuse it, or resell it (Guide and van Wassenhove, 2002). The activities related to the planning and execution of reverse supply chain operations are commonly referred to in the literature as 'reverse logistics'. The European Working Group on Reverse Logistics, REVLOG, defines Reverse Logistics as the process of planning, implementing and controlling backward flows of raw materials, in process inventory, packaging and finished goods, from a manufacturing, distribution or use point, to a point of recovery or point of proper disposal (source).

2.1.2 Closed-loop supply chain

At the end of every reverse supply chain, companies have the option to close the corresponding supply chain, by creating a loop after it or to leave it open, which means that products in the reverse chain will go to different 'destinations' from the original forward supply chain. These different 'destinations' are created when the returns are sold to brokers and recyclers, donated to charities or sent to landfills. Therefore, this concept is called closed loop supply chain where it consists of a reverse supply chain plus an extra loop to connect it to the original forward supply chain. It has to be noted that the returned product does not have to return to the production phase (initial phase) for the loop to be categorised as closed-loop. It can return to any phase along the forward supply chain (e.g. as spare components or refurbished products). As Guide and van Wassenhove (2002) define, a closed-loop supply chain (CLSC) includes the return processes, where the manufacturer has the intent of capturing additional value and further integrating all supply chain activities. Therefore, closed-loop supply chains include traditional forward supply-chain activities and the additional activities of the reverse supply chain.

In RSC and CLSC, the method to reach final destination where product returns are sent to; e.g. remarketing in secondary channel, dismantling for parts, recycling for raw material or landfill (disposal), is called disposition process, and the term disposition is used through out this thesis.

2.1.3 Open loop vs. closed-loop systems

Fleischmann *et al.* (2000) compare closed-loop and open loop systems. While both serve as product recovery networks, it is stated that the difference is essentially in the relationship between the incoming and outgoing flows of materials in these networks (Figure 2.1). Closed-loop systems are characterised by the formation of a flow "cycle" (Fleischmann *et al.*, 2000, pp. 660) since the sources of supply and falls in demand coincide. This is in contrast with open loops, where product flow enters and exits at two different points, in a "one way" configuration (Fleischmann *et al.*, 2000, pp. 660). In open-loop systems, products do not return to the original producers but will be recovered by other parties willing and able to reuse the materials and products (Kopicki *et al.*, 1993). Products are not returned to their original producer in open loop systems, but are used in other industries instead, such as recycling. In closed-loop systems however, products or packaging are returned to their original producers. An example of closed-loop activities would be remanufacturing and reuse (Fleischmann *et al.*, 1997).

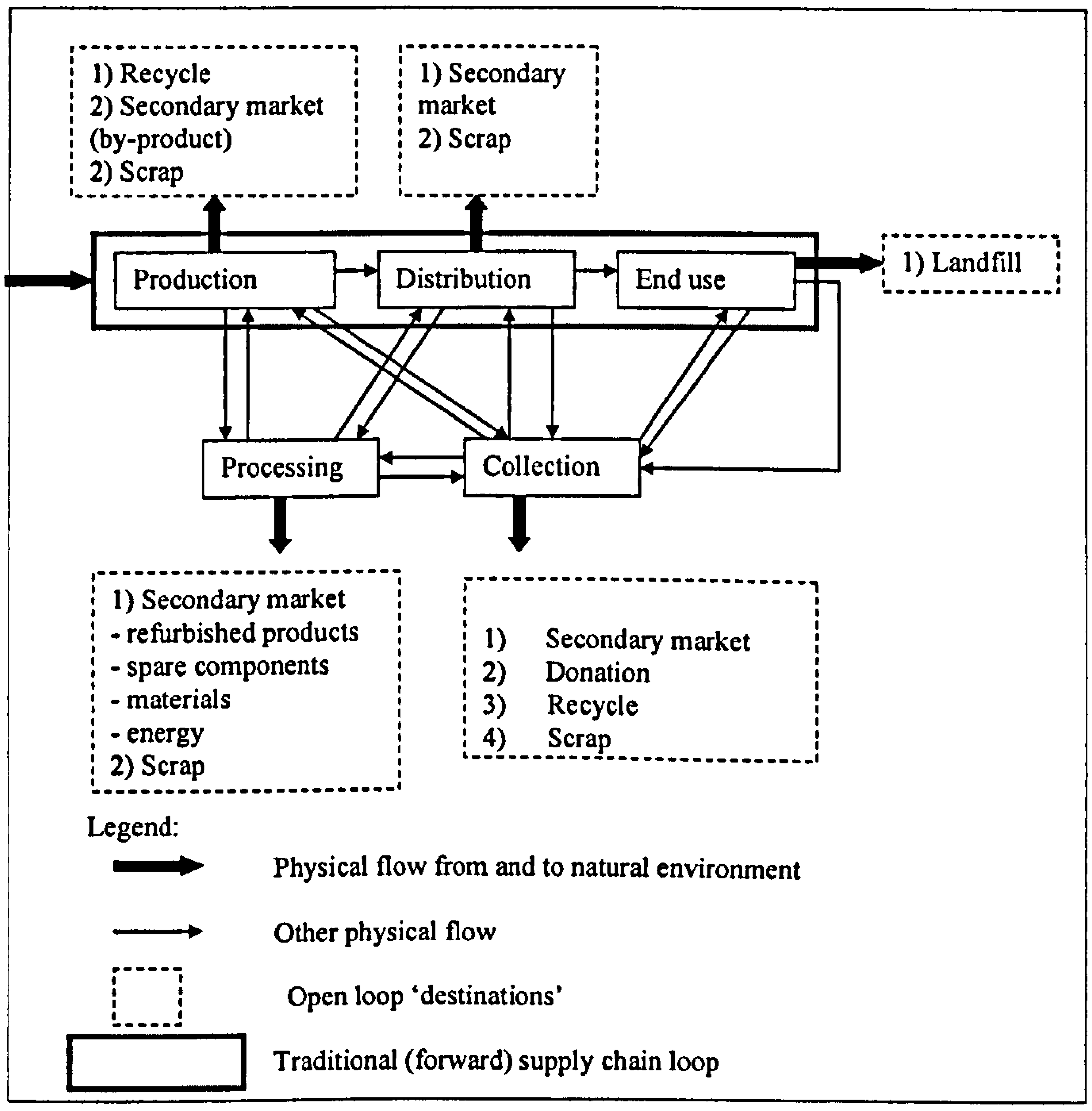

Figure 2.1. Closed-loops related to different phases in the life of a product [adapted from Flapper *et al.* (2005), with modifications made, marked in dotted lines]

2.1.4 Process route in reverse and closed-loop supply chains

For both open and closed-loops systems, there are extra activities involved in the overall process route in addition to the traditional forward supply chain activities. These additional activities include:

i) product acquisition to obtain the products from end-users;

ii) reverse distribution to move the products from the points of use to a point(s) of disposition;
iii) testing, sorting, and disposition to determine the product's condition and the most economically attractive reuse option;
iv) refurbishing to enable the most economically attractive of the options: direct reuse, repair, remanufacture, recycle, or disposal; and
v) remarketing to create and exploit markets for refurbished goods and re-distribute them

(Guide *et al.* 2003)

For a retailer, some of the products returned by customer are collected by suppliers from the retailer's warehouse. Therefore, only the first activity (product acquisition) affects the retailer, and the rest are carried out by the brand owner. However, usually all five activities are effected by any organisations who are operating on closed-loop supply chains. Case examples of open and closed-loop systems are shown in detail in Odeh (2008) and presented in Appendix 4.

To understand the whole concept of reverse supply chains, the characteristics of reverse supply chains have to be investigated. These characteristics are defined by the type of return products, the process, the players in each process and the drivers of the returns. In systematically identifying the underlying characteristics, they are based on the five activities governing the reverse and closed-loop supply chains as illustrated in Figure 2.2.

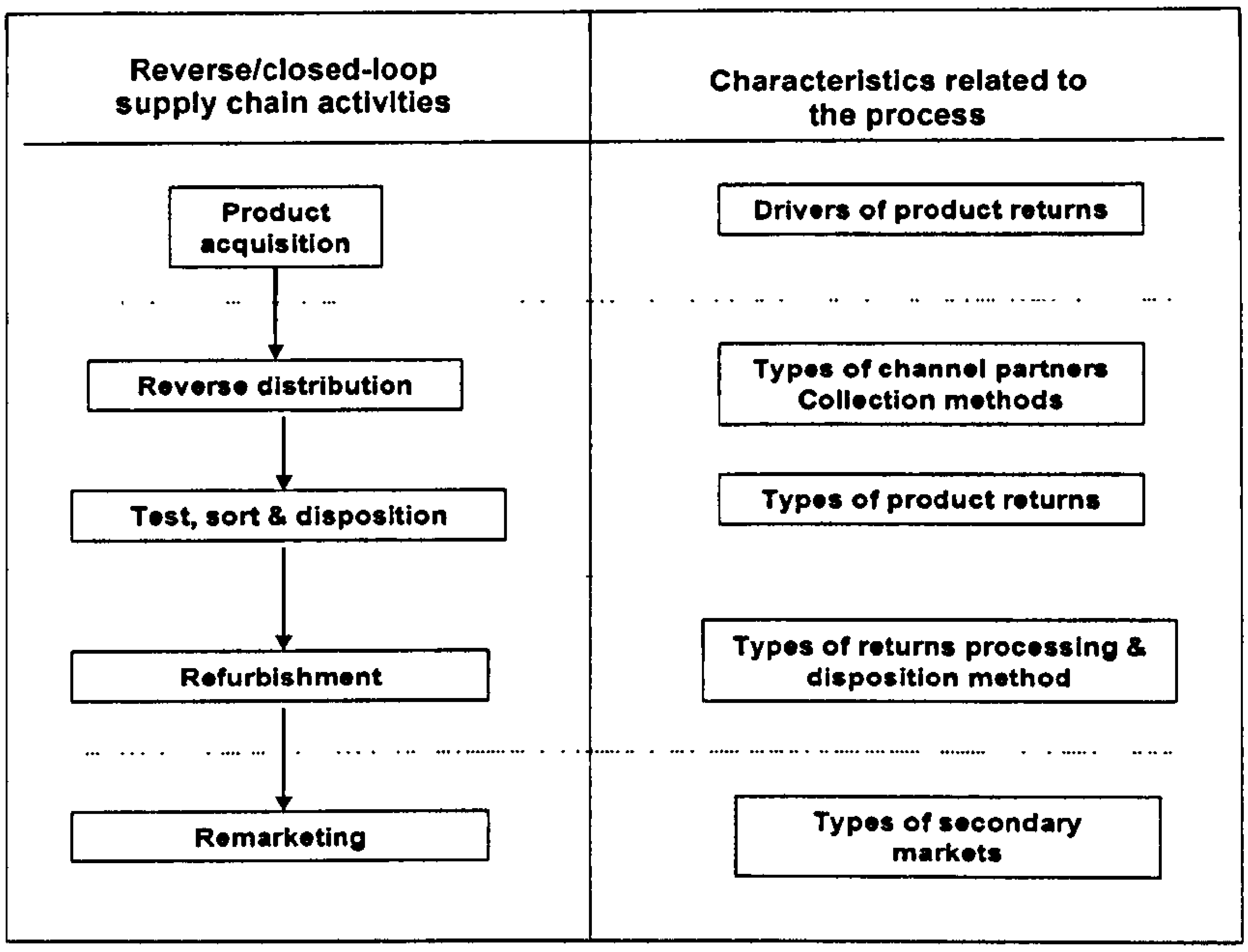

Figure 2.2 Characteristics of reverse/closed-loop supply chain according to the process/activities

2.2 Drivers of product returns

As mentioned in Chapter 1, this thesis concentrates on the management of product returns after they have left the manufacturer as finished products. The following section describes the characteristics of each type of product returns in a reverse supply chain system. Firstly, the reasons that products are flowing back from end customers must be studied. Users may return products for different reasons and at different stages in a product's lifecycle (Guide *et al.*, 2003). There are four main criteria identified by Fleischmann *et al.* (1997) to classify the situations in which reuse occurs. These are: the reuse motivation, the type of recovered goods, the form of reuse, and the involved actors.

Companies generally engage in CLSC activities due to economic drivers and environmental drivers (de Brito & Dekker, 2004; Guide *et al.*, 2003; Fleischmann *et al.*, 1997; Flapper *et al.*, 2005). De Brito & Dekker classify the types of drivers into three categories: economics, legislation, and corporate citizenship.

2.2.1 Business- economics

A direct economical benefit is the value that can be recovered from used products, such as components of electronic devices at the end of their useful life. The reuse option offers production cost and time saving where parts, components, materials and reusable packaging are reclaimed to the quality standard required and injected back into the forward supply chain (see case studies in Appendix 4). This view is supported by Flapper *et al.* (2005) who emphasise the fact that the role of operating in a closed-loop supply chain is closely related to the reduction of costs of several activities, including purchasing materials, production, distribution, and after-sales service. The reduction of costs resulting from fewer disposal activities involved is another major driver (Flapper *et al.*, 2005; Thierry *et al.*, 1995) especially given the significant rise in product disposal costs in recent years due to the scarcity of landfill and incineration capacity (Thierry *et al.*, 1995). Discarded materials can also have an economic value which is regarded as profitable by companies, such as scrap metal which can be recycled and mixed with virgin material later (de Brito & Dekker, 2004). Reverse logistics is also an effective option to clear out customers' obsolete or slow moving inventories, so that these customers can purchase more and newer goods (Andel, 1997).

Sometimes it is not the cost savings that attract companies to strive for effective reverse supply chain management. End-of-life products collection is initiated and reuse of product returns is maximised to achieve other strategic objectives. By collecting the high end products, companies are protecting their highly priced and new technology from entering competitor and grey markets. Companies in the same industry teamed up to instigate programs on finding alternatives to dispose of their products ethically and to examine better solutions in maximising the reuse option at component and part level. This is in attempt to prepare for any incoming legislation or even to avoid the necessity of legislation. The cost benefits from used product recovery can be passed down to customers, and offers an attractive option to customers which can improve a long-term relationship. This arrangement is discussed in Fleischmann *et al.* (2003) where it is highlighted that firms exploit product returns as a source of spare parts especially for service businesses.

2.2.2 Environmental legislation

In this area, Thierry *et al.* (1995) highlight the role of governmental action in encouraging companies towards reuse activities. It is stated that governments could take legislative actions such as banning the disposal of certain products, and obliging companies to take back their products at the end of their use. An example would be the producer responsibility laws, which are a set of legislative acts in the European Union (EU) by which companies are responsible for collecting and reusing their products (Guide and Wassenhove, 2001). A prominent element in these laws is the Waste Electrical and Electrical Equipment (WEEE) directive, which compels producers to be responsible for the handling of their end-of-life products, providing product information to the party in charge of its processing to ensure appropriate recycling, and establishing efficient collection systems where private households can dispose of unwanted products (de Koster *et al.,* 2005). Besides the product take-back laws directed for electronic and electrical equipment, Toffel (2003) specifies other take-back regulations in the EU mandating packaging (Packaging and Packaging Waste Directive), batteries (Germany's Battery Ordinance), and automobiles (Directive on End-of-Life Vehicles).

2.2.3 Corporate citizenship

While some actors in the chain have been forced to take products or packaging back, others have pro-actively done so to avoid the enforcement of regulations. Therefore, most companies have adopted reverse supply chain operations to pose corporate environmental responsibility and corporate sustainability. Being a 'green' company has become an important marketing element (Rogers and Tibben-Lembke, 1999). Most reuse programs and recycling activities are very attractive and are listed in the company's annual reports which are presented to shareholders and public bodies (e.g . Nike, British Telecoms, Xerox, and Rolls-Royce).

2.3 Types of product returns

Numerous classifications of product returns have been given by several authors in the past according to different categories. Fleischmann *et al.* (1997) give three categories; reusable packages, rotatable spare parts and consumer goods, and identify them according to the time taken before their function ends and the reason behind the reuse activity. Classification provided by de Brito & Dekker (2004) considers product returns classified according to three phases of forward supply chain: manufacturing, distribution and customer use returns. Return flows for each phase are listed according to the return reasons related. Rogers & Tibben-Lembke

(2001) broadly identify two types of reverse flows depending on the type of returns: reverse flow of products, and reverse flow of packaging. It is explained that each type has its own return reasons; for example packages such as bottles are returned to be reused, while some products are returned to recover remaining value by processes like remanufacturing, refurbishing, etc.

The following classifications are presented to address systematically the products returned at each process stage along the supply chain (please refer to Figure 2.3). At the manufacturing stage, any finished products that do not fulfil quality specifications are rejected and refurbished before entering the manufacturing line to be tested again. Any by-products from the manufacturing process are collected and reused or recycled especially if expensive raw materials are involved (Spengler, 1997). During the distribution of finished products, returns can result from any damage occurred during transit to retailers or shops. At the retailer or distributor points, product returns may come from stock adjustments, defective in storage and also obsolete products. At the last stage which is with the end user, products are returned because of liberal customer policies resulting in convenient returns. Other types of product returns from end customers are warranty returns, end-of-use returns (Schultmann *et al.*, 2003, Geyer and Jackson, 2004) and end-of-life returns (Toffel, 2003).

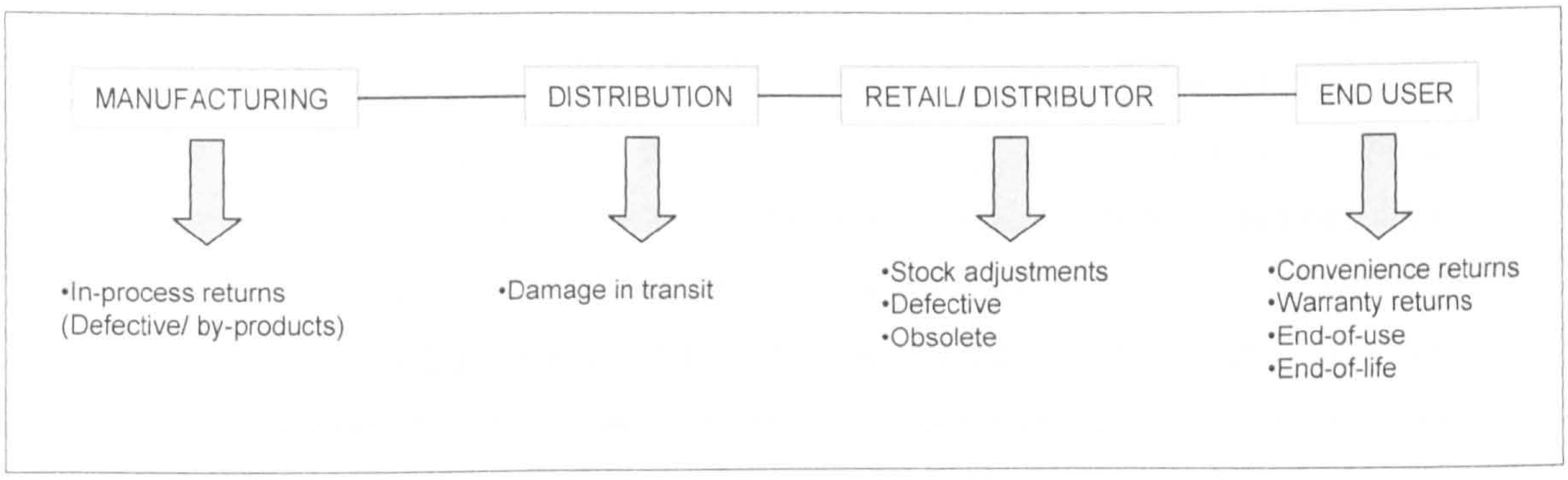

Figure 2.3 Types of products from each process stage

2.4 Collection and distribution methods and types of channel partners

One factor in achieving an effective reverse supply chain program is efficient establishment of schedules, transportation and networks. An example of such strategy is that of assigning supply trucks which carry new products and materials to nearby sites to backhaul the older parts and materials to the local supply location (Moore, 2005). For a recovery network which involves a closed-loop system, the network model described by Fleischmann *et al.,* (2001) is explored. There are three facilities involved:

- **disassembly centres** which house the inspection and separation activities
- **factories** for reprocessing and/or new production
- **distribution warehouses** to keep the inventory of unprocessed and processed returns

In general, the recovery networks form a 'bridge' between two markets, which act as the network boundaries, namely:

- **"disposer market"** where used products are set free by their former users
- **"reuse market"** with demand for recovered products

There are two major types of collection methods; centralised and decentralised. Every retailer with shops or stores is more likely to centralise the return authorisation (de Koster *et al.,* 2002). This allows the possibility of identifying the instant (time) for particular types and volumes of returns (quantity, quality and diversity) being collected. To study the differences between the concepts of centralisation and decentralisation, a case study which involves a manufacturer and two retailers by Savaskan and van Wassenhove (2006) is utilised. In the centralised system, the manufacturer collects the used products directly from the consumers (e.g., as in print and copy cartridges) whereas in the decentralised system, the two retailers collect the product returns (e.g., as in single-use cameras and cellular phones). The decentralisation of product collection activities results in incentives for retailers to reduce their margins with the expectation of compensation through buyback payments for returned products. In this case, the competition between the two retailers drives down the retail prices and the manufacturer benefits from this as sales volume increases.

In a RSC or CLSC, there are a number of channel partners involved along the supply chain. For companies operating in an open-loop system, reverse distribution may also be outsourced to other parties such as dedicated third-party logistics (3PL) providers. Besides logistics, outsourcing also applies to other activities such as sorting, repairing, recycling and disposal. The activities concerning customer contact, however, are less likely to be outsourced, such as complaint handling, administration and finance (Verstrepen, 2008). Nevertheless, some companies are seriously considering a "closed-loop" approach in order to achieve the best way to handle product returns, service contract returns, product recalls, used equipment and replacement parts for refurbishment, as well as reuse or sale as raw material (Moore, 2005).

Although the RSC could include the same channel participants as the FSC, usually the reverse flows are either supplemented or entirely supported by alternative channel participants (Prahinski and Kocabasoglu, 2005) as shown in Figure 2.4. One channel player which is involved in all links is an independent logistics provider, which is also a typical outsourcing service for FSC. When there is more than one party involved in the reverse supply chain, coordination is important. Information support is one way to develop linkages between channel partners to achieve efficient reverse logistics operations (Daugherty *et al.*, 2002).

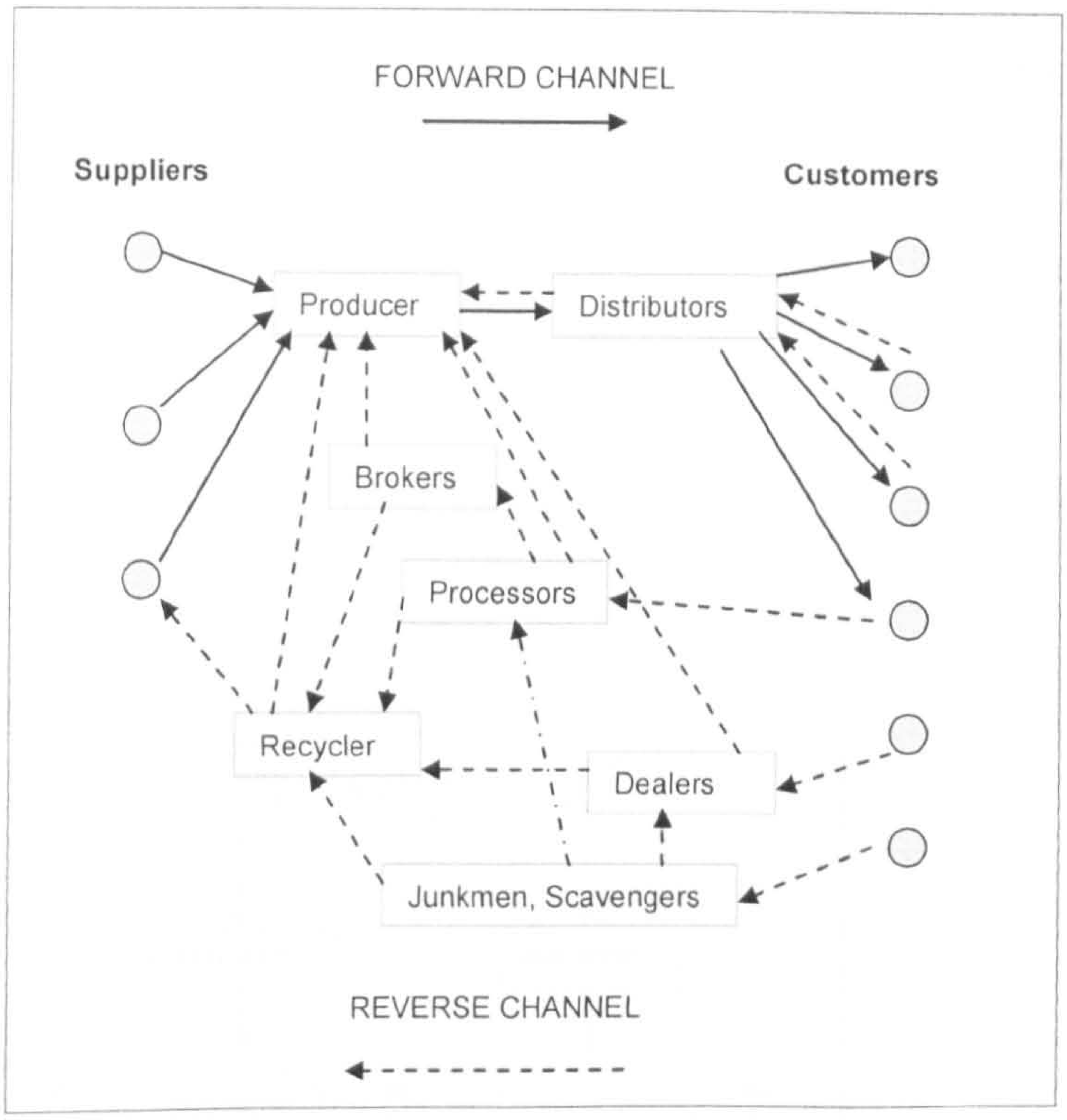

Figure 2.4 Channel partners involved in RSC and CLSC (adapted from Prahinski and Kocabasoglu, 2005)

2.5 Types of returns processing and disposition method

In RSC, there are additional processes when compared with FSC. The processes are dependent on the condition (quality) of the returns and the appropriate channels are chosen based on recovery options. The selection logic is described in detail by Rahimifard (2004) and illustrated in Figure 2.5. The main activities are highlighted with the process routes shown to match each decision taken. To understand these extra activities further in the reverse channel, this research refers to the analysis by Thierry *et al.* (1995) who presents a categorisation of product recovery options where each of them implies collection of used products and components, reprocessing, and redistribution. The only thing that is different involves the reprocessing activities. There are five main activities: repairing, refurbishing, remanufacturing, cannibalisation (in the context of component re-use) and recycling. *Repair* is done to return used products to "working order" by fixing or replacing broken parts. The quality of repaired products is generally lower than the quality of new products. *Refurbishing* requires replacement of critical modules if needed. The quality standards of refurbished products are varied; they can be less rigorous than, or as rigorous as, those for new products. *Remanufacturing* transforms the product up to the 'new' quality standards by products disassembly and extensive inspection on all modules and parts.

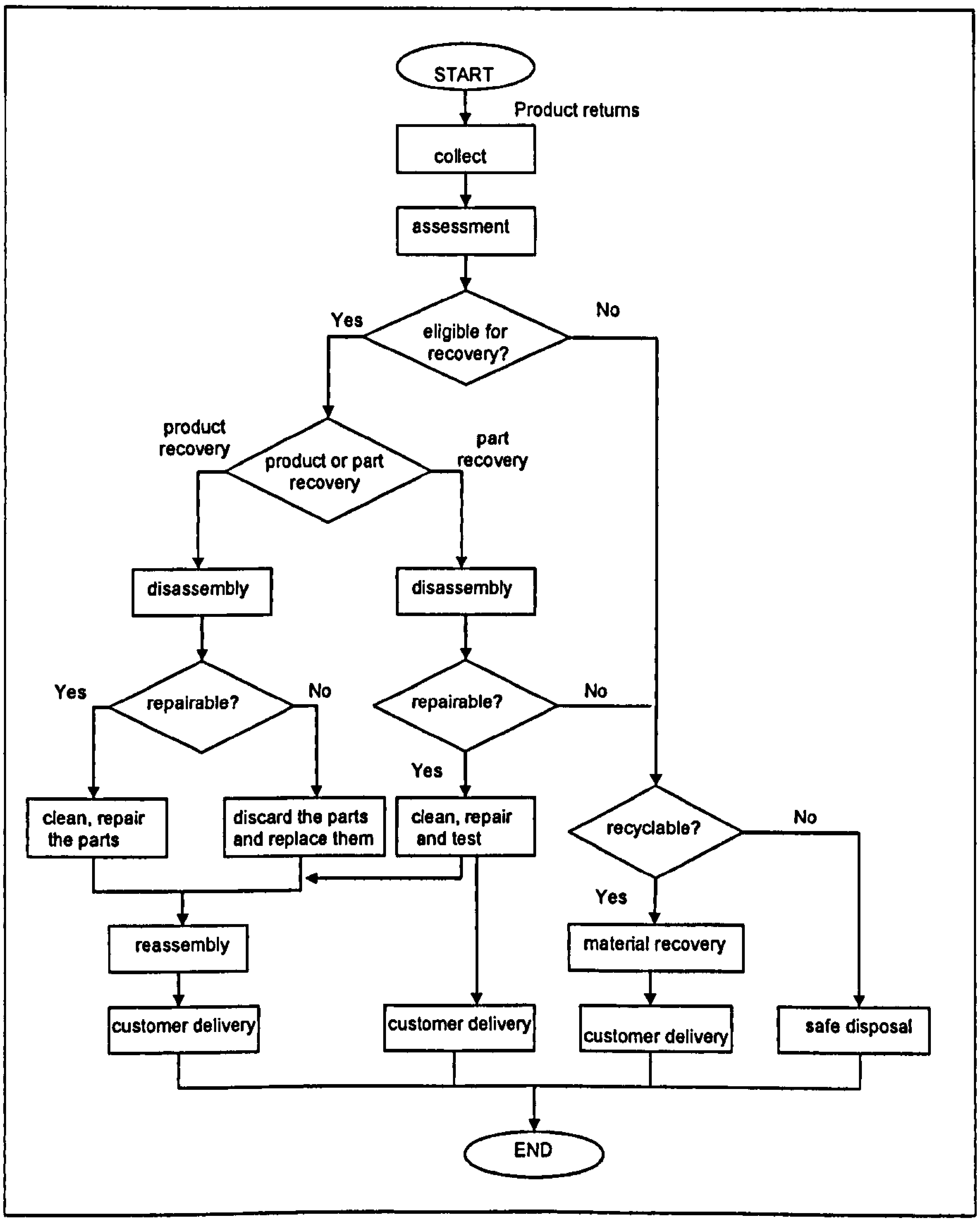

Figure 2.5 Process logic of product returns for RSC (adapted from Rahimifard, 2004)

Worn-out or outdated parts and modules are replaced and those are repairable are fixed and tested. *Cannibalisation* involves the work to salvage some parts to be reused in repair, refurbishing, or remanufacturing of other products and components. The process in which they will be reused will determine the quality standards of the cannibalised parts. Cannibalisation will select the parts to be reused and the remaining parts of the product are not needed. *Recycling* requires disassembly of parts where they are separated to acquire the distinct materials. In this process, the original physical and functional structures are not retained. Table 2.1 lists the main characteristics of, and differences between, those recovery options.

Table 2.1. Comparison between product recovery options

	Level of Disassembly	**Quality Requirements**	**Resulting Product**
Repair	To product level	Restore product to working order	Some parts fixed or replaced by spares
Refurbishing	To module level	Inspect all critical modules and upgrade to specified quality level	Some modules repaired/ replaced; potential upgrade
Remanufacturing	To part level	Inspect all modules and parts and upgrade to as new quality	Used and new modules/parts combined into new product; potential upgrade
Cannibalization	Selective retrieval of parts	Depends on process in which parts are reused	Some parts reused; remaining product recycled/ disposed
Recycling	To material level	High for production of original parts; less for other parts	Materials reused to produce new parts

(Thierry *et al.* 1995, p. 120)

At the strategic-planning level, the design of a RSC is greatly determined by the options for recycling or disposal (sinks) (Schultmann *et al.*, 2003).

2.6 Types of secondary markets

If the product returns fulfil the quality standard for direct resell, they will be re-stocked on the shelves at the premium selling price. With lower quality products, they will either sell in store at a much lower price or at designated clearance shops.

Many retailers, however, opted to sell low value product returns to brokers to be sold at other markets such as flea markets. Scrapping is a popular option too as it is the easier disposition choice.

2.7 Facilitating factors in achieving effective closed-loop supply chains

In identifying success factors in managing CLSC, the type of product recovery options used and the type of product returns should be considered. Guide and van Wassenhove (2003) used these two elements in identifying every success factor of each of their case study. For remanufacturing activities involving products such as photocopiers, these success factors are presented:

- Availability of the information systems that support the forecasting and control of returned goods in terms of time, quantity, and quality. The information must be accurately relayed to customers, and marketing schemes need to be developed to ensure that manufactured goods have the same quality as new goods.
- Strong supplier relationships that accommodate the reduction in the number of purchased parts and components, as well as the changes in design requirements.

Flapper (2003) emphasises that product design is also an important factor so product designers should consider the issues in the collection, disassembly, maintenance, and reassembly of products at the end of their use.

For remanufacturing of short life-cycle, highly seasonal consumer electronics such as laptops and mobile phones, Guide and van Wassenhove (2003) list the following factors:

- Ability to forecast the flow (supply and demand) of returned goods
- Ability to accommodate a fast and responsive recovery system, bearing in mind the perishability quality of the products
- The use of e-commerce in acquiring worldwide trading opportunities and in identifying technology differences between different countries.

Flapper (2003) highlights the selection of operations to be outsourced or those to be performed in-house as another key element of CLSC's success. Three activities are identified where companies have to make this decision:

- **Supply**

In acquiring the supply of returned goods, companies have the option of a bring system, where customers are responsible for returning their products. Alternatively, a pickup system could be used to collect returns, where the company either uses its own distribution system or outsources the collection process to a specialised service provider.

- **Processing**

A company may outsource some operations to other dedicated parties, or even to the owners of the products themselves, such as separating different coloured glass bottles and removing metal and plastic caps in households.

- **Distribution**

Although some companies use their own logistics for the distribution of recovered goods, most tend to outsource this activity in order to protect their image, and to accommodate to the geographically separated markets of new and recovered goods.

Another element contributing to the success factors is the use of internet and e-commerce Blumberg (2005). It is explained that web-enabled systems allow easy sharing and exchange of information, bringing buyers and sellers together in an online basis. This is particularly important in service parts supply chains since they reduce the need of companies to maintain high inventories. The internet is also a good marketing place for returned merchandise and in educating customers about products, thus reducing the numbers of returns resulting from misinformed customers (Blumberg, 2005 and Rogers & Tibben Lembke, 2002). Moreover, with the use of the internet, customers can manage their returns online (print shipping labels, track their returned products, etc.) reducing the need for interaction with employees, thus reducing costs for the vendor/ retailer (Blumberg, 2005).

Having a Centralised Return Centre (CRC) also contributes to the success of CLSC (Rogers and Tibben-Lembke, 2002). Any members of staff who work in a CRC are more familiar with returns handling and more likely to get specialised training in the area when compared with the in-store workers. Experienced workers play an important part in identifying defects in returned products and making the best disposition decisions thus cutting down the amount of time in sorting and grading incoming product returns.

Another advantage of having a CRC is the reduction of shipping costs since compiling returns in CRCs and moving them to their final destination in partial or full truckloads is more cost-efficient than shipping small batches from retailers to disposition channels. In addition, large volumes of product returns at CRCs are more attractive to brokers as they can gain more revenue than small quantities at retailers' stores.

Nonetheless, the final key element of success factors mentioned by Rogers & Tibben-Lembke (2002) cannot be applied to product returns with high obsolescence rate or even to high value items. The previous success factor corroborates the strategy that involves early disposition of returned products to prevent the loss of product value, as well as incurring additional costs. The longer a returned product is stored without sorting or processing, the higher the likelihood of its damage or obsolescence, in addition to the costs associated with its storage and material handling.

2.8 Constraints in management issues corresponding to effective closed-loop supply chains

One of the objectives in developing the performance measures for closed-loop supply chains is to control the process along the traditional and reverse supply chains from adapting the common issues of product returns handling. Even though there is the need of interdisciplinary research to understand and resolve the issues, this section will examine the how far they have been explored and relate how each of them can be measured periodically.

2.8.1 Variation of product-life stage for product returns

Companies with high product diversity may receive different combinations of both cost-effective and time sensitive product returns. At the same time, there are perhaps a number of products – each of which is at a different stage of its life-cycle - but entering the reverse supply chain within the same collection. Especially with remarketable products, this limitation requires specific strategy as discussed by Blackburn *et al.* (2004) and Guide Jr. *et al.* (2005) which basically groups the returned products according to the time-sensitivity towards value erosion.

For end-of-life returns, there are products that are typically not designed for end-of-life value recovery, increasing the probability to be sent to landfill. Geyer and Jackson (2004, p.59) relate this issue with three different constraints:

- limited access to end-of-life products leaving the use phase
- limited feasibility of end-of-life product reprocessing
- limited market demand for the secondary output from reprocessing

Any of these constraints can create inefficiencies that can completely dominate the economic and environmental performance of value recovery from end-of-life products (Geyer and van Wassenhove, 2002). Case studies carried out to research the best strategy to approach remanufacturing and reuse of end-of-life returns includes Spengler and Schroter (2003), Cattani and Souza (2003), and Teunter and Fortuin (1998). Disassembly and remanufacturing of end-of-life products can be difficult when the product designs do not support that objective.

2.8.2 Obsolescence point

Every reverse supply chain has five basic sub activities as described earlier in this chapter. The length of time for each activity differs from one reverse supply chain to another, and is based on the characteristics of the returned product and also the reverse supply chain activities involved. Therefore, the total time for the returned product to reach the final resale or reuse point is a significant aspect. This is highlighted by Blackburn *et al.* (2004) where lead time in processing time-sensitive returns, such as highly innovative electronic products, is vital in saving the crucial residual value for resale in the secondary market. A case study on HP (Guide Jr. *et al.*, 2005) also finds that the obsolescence issue is a major contributor of the value loss in its remanufacturing activity. The characteristics in each of the product's life-cycle stage must be recognized to maximise the value recovery of the returned product (Tibben-Lembke, 2002). Retailers with low margin merchandise also face obsolescence along the return process which can effect a significant profit loss when the product sorting and re-shelving take as long as three weeks (Norek, 2002). Obsolescence is a common problem when remanufacturing capacity does not match inventory holding capacity (Östlin *et al.*, 2008).

2.8.3 Uncertainty

The most recognized problem with handling product returns is the uncertainty of the incoming returns flow which relates to quality, quantity and timing (Guide and van Wassenhove, 2002). In recovery networks, uncertainty in terms of returns' timing and quantity may result in inconsistency between the supply and demand. It is also difficult to predict the level of quality and availability of returns received which highlight the importance of separation and inspection as part of the recovery process (Fleischmann *et al.,* 2001). Therefore, this issue makes supply uncertainty a major characteristic in a recovery network. Product diversity is also one main source of uncertainty (de Koster *et al.,* 2002).

Although Guide *et al.* (2003) identify that most companies do not have a mechanism for controlling the aforementioned uncertainty, de Koster *et al.*(2002) found that all nine retailers' warehouses in their case studies are capable of minimising the uncertainty on quality, quantity, time, and product diversity of returned products.

The case studies concentrating on uncertainty usually involve product acquisition management which includes de Koster *et al.*(2002), Guide and van Wassehove (2001), Guide and Jayaraman (2000), Zikopoulos and Tagaras (2007). Fleischmann *et al.* (2000) discuss the uncertainty relating to network design issues by referring to the case studies published earlier; Fleischmann *et al.* (1997), Krikke *et al.* (1999) and Thierry (1997).

When dealing with the first batch of reconditioned and refurbished products of a new model or a new version, the uncertainty in finding secondary markets and resale prices can also present difficulties (Prahinski and Kocabasoglu, 2005). Nonetheless, the level of uncertainty can be hugely affected by the external parties involved along the reverse and closed-loop supply chains, including suppliers, logistics providers, warehouse operators, buying firms and government (Carter and Ellram, 1998). Further study is carried out by Kocabasoglu *et al.* (2007) to investigate reverse supply chains investment decisions when responding to external factors that includes business climate such as rate of change in markets, competition, customer expectations and business relationships. These factors affect the level of revenue received from selling refurbished products and parts and also affect the level of cost to process and dispose the product returns.

Even though there is an assumption that 'return rates, quality, and timing are all outside the direct control of the firm' (Guide and van Wassenhove 2001, p. 144), there are emerging discussions such as Guide *et al.* (2005), Blackburn *et al.* (2004), Fisher(1997), Lee (2002) and Morana and Seuring (2007) which demonstrate that companies have the ability to devise strategies to attain the most effective and profitable returns management.

2.8.4 Cannibalisation & brand damage

The resale of product returns in the secondary market can potentially reduce the number of sales of new products in the primary market. Among the reasons to support this is the consumers' attention towards used, secondary rate products which are offered at a fraction of the price of new products whilst offering a similar level of function with new products though sometimes with cosmetic and outer packaging imperfections. From the Guide Jr. *et al.* (2005) project with HP on their refurbishment operation of notebooks and desktop PCs, the resale of returned equipments with lower functional quality has been suspected of damaging HP's brand name. Cannibalisation is also cited as a setback in the overall profit of an organisation when the sales in secondary channels are believed to reduce the new products' sales (Schatteman, 2003).

No particular research has been found which concentrates on the study of the effects of the sales in the secondary market by third party sellers, remanufacturers or by the original manufacturer on the sales of new products by the original manufacturer. Majumder and Groenevelt (2001) examine the competition between third party manufacturers and the original manufacturer on the cost and sales of recycled products and the cost of manufacturing new products.

2.9 Summary

This chapter is presented to discuss the background of reverse and closed-loop supply chains. It started with the definition of RSC and CLSC, and the differences between the two supply chains are discussed. The process governing the CLSC is further reviewed, consisting of five main activities. Then, the characteristics of RSC are analysed according to the each of the five activities mentioned. The characteristics are discussed based on types of product returns, collection and distribution methods, types of returns processing and disposition methods and types of secondary markets. Then, the facilitating factors in achieving effective CLSC are examined. Finally, a number of constraints in management issues is identified which needs to be addressed in order to achieve an effective reverse and closed-loop supply chain which requires a systematic monitoring system. The next chapter consists of a literature review on PM in supply chain management to investigate the requirement for setting up an efficient PM for a supply chain and to look at the existing PM frameworks and models in a forward supply chain.

Chapter 3

A review of performance measurement in supply chain management

This chapter provides an overview of the existing performance measurement (PM) literature on forward supply chains. The chapter starts with the definitions of the context and the importance of PM in forward supply chains. Then, the categorisation of individual PM is recognized and the PM at various hierarchical levels is addressed. Next, a review of previous conceptual PM frameworks in the supply chain based upon different concepts is studied. This section of the chapter has been divided into three parts. The first part deals with the classification of PMS. The second part discusses the structural frameworks, and the final part examines the procedural frameworks. Finally, the need for PM in RSC and CLSC is identified and the research gaps are presented.

3.1 Introduction: the concept of performance measurement in supply chain

To manage the reverse and CLSC strategically, companies have to recognize carefully all kinds of issues that arise in implementing, monitoring, and managing these activities so that optimal value recovery can be obtained from the returned products. This outcome is commonly desired by all companies engaged in managing reverse supply chains and should be expressed in their strategic objectives. To meet the objectives, the output of the processes must be measured and compared with a set of standards (Gunasekaran *et al.*, 2004). Furthermore, performance measurement is an activity that managers carry out in order to reach predefined goals that are derived from the company's strategic objectives (Lohman *et al.*, 2004). Therefore, in order to derive the maximum benefit from reverse supply chain operations, a company should monitor its reverse supply chain activities through a performance measurement system that can effectively give true results, according to the characteristics of the products' return types and the nature of its reverse supply chain network.

Research on PM has gone through several phases since 1970s, where researchers examined how organisations used accounting systems especially budgeting as tools for performance measurement. In the 1980s, the focus was put essentially on the budgeting process and its impact on performance. The inadequacies of using only financial PM in manufacturing have been well documented in the literature (Medori *et al.,* 1995). Therefore, throughout the 1990s, performance measurement incorporating non-financial measures has been a topic of great interest. The scope of the research on performance measurement began to broaden at the beginning of the 1990s. Dixon et al. (1990) and Kaplan and Norton (1992, 1993, 1996) developed new perspectives and frameworks to organize PM. Nanni *et al.* (1992) suggested that firms should increase their level of PM competence. The degree of competence would depend on the fit between the design of the PM and the strategy of the firm. Kaplan and Norton suggested that the performance of the firm would increase with the use of a balanced scorecard. Only a few empirical studies were conducted during the 1990s and they have not really been able to test the extent to which these prescriptions are followed by organisations and their impact on the performance.

The works of various authors in academic journals, publications in practitioner-oriented and in books are used in establishing the need for supply chain PM and to describe in general terms how it should be addressed – emphasis is on measurement systems and approaches as opposed to specific measures. Neely *et al.* (1995) define a performance measurement system (PMS) as the set of metrics used to quantify both the efficiency and effectiveness of actions. According to Beamon (1999), however, it holds more than metrics. She stresses that a performance measurement research should focus on three outlines: analyzing performance measurement systems that are already in use; categorising performance measures and then studying the measures within a category; building rules of thumb/ frameworks by which performance measurement systems can be developed for various types of systems. Wisner and Fawcett (1991) identify the need for performance measures to be reviewed and changed to ensure that measures remain relevant in the last step of their nine step process. They highlight the need to "re-evaluate the appropriateness of the established PMSs in view of the current competitive environment". Bititci *et al.* (2000) acknowledge the need for PMSs to be dynamic to reflect changes in the internal and external environment; review and prioritise objectives as the environment changes; deploy changes in objectives and priorities; and ensure gains achieved through improvement programmes are maintained.

3.1.1 Defining performance measurement

As PM is a subject that is often discussed but rarely defined, it is necessary to clarify its meaning more clearly. Neely *et al.* (1995) describe performance measurement as the process of quantifying action, where measurement is the process of quantification and action correlates with performance. They also propose that performance should be defined as the efficiency and effectiveness of action, which leads to the following definitions (adopted in this doctoral thesis).

- *Performance measurement* (PM) is defined as the process of quantifying the efficiency and effectiveness of action.
- A *performance measure* is a set of a metrics used to quantify the efficiency and/or effectiveness of an action.
- A performance metric is a definition of the measure, how it will be calculated, who will be carrying out the calculation, and from where the data will be obtained.

The definition of performance attributes is adapted from SCOR version 7.0 which is as follows:

'The Performance Attributes are characteristics of the supply chain that permit it to be analyzed and evaluated against other supply chains with competing strategies.'

(SCOR version 7.0)

A performance measurement system (PMS) is a system that is clarifying PM boundaries, specifying PM dimensions or views and may also provide initial intuitions into relationships among the PM dimensions (Rouse and Putterill, 2003).

3.2 Categorisation of individual performance measures

As there is a large number of performance measures discussed in the literature, this thesis considers how they are categorised. In the earlier literature, performance measures were usually divided into *cost-related* and *non-cost-related* performance measures. The usefulness of such classification, however, is undeniably limited. A more informative and commonly used classification is to group individual performance measures in terms of the five manufacturing performance objectives (Slack *et al.*, 2001):

- Quality
- Speed
- Dependability

- Flexibility
- Cost

As illustrated in Table 3.1, many examples of different performance measures are listed under these five categories. Furthermore, in this classification, product-and-process development performance measures belong to the flexibility category. Nonetheless, several authors suggest that these types of performance measures should have their own category called *innovativeness* (or innovation), because of the recent growth of knowledge-intensive areas in the industry (Jackson, 2000), (Hall *et al.,* 1991).

White (1996) introduces another classification by further extending the five performance objectives by dividing individual performance measures into the following taxonomy:

- *Source of data-* internal (data from sources within the organisation) or external (data from sources outside the organisation)
- *Type of data* – subjective (based on perception or opinion) or objective (based on observable facts not involving opinion)
- *Reference* – benchmark (compares an organisation with others) or self-referenced (does not involve any comparison with another organisation)
- *Orientation to process* – input to some process or outcome of some process

Table 3.1: Typical individual measures of performance (Slack *et al.,* 2001), (Wisner and Fawcett, 1991)

Performance objective	Some typical performance measures	Performance criteria that link firm strategy to operations decisions
Quality	Number of defects per unit Level of customer complaints Scrap level Warranty claims Mean time between failures	% defect reduction % scrap value reduction % unscheduled downtime reduction % supplier reduction % of inspection operations eliminated
Speed or innovation	Customer query time Order lead time Frequency of delivery Actual versus theoretical throughput time Cycle time	% increase in annual investment in new product and process research and design % reduction in material travel time between work centres % increase in annual number of new product introduction % increase in common parts per product
Dependability	Percentage of orders delivered Average lateness of orders Proportion of products in stock Schedule adherence	% reduction in purchased lead time % reduction in lead time per product line % increase in portion of delivery promises met
Flexibility	Variance against budget Utilisation of resources Labour productivity Added value Cost per operation hour Minimum delivery time/average delivery time	% inventory turnover increase % reduction of employee turnover % improvement in labour/ desired labour % reduction in total number of data transactions per product % average set-up time improvement per product line

This classification shows that PM is not just a question of tracking a few important performance objectives within the company. PM can also be extended to include various perspectives, including competitors, suppliers and customers and it must rely on both tangible and intangible data.

Flapper *et al.* (1996) introduce a classification of performance measures involving three intrinsic dimensions:

- *Decision type- strategic/ tactical/ operational.* This dimension focuses on the kind of decision the measure is meant to support.
- *Aggregation level- overall/ partial.* This dimension tells if the measure is of overall or partial nature.
- *Measurement unit – monetary/ physical/ dimensionless.* This dimension relates to which unit the measure is expressed in.

As stated earlier, classifications of performance measures can be very useful to the measurement practitioner as sources for finding potential performance measures. An important point that must be emphasized, however, is that a classification does not necessarily give an appropriate summary of what performance measures a particular company should include in its PMS. The design of a PMS should be derived from a company's strategic objectives and some strategic objectives can in turn make a category of performance measures unusable.

3.3 Performance measures at various hierarchical levels

In the previous section it was stated that a performance measure could be categorised according to what type of decision it is meant to support. This issue leads to another important discussion. Namely, different performance measures are needed for various hierarchical levels of an organisation. For instance, the management of a company will not have the same performance measures as the personnel working at an assembly line. Nevertheless, it is vital that there is a clear link between the performance measures at all hierarchical levels, so that each function in a company works towards the same objectives. Normally, most decisions in the top of an organisation have a strategic focus, while decisions at lower levels are more tactically and operationally orientated:

- At the *strategic level* performance measures are related to decisions having effect on issues with a time scale of several years. Such measures can tell an organisation about the soundness of their strategic decisions.
- At the *tactical level* performance measures covers from a monthly up to a yearly period, and can be said to encompass issues such as which suppliers are used, which overall manufacturing technologies are utilised etc. These measures are important in setting boundaries for the actual operations of the organisation.
- At the *operational level* performance measures deal with operations and business processes of the organisation on a daily, weekly or monthly basis.

Clearly, to have a strategic performance measure without related tactical and operational measures is not appropriate (Flapper *et al.*, 1996). In other words, it is important that a performance measure can be divided and correlated between these three levels. As shown in Figure 3.1, a performance measure at the strategic level should be broken down into specific measures in the tactical level, and further down to the operational level (Jackson, 2000).

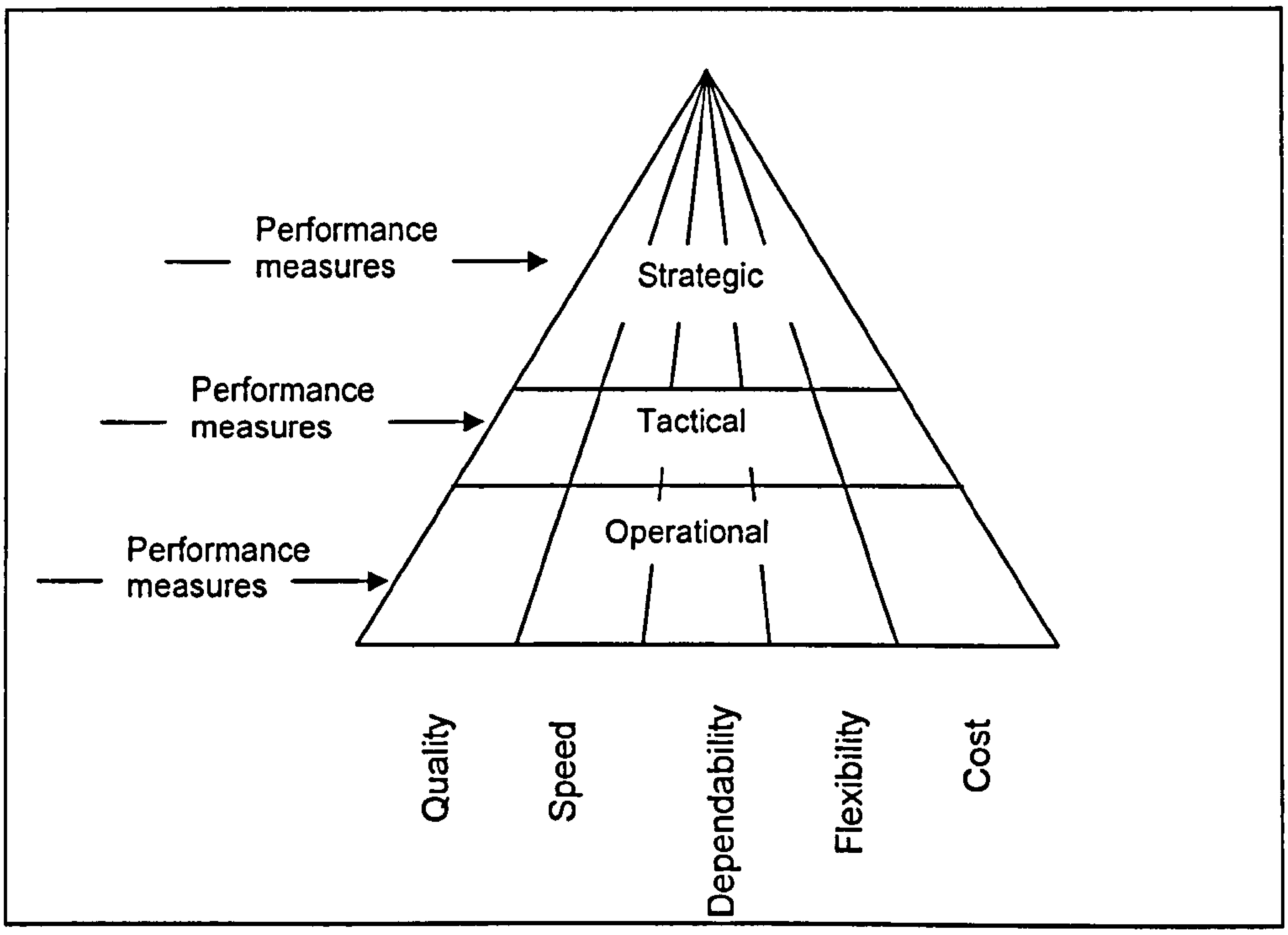

Figure 3.1 Performance measures of three different levels (modified from Jackson, 2000)

3.4 Existing frameworks and models for PM

In the previous sections, different types of individual performance measures have been classified in a number of ways. Now the discussion turns to the more extensive conceptual frameworks that have been developed in order to help measurement practitioners to design PMS. Some of these frameworks are very strict about which performance measures will be included in the PMS. Others emphasise that a company should have a unique PMS and guide the measurement practitioners on how to select and design performance measures. All conceptual frameworks, however, universally endorse a particular typology (or arrangement) in which the performance measures in the PMS must be structured. They are also mainly focused on the first of the four phases of PMS development (see section 1.5).

3.4.1 Classification of PMS

In a PMS a set of measures is combined in order to get a complete picture of the performance of a company. Toni and Tonchia (2001) identify five typologies describing the classification of existing PMS in the literature.

1. *PMS that are strictly hierarchical,* characterised by cost and non-cost performance on different levels of aggregation, till they ultimately become economic financially (see for example: Lockamy and Cox, 1994).
2. *PMS that are "balanced scorecard",* where several separate performances, which correspond to diverse perspectives (financial, customer, etc), are considered independently (Kaplan and Norton, 1992), (Maskell, 1991).
3. *PMS that can be called "frustum",* where there is a synthesis of low-level measures into more aggregated indicators, but without the scope of translating non-cost performance into financial performance (Cross and Lynch, 1992).
4. *PMS that distinguish between internal/external performances* (Thor, 1993).
5. *PMS that are related to the value chain* (Sink and Tuttle, 1989), (Moseng and Bredrup, 1993).

The models described above can in turn be distinguished by three different architectonic connotations: *vertical (or hierarchical), balanced (or a "tableau")* and *horizontal (or by process).* These architectonic connotations lead to the classification of PMS illustrated in Figure 3.2 (Toni and Tonchia, 2001).

<table>
<tr><td>Architecture Vertical</td><td>strictly hierar-chical models</td><td></td><td rowspan="2">Frustum models</td><td></td><td></td></tr>
<tr><td>Architecture Balanced</td><td></td><td>"balanced score-card" models</td><td rowspan="2">Models with internal-external performances</td><td></td></tr>
<tr><td>Architecture Horizontal</td><td></td><td></td><td></td><td>Models related to the value chain</td></tr>
</table>

Figure 3.2 : Classification of PMS (Toni and Tonchia, 2001)

The discussions of PM for supply chain management that consists of frameworks, models and systems can be segregated into two groups; *procedural and structural* (Folan and Browne, 2005). The *procedural* element in PM defines the step-by-step method of how to design a PM elaborated from a specific strategy. *Structural* element on the other hand highlights the administrative and selection elements of the PM process. A structural framework commonly specifies a typology for performance measure management. Folan and Browne also point out that an important rule for a successful PMS should consist of both procedural and structural frameworks, with an addition of other performance management tools such as lists of measures, etc. The following review on PM frameworks and models will adapt Folan and Browne types of classification.

3.4.2 Structural PM frameworks

A number of frameworks are being examined in order to search for a suitable template. The shortcomings of traditional measurement systems have triggered a performance measurement revolution (Eccles, 1991; Neely, 1999). The following publications emphasise that there are ongoing needs for more relevant, integrated, balanced, strategic, improvement oriented and dynamic PM. This resulted in the development of frameworks, models, methodologies, tools and techniques to facilitate the development of new PM. There are many *structural* PM frameworks which incorporate a number of different perspectives such as financial vs. non-financial, internal vs. external and etc.

Performance Measurement Matrix (Keigan *et al,* 1989)

Similar to the Balanced Scorecard but not as an extensive framework is the *performance measurement matrix* (Figure 3.3), which promotes PMS that integrates four different classes of business performance: cost and non-cost, internal and external.

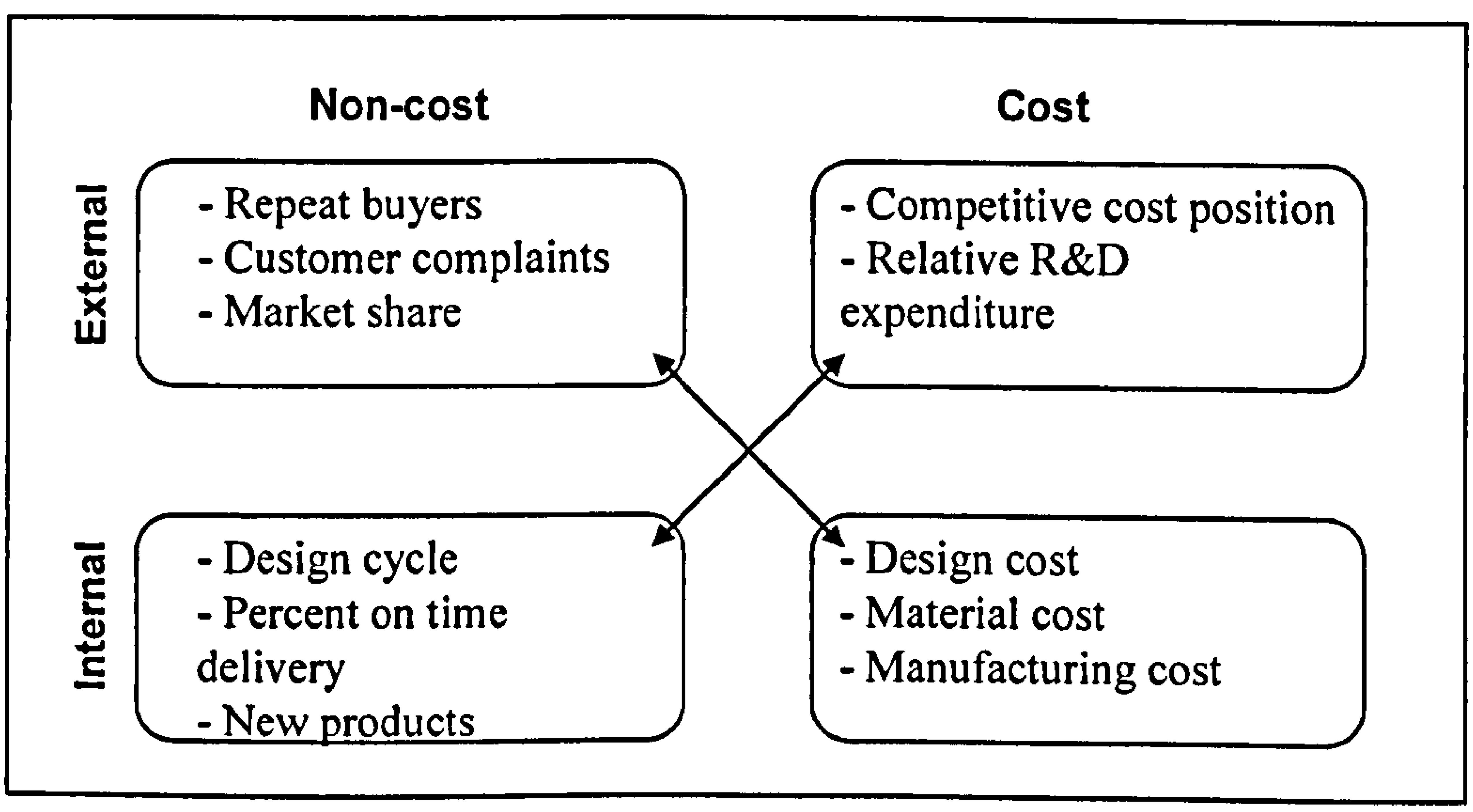

Figure 3.3 The performance measurement matrix (Keegan *et al.*, 1989)

The Balanced Scorecard (Kaplan and Norton, 1992)

One of the most well known conceptual PMS frameworks is the Balanced Scorecard which employs performance metrics from four perspectives (Figure 3.4):

- financial (how do we look to shareholders?)
- customer (how do customers see us?)
- business process-internal (what must we excel at?)
- technology perspectives- innovation and learning (can we continue to improve and create value?)

By combining these different perspectives, the balanced scorecard focuses to help managers understand the interrelationships and tradeoffs between alternative performance dimensions and leads to improved decision making and problem solving. Each balanced scorecard is distinctive from one company to another and it contains a set of measures that is derived from strategic goals of the particular company.

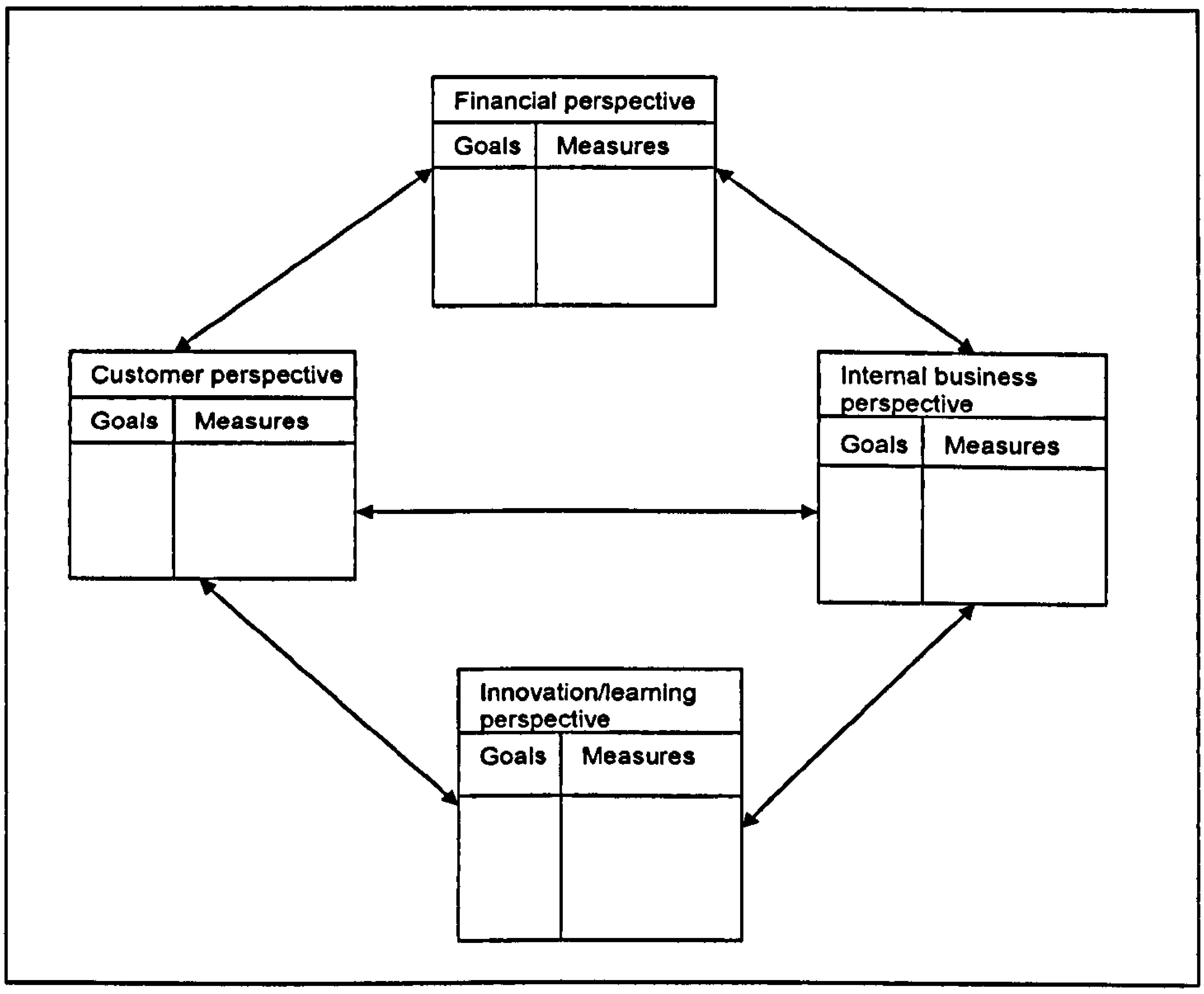

Figure 3.4: The balanced scorecard (Kaplan and Norton, 1992)

The performance pyramid (Cross and Lynch, 1992)

An important requirement of a PMS is that there must be a clear link between the performance measures at the different hierarchical levels in the company, so each function and department strives towards the same goals. One example on how this link can be achieved is through the *performance pyramid* (Figure 3.5), which is called SMART - strategic measurement analysis and reporting technique. The model proposes to break down the objectives of the company along four levels and starts at the top of the pyramid with the *company's vision*. The second level, *business units*, comprises the company's key results, objectives and measures in two ways: reaching short-term targets of cash flow and profitability; and achieving long-term goals of growth and market position. The *business operating system* bridges the gap between top-level and day-to-day operational measures. Finally, four key performance measures are used at departments and work centres on a daily basis.

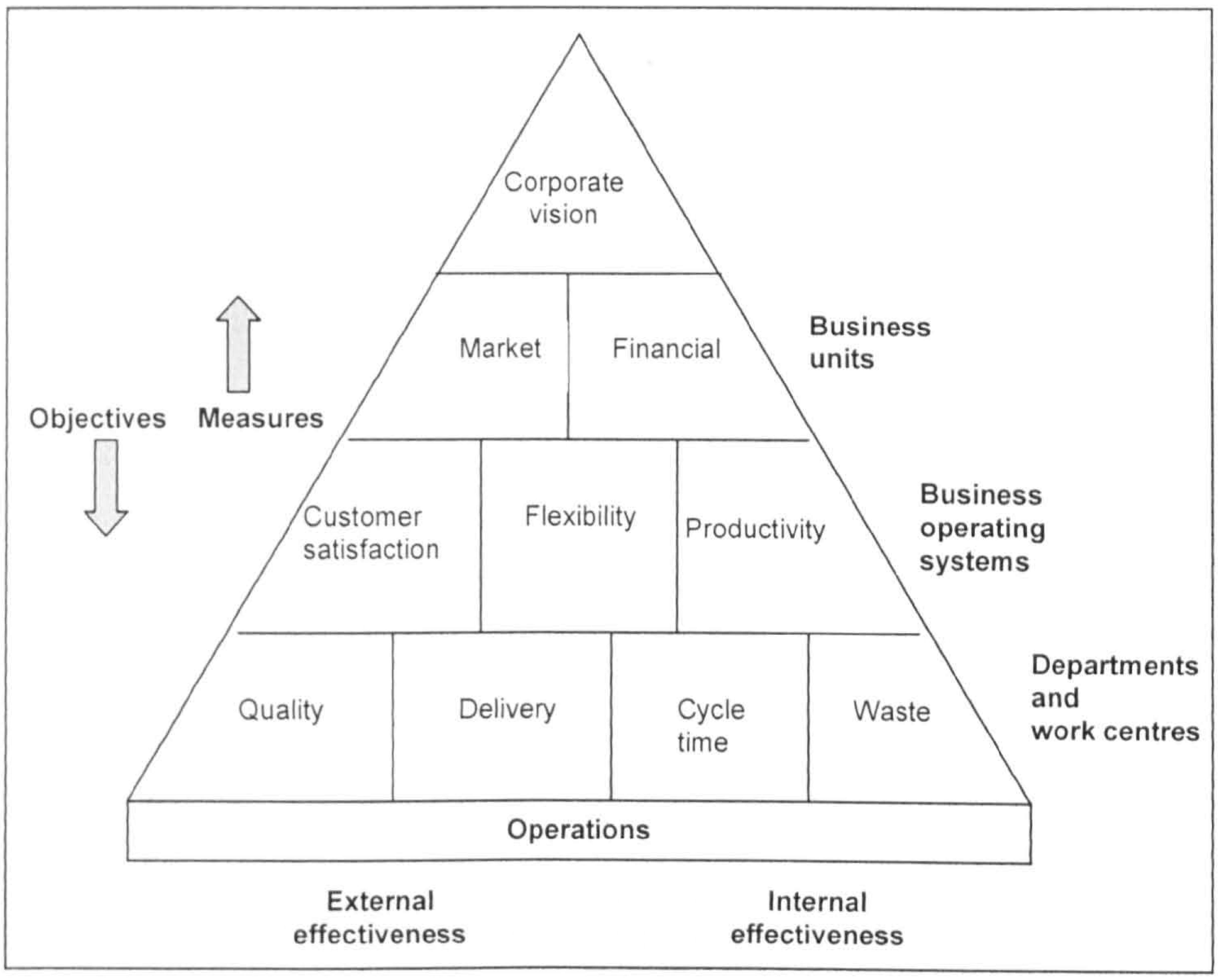

Figure 3.5 The performance pyramid (Cross and Lynch, 1992)

Performance Measurement Questionnaire (PMQ) (Dixon *et al.*, 1990)

This framework is developed to help managers identify three areas:

- the improvements needs of their organisation
- to which extent the existing performance measures support improvements
- the agenda for performance measure improvements.

The result of the PMQ is evaluated in four types of analysis: alignment, congruence, consensus and confusion.

The Sink and Tuttle framework (Sink and Tuttle, 1989)

This framework is a classical approach to designing a PMS (see Figure 3.6), which claims that the performance of an organisation is a complex interrelationship between seven performance criteria.

1. *Effectiveness*, which involves doing the right things, at the right time, with the right quality. In practice, effectiveness is expressed as a ratio of actual output to expected output.
2. *Efficiency,* defined as a ratio of resources expected to be consumed to resources actually consumed.
3. *Quality,* where quality is a wide concept. To make the term more tangible, quality is measured at several checkpoints.
4. *Productivity,* which is defined as the traditional ratio of output to input.
5. *Quality of work life,* which is an essential contribution to a well performing system.
6. *Innovation,* which is a key element in sustaining and improving performance.
7. *Profitability/ budgetability,* which represents the ultimate goal for any organisation.

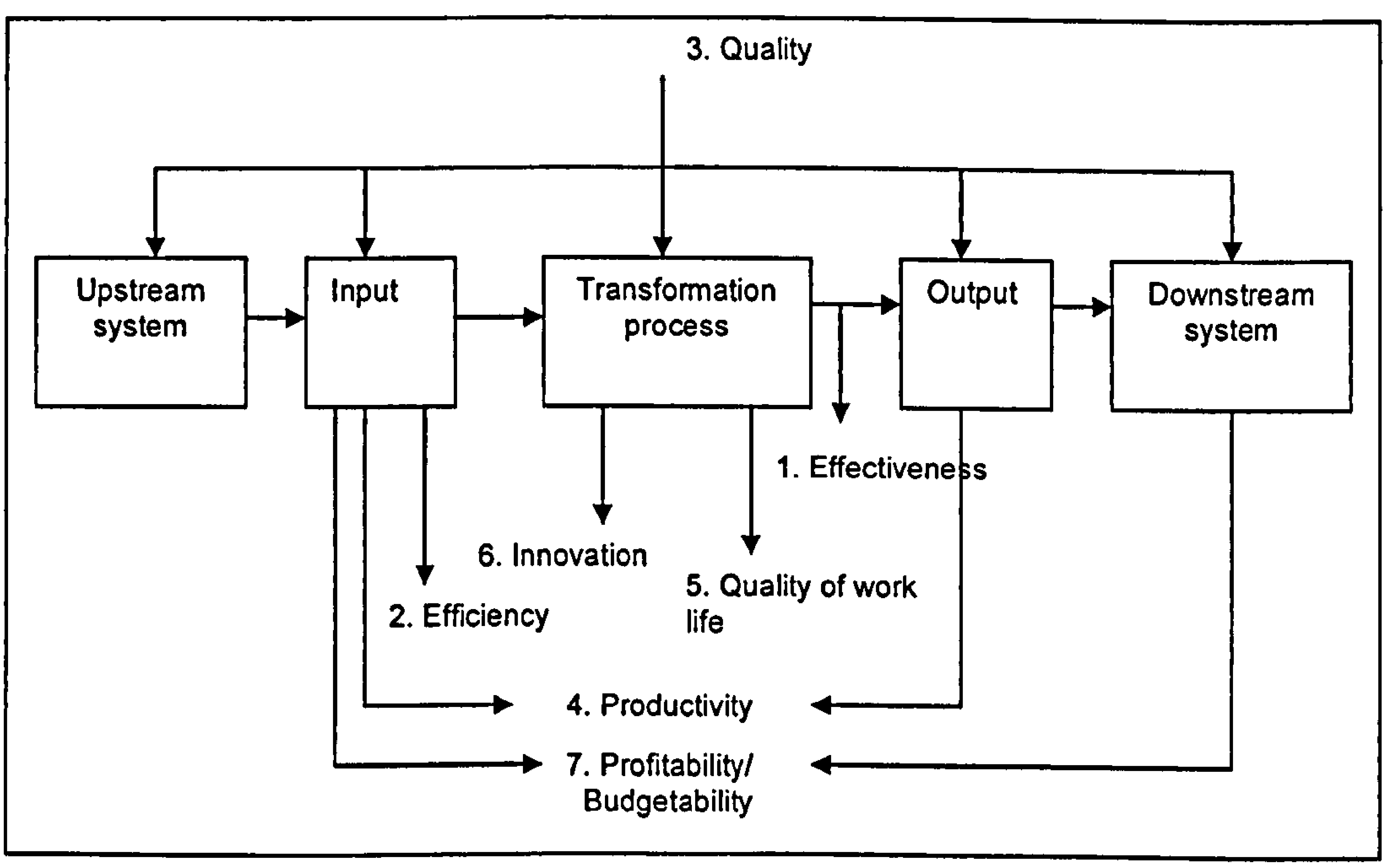

Figure 3.6 Definitions of seven performance criteria (Sink and Tuttle, 1989)

The performance prism (Neely *et al.*, 2001)

This framework emphasises five distinct but linked perspectives of performance:

1. Stakeholder satisfaction- Who are the stakeholders and what do they want and need?
2. Strategies- what are the strategies we require to ensure the wants and needs of our stakeholders?
3. Processes- What are the processes we have to put in place in order to allow our strategies to be delivered?
4. Capabilities- What are the capabilities we require to operate our processes?
5. Stakeholder contributions- What do we want and need from stakeholders to maintain and develop those capabilities?

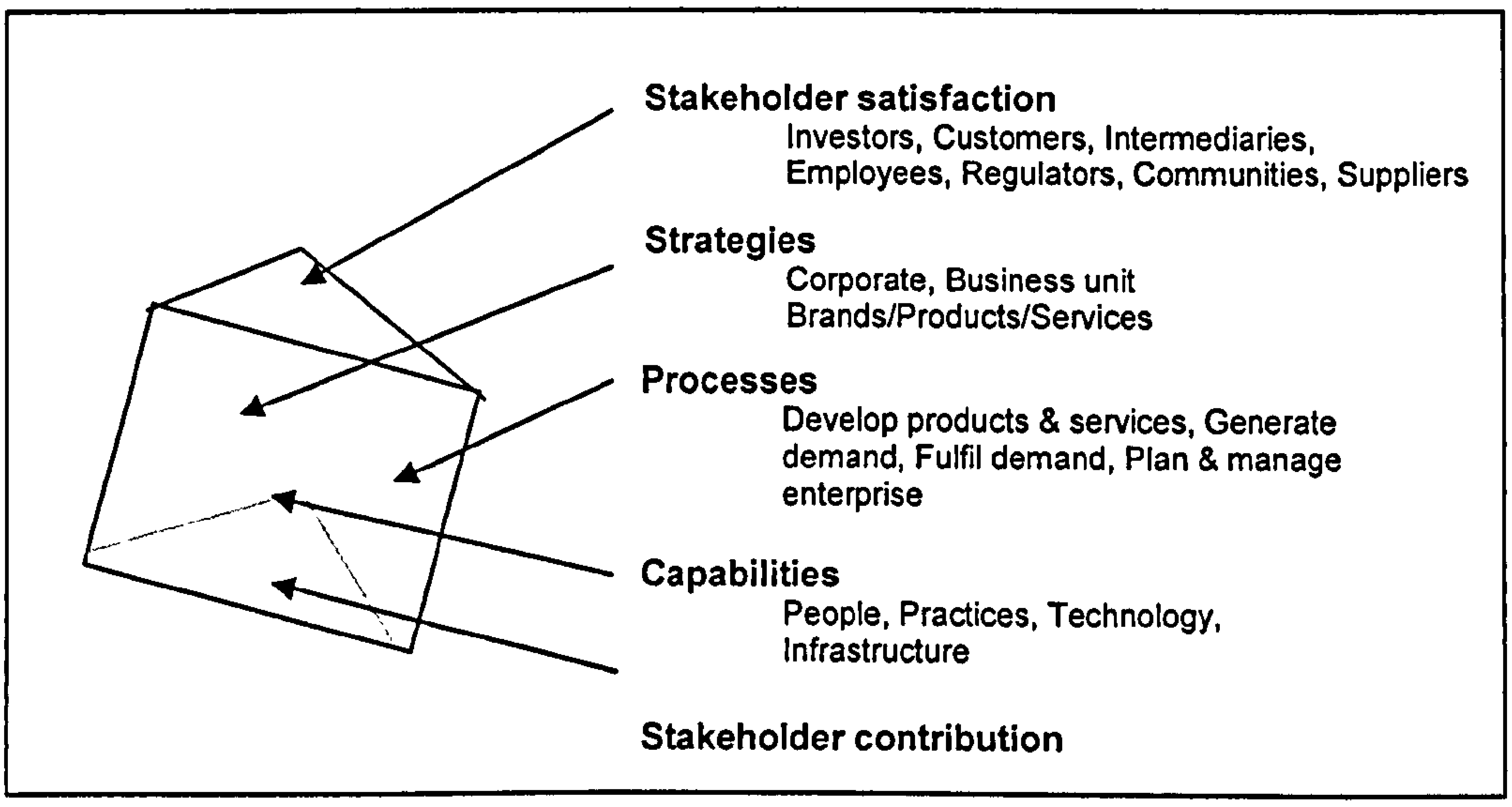

Figure 3.7 The performance prism (Neely *et al.*, 2001)

Rafele (2004) presents a framework which was developed by defining a hierarchy of activities classes, which contribute to the level of service in each tier of the supply chain, and he shows some examples of the indicators inside each class. The user only has to attribute each indicator used in the logistic practice to the classes for defining correctly the contribution of each activity (linked to a specific indicator) inside the overall process. In such a way he claims a company could identify its own indicators among the others or consider new ones individually. Beamon (1999) presents a framework for the selection of the performance measurement systems for manufacturing supply chains and provides a useful performance measures evaluation. An appropriate supply chain performance should be inclusive, where it must measure all pertinent aspects of the supply

chain; there are interactions among important supply chain characteristics and the performance measures are related to the strategic goals of the organisation.
This section selected a number of conceptual frameworks in the field of PM to assess the existing practice in FSC. Extensive reviews of other frameworks have been widely investigated by Toni and Tonchia (2001), Neely *et al.* (2005), Folan and Browne (2005) and Gunasekaran and Kobu (2007).

3.4.3 Procedural PM frameworks

Procedural frameworks provide step-by-step guidance for developing performance measure management. These frameworks all have their relative benefits and limitations, with the most common limitations being that little guidance is given for the actual selection and implementation of selected measures. There are in general three objectives for developing and implementing a performance measurement system: monitoring, controlling and directing (Bowersox and Closs, 1996). Monitoring measures track historical performance for reporting to management and customers. Controlling measures track ongoing processes and are used to refine a logistic process in order to bring it into compliance. Directing measures are designed to motivate personnel, where the measures are usually designed to encourage personnel to achieve higher levels of performance, for example productivity. For this type of measure, both positive and negative performance must be measured and sometimes credits are given to positive performance where a typical example is bonus pay.

There are a number of suggestions to specify criteria towards achieving an effective PMS. Keebler *et al.* (1999) claim meaningful performance measurements should meet 10 specific criteria (Table 4) which offer a useful framework for any company which wants to create an effective performance-measurement program. These criteria are given as general principles which every logistics manager can follow.

Table 3.2. 10 specific criteria for a good performance measurements

A good performance measure:	Description:
• Is quantitative	The measure can be expressed as an objective value.
• Is easy to understand	The measure conveys at a glance what it is measuring and how it is derived.
• Encourages appropriate behaviour	The measure is balanced to reward productive behaviour and discourage "game playing."
• Is visible	The effects of the measure are readily apparent to all involved in the process being measured.
• Is defined and mutually understood	The measure has been defined by and/or agreed to by all key process participants (internally and externally).
• Encompasses both outputs and inputs	The measure integrates factors from all aspects of the process measured.
• Measures only what is important	The measure focuses on a key performance indicator that is of real value to managing the process.
• Is multidimensional	The measure is properly balanced between utilization, productivity and performance, and shows the trade-offs.
• Uses economies of effort	The benefits of the measure outweigh the costs of collection and analysis.
• Facilitates trust	The measure validates the participation among the various parties.

(Source: Keeping Score: Measuring the Business Value of Logistics in the Supply Chain, University of Tennessee and Computer Sciences Corp., published by the Council of Logistics Management, 1999).

Globerson (1985) refers to a number of conditions that could be used to select a preferred set of performance criteria:

- Performance criteria must be chosen from the company's objectives.
- Performance criteria must make possible the comparison of organisations which are in the same business.
- The purpose of each performance criterion must be clear.
- Data collection and methods of calculating the performance criterion must be clearly defined.
- Ratio-based performance criteria are preferred to absolute number.
- Performance criteria should be under control of the evaluated organisational unit.
- Performance criteria should be selected through discussions with the people involved (customers, employees, managers).
- Objective performance criteria are preferable to subjective ones.

Maskell (1989) identifies similar types of performance criteria, focusing more on an operational view.

1. the measures should be directly related to the firm's manufacturing strategy;
2. non-financial measures should be adopted;
3. it should be recognized that measures vary between locations - one measure is not suitable for all departments or sites;
4. it should be acknowledged that measures change as circumstances do;
5. the measures should be simple and easy to use;
6. the measures should provide fast feedback; and
7. the measures should be designed so that they stimulate continuous improvement rather than simply monitor.

Performance criteria related to the organisation role is presented by Blenkinsop and Davis (1991) with the following guidelines:

- Departmental goal-setting without creating inconsistencies in policy or excessive interdepartmental conflict
- Whether the measure is a valid indicator of the performance group
- An appropriate mix of integration and differentiation (i.e. goals set both horizontally and vertically within the framework of the organisational chart).
- A thorough understanding of the existing measurement systems, both formal and informal, spoken and unspoken, as they are perceived
- Management consensus concerning the organisation's objectives and the means at its disposal for attaining them
- The corporate culture
- Long-, short- and medium-term goals (both financial and non-financial), not a fixation with "this month's" sales figure.
- Part-ownership of problems - so that a solution has to be found across functional boundaries and the escape route, "it's somebody else's fault" (often the ethereal "company's" fault), no longer has any meaning or validation.
- Total commitment from all involved, so that the "end-of-the-month" syndrome - a system driven by sales value - does not rear its ugly head at the end of the first month following implementation and each and every subsequent month thereafter.

In designing an effective PMS, several aspects must be taken into consideration. A method is crucial by which organisations can create PMS suited to their own special requirements and circumstances rather than a standard set of measurements created by experts and imposed on organisations (Sink and Tuttle, 1989). A number of methods are recognized to respond to the issue. In designing an effective PMS, several aspects must be taken into consideration. Instead of providing criteria for PMS design, the following discussions choose to provide step-by-step guidelines in designing a PMS for a supply chain.

Thor (1993) present ten different rules for building performance measures:

1. Clearly identify your purpose for measuring
2. Choose an appropriate balance between individual and group measures
3. Measure all the key elements of performance
4. Be sure the measures adequately reflect the customer's point of view - whether the customer is external or internal
5. Use care in generating competitive benchmarks
6. Give some time to tedious technical adjustments
7. Develop or modify the system as particularly as possible
8. Cost/benefit analysis also applies to data availability
9. If strategies change, so can measures
10. Performance improvement is a long-term process; top management patience is needed toward newly measured results

Neely *et al.* (1995) suggest guidelines on the design of PMS which incorporate the selection of measures and the actual structure of PM.

1. Clearly define the firm's mission statement
2. Identify the firm's strategic objectives using the mission statement as a guide (profitability, market share, quality, cost, flexibility, dependability and innovation)
3. Develop an understanding for each functional area's role in achieving the various strategic objectives
4. For each functional area, develop global performance measures capable of defining the firm's overall competitive position to top management

5. Communicate strategic objectives and performance goals to lower levels in the organisation. Establish more specific performance criteria at each level
6. Assure consistency with strategic objectives among the performance criteria used at each level
7. Assure the compatibility of performance measures used in all functional areas
8. Use the PMS
9. Periodically re-evaluate the appropriateness of the established PMS in view of the current competitive environment

Wisner and Fawcett (1991) have shown that a firm's strategy should be the origin of a PMS and present the following nine-step process:

1. Clearly define the firm's mission statement.
2. Identify the firm's strategic objectives using the mission statement as a guide (profitability, market share, quality, cost, flexibility, dependability and innovation).
3. Develop an understanding of each functional area's role in achieving the various strategic objectives.
4. For each functional area, develop global performance measures capable of defining the firm's overall competitive position to top management.
5. Communicate strategic objectives and performance goal to lower levels in the organisation. Establish more specific performance criteria at each level.
6. Assure consistency with strategic objectives among the performance criteria used at each level.
7. Assure the compatibility of performance measures used in all function areas.
8. Use the PMS to identify competitive position, locate problem areas, assist the firm in updating strategic objectives and making tactical decisions to achieve these objectives, and supply feedback after the decisions are implemented.
9. Periodically re-evaluate the appropriateness of the established PMS system in view of the current competitive environment.

Medori and Steeple (2000) propose an integrated framework for auditing and enhancing PMS. This process approach consists of detailed described stages (see

Figure 3.8). Similar to other frameworks, the starting point begins with defining the company's manufacturing strategy and success factors (stage 1).

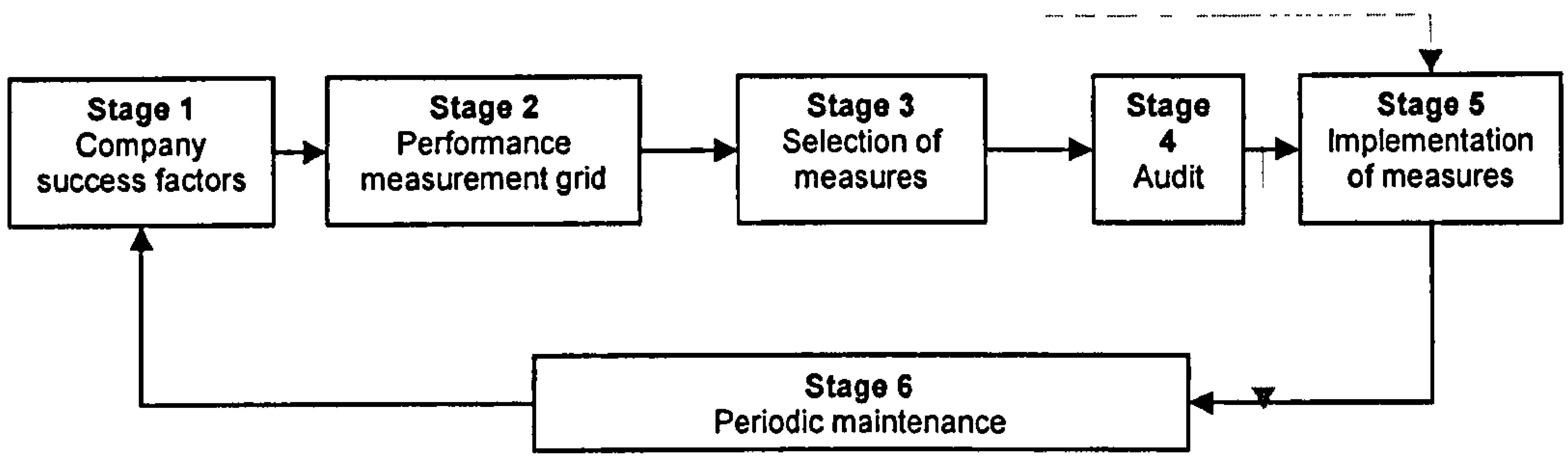

Figure 3.8 A PMS audit and enhancing method (Medori and Steeple, 2000)

In the next stage, the primary task is to match the company's strategic requirements from the previous stage with six defined competitive priorities (e.g. quality cost, flexibility, time, delivery and future growth (stage 2). Then, the selection of the most suitable measures takes place by the use of a checklist that contains 105 measures with full descriptions (stage 3). After the selection of measures, the existing PMS is revised so it can be decided what existing measures will be kept (stage 4). An essential activity is the actual implementation of the measures in which each measure is in detail described by eight elements: title, objective, benchmark, equation, frequency, data source, responsibility and improvement (stage 5). Finally the last stage is revolved around periodically reviewing the company's PMS (stage 6).

In contrast to the previous processes, this one is beyond "being simple guidelines" and can actually be followed by a measurement practitioner in practice. A major advantage is that it can be used both to design a new PMS and enhance an existing PMS. It also provides a unique description of how performance measure should be realised. Its limitations are mainly located in stage 2 where a PM grid is created in order to give a PMS its basic design. Not much guidance is given, and the grid is only constructed to consider six competitive priorities (e.g. quality, cost, flexibility, time, delivery and future growth). In addition to the above, performance measures can be divided into many other categories which are not included in the method described above.

3.5 The need for PM in RSC and CLSC.

PMS do vary a great deal between one organisation and another. This is because measurement systems are directly related to company strategies, with strategies generally being unique to each individual company. As a consequence the PMS need adjustments as traditional measurement approaches may limit the possibilities to optimize the RSC and CLSC as a whole.

PMS for RSC and CLSC have been mentioned as important research areas but there is no discussion found on PMS designs or frameworks. Previous studies concentrating on different performance metrics for RSC and CLSC were also unavailable. Herold and Kamarainen (2004) emphasise that no previous studies were found on different performance metrics for RSC. This is concluded when they identify challenges in managing product returns that were common to companies across industries and classify gaps in the theory. One of the key topics is measuring costs and performance. They outlined three papers employing three different approaches to examining the cost impacts of reverse logistics. Tibben-Lembke (1998) discussed them in combination with the total costs of ownership concept. Goldsby and Closs (2000) give valuable insights into using activity-based costing to re-engineer reverse logistics processes, identifying a number of activities, cost drivers and resources used in reverse logistics. Guide and Van Wassenhove (2002) introduce the economic value-added (EVA) approach to examine the profitability of reuse activities. Rogers *et al* (2002) mention metrics briefly in their returns management process and emphasise the importance of measuring performance. They suggest return rates and financial impact of returns as appropriate measurements. To measure the financial impact of returns the EVA approach is suggested. Results show that the valuation of returned products is important and the way in which it could have an impact on profitability. It is clear that the EVA approach has significantly contributed to determine the value of a returned product.

PM is also mentioned as an important issue in the roadmap for redesigning reverse supply chain by Guide and Wassenhove (2005). They conclude that identifying and developing the right performance metrics should be followed by a systematic tracking system. Kongar (2004) indicates that reverse supply chain management demands an appropriate evaluation approach as it differs from forward supply management in many aspects. A scorecard prototype, named ESCAPE is introduced to act as a green Balanced Scorecard designed to measure the performance of supply chain management (SCM) while defining the appropriate performance measures for SCM. Linear Programming is used to assist in classifying preference criteria for performance indicator selection. The difference between ESCAPE and the conventional Balanced Scorecard is that, in ESCAPE, it includes environmental perspective as the fifth perspective, quoting:

'Environmental perspective concentrates on achieving an environmentally benign supply chain while maintaining the efficiency'.

Besides suggesting the possible inclusion of environmental performance indicators, the approach presented does not take into account any characteristic of the RSC, despite making it clear that there are significant differences between FSC and RSC.

Hervani *et al.* (2005) introduced a performance measurement for green supply chain management (GSCM). In this paper, GCSM involves addressing the area of; Green Purchasing, Green Manufacturing/Materials Management, Green Distribution/Marketing and Reverse Logistics. Here, the term 'reverse logistics' is described as "closing the loop" of a typical forward supply chain and including reuse, remanufacturing, and/or recycling of materials into new materials or other products with value in the marketplace. The research, however, forms a system framework with a focus on integrating works in supply chain management, environmental management, and performance management. Environmental performance indicators are treated as the core requirements of the GCSM performance measurement systems (GCSM/PMS) where the indicators will be used when evaluating the environmental performance of activities, process, hardware and services. The initial step in designing the GCSM/PMS is defining the overall goal(s): ISO certification and guidelines associated with environmental performance management are used. Performance measures for reverse supply chain were not found. While green or environmental PM may lead to cost savings and better RSC operations, it is clearly not the same as measuring performance of a RSC or CLSC. Indeed, environmental performance measurement focuses more on issues like reducing raw material and energy usage, identifying cleaner manufacturing processes and waste minimization opportunities, and compliance with legislative requirements; but it tends to lack a business view perspective (see e.g. Guide and Van Wassenhove, 2003). The research also believes that a business view is crucial to manage adequately the performance of reverse supply chain processes.

Nevertheless, several items in the literature propose important performance metrics to be used in certain circumstances for RSC and CLSC. Blackburn *et al.* (2004) demonstrate how they apply key concepts from forward supply chain design - coordination, postponement, and the bullwhip effect and make a modification to the concept of product postponement .They call this concept "preponement". Managers should make product returns disposition as early as possible to avoid processing returns with no recoverable value. They suggest it can greatly benefit the profitability of a firm by avoiding unnecessary processing expenses, while at the same time providing faster recovery of products with significant value. The authors conclude that time should be regarded as an essential performance metric as their study reveals that many firms do not track or record time metrics in their returns process; they are unaware of the magnitude of losses in product value simply caused by time delays at different stages in the process. As an example, only when firm ABC began recording time metrics did they realize that it was taking several months for returned products to reach the manufacturing facility. Because returns are perishable assets, the percentage of asset value recovered is directly proportional to the speed of recovery and disposition method of the returned product. In a reprocessing model of bulk recycling, Lu *et al.* (2000) specify three performance metrics in achieving maximisation of material recovery profits;

- Shipment load filling time
- Purity and values of recovered materials
- Recycling costs

While investigating the performance of a computer company in supporting its reverse supply chains operations, Tan *et al.* (2002) address the issue of old metrics which do not help managers in making correct decisions. Thus, a new set of metrics is proposed:

- Number of spare parts that are returned whose product costs are lower than shipment costs.
- Number of returned spare parts which, in the past six months or more, were not demanded.
- Number of returned spare parts that are not authorised, particularly parts that should be scrapped in the local country.
- Number of returned shipments that are being held at customs or which are penalised for inaccurate or incomplete shipment information.
- Turnaround time for the entire reverse logistics operation.

Daugherty *et al.* (2001) discuss the effectiveness of RSC programs when related to the companies' commitment of resources to the development of RSC capabilities. The impact was assessed based on two types of resources; management and financial, and they give a grounded empirical evidence to support the basic premise of resource-based theory and the relationship between resource commitment and program performance. The results suggest that the commitment of management resources has more influence on the achievement of reverse logistics program goals than financial resource commitment. Nevertheless, they conclude that both are undoubtedly necessary for program success and findings may be reflective of reluctance by firms to devote resources to reverse logistics programs. Financial resource commitment was found to be relatively low among the respondent firms. The study also identifies that neither managerial nor financial resource commitment was found to be strongly related to cost containment. Autry *et al.* (2001) give an interesting insight as the article provides a list of RSC-related performance measures that was used in a questionnaire survey among 212 CEOs at US catalogue companies selling electronic goods. They look at how RSC performance and satisfaction with RSC service are influenced by industry, firm size/sales volume, and internal or external assignment of responsibility for disposal. The performance and satisfaction measures were developed following a literature search and subsequent pre-testing with logistics professionals.

Besides academicians, practitioners also realise the importance of performance measurement in a reverse and closed-loop supply chain. The use of appropriate strategies and metrics put a reverse supply chain to play as a part of important product and customer life-cycle strategies, and can serve as a foundation for identifying customer loyalties and increasing market share (Moore, 2005). For example, for Toshiba's laptop computer repair process, turnaround time is used as a key metric and it is communicated to customers as a base to build customer loyalty, improve customer satisfaction, and save millions of dollars by streamlining its service operations and gaining better inventory visibility (UPS, 2004). Rupnow (2006) highlights the importance of performance measurements to benchmark and monitor returns processing activity by looking at the best practices at several leading companies such as Nintendo, US Robotics, Mitsubishi, Philips and Microsoft Xbox. A list of key goals and metrics is identified in helping these leading companies to succeed:

- Reduce overall returns
- Reduce cost to process returns
- Increase recovery
- Reduce inventory
- Increase velocity or turn-around time
- Increase customer satisfaction

Sells (2008) emphasises that reverse supply chains require operational performance metrics which are linked to business objectives. Reverse supply chains should focus on suppliers and present a detail performance measurement concentrating on material availability. To address other issues in reverse supply chains, six performance attributes are proposed with the appropriate performance metrics, as illustrated in Table 3.3:

Table 3.3: Performance attributes and performance metrics for reverse supply chains concentrating on material supply consistency

Performance attributes	Definition	Performance metrics
Adaptability	The sustainable reduction and increase in quantities that can be achieved in 30 days (without backorders, cost penalties or inventory	•Downside and Upside Source Adaptability •Downside and Upside make Adaptability •Downside and Upside Deliver Adaptability
Order Fulfilment Cycle Time	The average actual cycle times consistently achieved to fulfil requisitions	•Return Cycle time •MRO Cycle time •Deliver Cycle time
Perfect Order Fulfilment	The percentage of orders delivered on-time, in full, with complete documentation, using customer's definition of on-time and complete to determine Material Availability	•% Orders placed without error •%Orders scheduled to customer request date •%Orders received damage free •% Orders with correct logistics documents
Cash-to-Cash Cycle Time	The time it takes for cash invested in materials to flow back into the company after finished goods have been delivered to customers	•Inventory Days of Supply •Days Sales Outstanding •Days Payable Outstanding
Life Cycle Cost	All direct, indirect, and overhead expenses associated with the logistics& sustainment after full material release	•Cost of Return •Cost to Source •Cost to Deliver •Cost to Plan
Cost of Goods Sold	The cost associated with buying raw materials and producing finished goods. This cost includes direct costs (labour, materials) and indirect costs. Generally expressed as % of sales	•Direct Material Cost •Direct Labour Cost •Surcharges

(Adapted from Sells, 2008)

3.5.1 SCOR Model as a tool

An important requirement of a PMS is that there must be a clear link between each supply chain activity to its performance measurement. This is answered by one supply chain model known as the Supply Chain Operations Reference model

(SCOR), which is widely recognized as a data tool for viewing broad activities across a supply chain and assessing performance towards potential improvement (Schultz, 2003). SCOR has been depicted as a framework that results in best-in-class performance (Lockamy III and McCormack, 2004) and this is supported by Davenport (2005) by ruling out:

'Hundreds of organisations (from Alcatel to the U.S Navy) have begun to use the SCOR model to evaluate their own processes; software vendors such as SAP have begun to incorporate SCOR flows and metrics into their supply chain software packages.'

It is a model that links process elements, metrics, best practices and the features associated with the execution of a supply chain. In SCOR, one section can be associated with reverse and close-loop supply chains. The "RETURN" element was introduced in Version 4, and it is fully implemented in Version 5 in 2001. The term "RETURN" refers to processes associated with returning or receiving returned products 'for any reason'. These processes extend into post-delivery customer support. The Return element describes the return of raw materials (Source stage) and receipt of returns of finished good processes (Deliver stage) (see Figure 3.9). The performance metrics incorporated in the SCOR model are inter-organisational and process-oriented, and combine customer-facing areas (reliability, responsiveness and flexibility) and internal-facing areas (cost and assets).

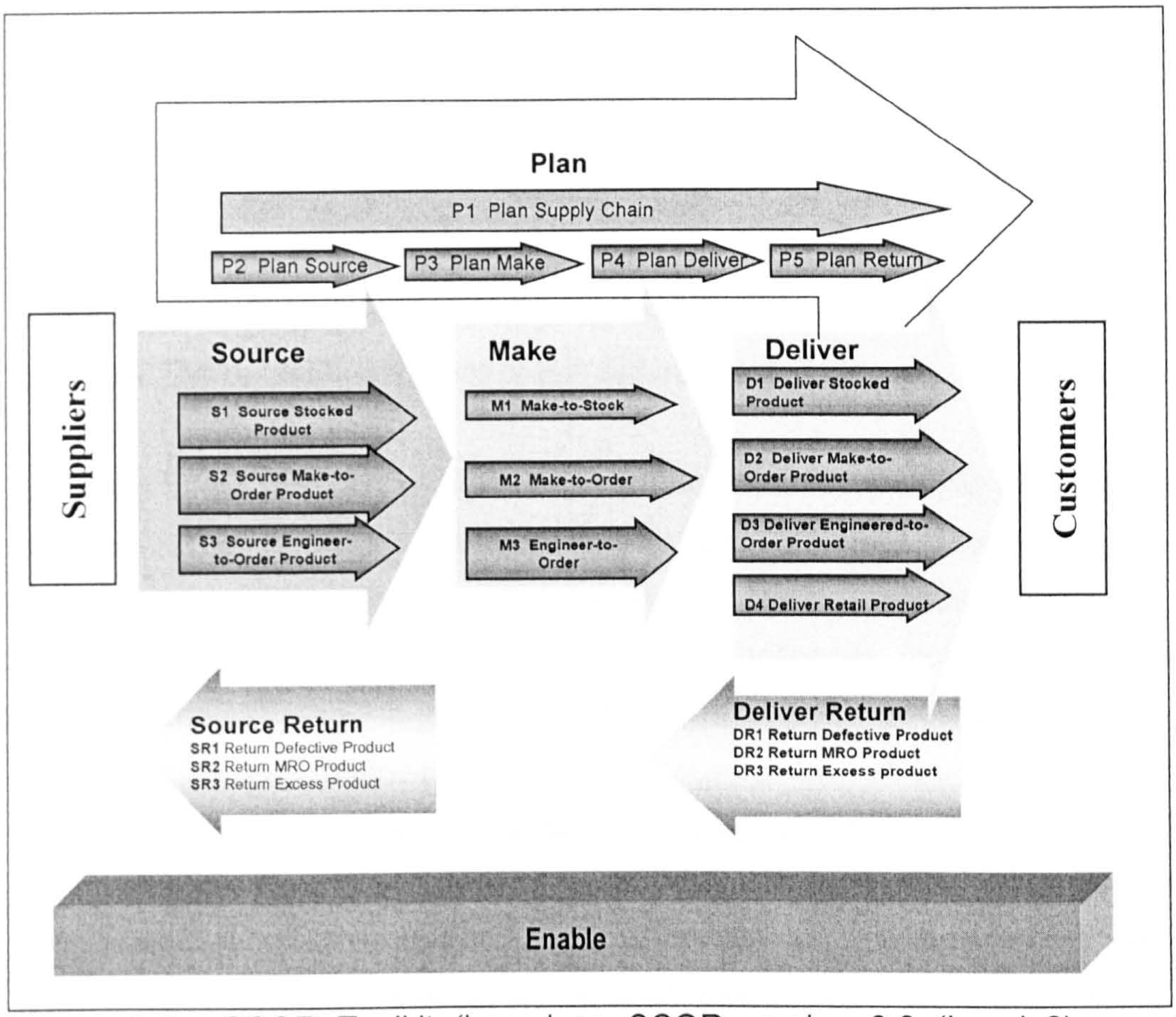

Figure 3.9: SCOR Toolkit (based on SCOR version 9.0 (Level 2) overview booklet, SCOR online)

While SCOR has made some efforts to incorporate the performance measurement of the returns processes, this aspect is still somewhat in its infancy. Apart from defective products, Maintenance, Repair and Overhaul (MRO) products and excess raw materials, there are many other types of returns which are currently not supported in SCOR. Product returns such as convenience returns, end-of-life returns, end-of-use returns and stock adjustment returns. These different returns require different handling and recovery processes, and should be assessed against different objectives. The suggested performance metrics are linked to each of the process's stage of RETURNS element without addressing to the characteristics of each type of product return. It is not very clear in SCOR how to select suitable performance metrics according to the key characteristics of the returns and the nature of the recovery process. The performance metrics listed is a form of a general guideline in measuring performance of reverse supply chain without any indication of important characteristics of the products (seasonal, functional) and characteristics of process (disposition method, remarketing options) .

3.6 Research gap

By reviewing the literature on RSC and CLSC, linking the issues on the requirement of implementing PM in a supply chain, five research gaps are identified. The research gaps are presented in Figure 3.10.

As shown in the previous section, although the importance of PM in achieving an effective RSC or CLSC, the researchers fail to demonstrate a systematic approach in designing a PMS for RSC and CLSCs. Step-by-step guidelines in constructing a PMS is crucial considering the differences of challenges faced in reverse and CLSCs, compared with PM for FSC which is a much better developed area.

PM for a RSC or a CLSC should be able to address all issues in managing product return, from the product acquisition stage to the re-market point. This will involve using a number of performance metrics, which can be adopted from FSC PM, or specific metrics applied exclusively to RSC and CLSC. This discussion is not found in any literature, as most of the case studies investigated only propose a specific performance metric to address a particular issue involved in the problematic case subject. In order for a PMS to work effectively, all PMs should be able to measure the performance of the overall RSC or CLSC at all process stages.

Moreover, it has been shown that although PM for RSC and CLSC has been acknowledged in several green and environmental supply management practices, there are still misunderstandings beyond the concept; some researchers may not look at RSC and CLSC as a business opportunity and others do not address the actual need of measuring performance according to the characteristics of the product return and the issues in managing the RSC and CLSC. The problems are not identified; therefore the performance metrics suggested are not sufficient to give meaningful data.

In designing a PMS, strategic objectives of a company is vital in providing a starting point to devise a meaningful PMS. There is, however, no linkage between the characteristics of a RSC and a CLSC with the set-up strategic objectives were found. By identifying the comprehensive but precise strategic objectives, only predefined goals of the company can be achieved. Therefore, there is a need to propose a systematic rule in selecting the appropriate strategic objectives in RSC and CLSC at the primary step in designing a PMS.

One thing is certain; there is an abundance of empirical research of PMS in FSC. The existing research, however, failed to include any case studies concentrating on the practice of PMS in a RSC and CLSC. Furthermore, although there a number of researchers who have looked at how a RSC or a CLSC is different in terms of supply chain management issues with FSC, the lack of comparison in the PMS area between the two supply chains is obvious.

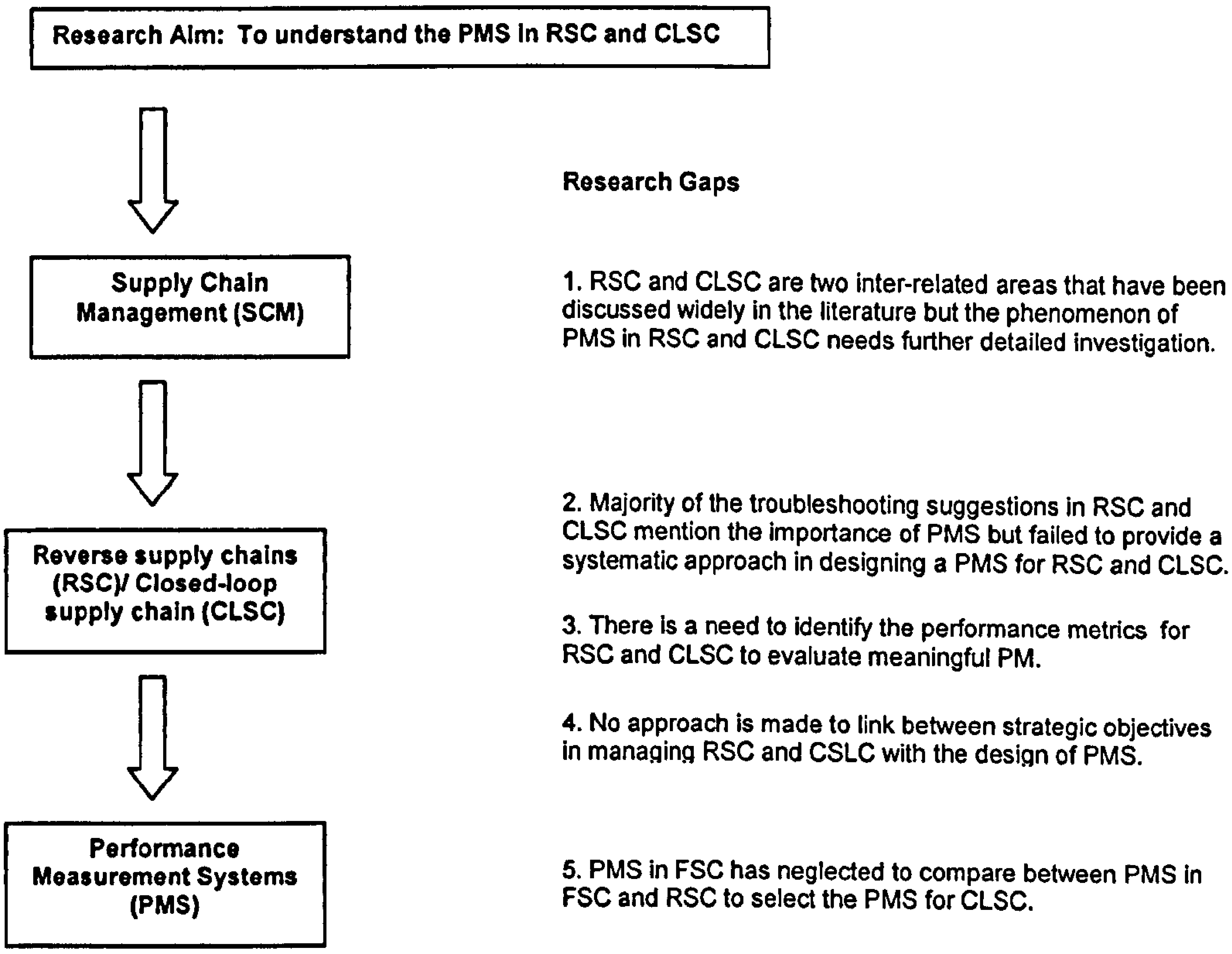

Figure 3.10: Research gaps

3.7 Summary

This chapter has provided the background to this research by reviewing the literature related to the research area that is PMS. A systematic approach in designing a PMS is crucial to ensure all the related, key elements are considered. This can be achieved by capturing the strategic objectives in managing RSC and CLSC and linking them with the performance metrics. The existing PM frameworks and models in a forward supply chain provide basic learning in developing a PM for a RSC or CLSC. The literature review also identified clear research gaps which are presented as the following:

- First, RSC and CLSC are two inter-related areas that have been discussed widely in the literature but the phenomenon of PMS in RSC and CLSC needs further detailed investigation.
- Second, the majority of the troubleshooting suggestions in RSC and CLSC mention the importance of PMS but failed to provide a systematic approach in designing a PMS for RSC and CLSC.
- Third, there is a need to identify the performance metrics for RSC and CLSC to evaluate meaningful PM.
- Fourth, no approach is made to link between strategic objectives in managing RSC and CSLC with the design of PMS.
- Fifth, PMS in FSC has neglected to compare between PMS in FSC and RSC to select the PMS for CLSC.

The research gaps have led to a focus on developing a framework of PMS for RSC and CLSC as presented in Chapter 5. The framework should give guidelines on how to set strategic objectives of RSC and CLSC according to the characteristics of product returns and the characteristics of the RSC/CLSC itself. In addition, the framework should include the appropriate performance metrics related to each strategic objective to ensure a company's preset goals can be realised. The next chapter describes and justifies the research methodology used to achieve the research aims.

Chapter 4

RESEARCH METHODOLOGY

This chapter begins with describing the research process which consists of three stages. Then, the rationale of the research approach is explained where the characteristics of research problem, philosophical issues and choice of research method and research strategies are discussed. As the case study system is adopted for this research, the strengths and limitations are examined. The research strategy is further justified with the rationalisation of the selection to use multiple case studies and why UK industry is chosen for the case study. Next, the application of triangulation on data collection methods and data sources are explained and in this section, the rationale, the selection of respondents and the procedure used for interview and questionnaire methods are presented. This is followed by the discussion of the analysis of data used for the interview and questionnaire. Finally, the validity and reliability of the research are considered.

4.1 Introduction

People undertake research in order to find things out in a systematic way, thereby increasing their level of knowledge (Jankowicz, 2000). This research relies on phenomenological principles incorporating also some positivistic principles. This research is also driven by a real-world problem, therefore problem-oriented research seems to be the right choice as research type. As the researcher is, for most of the time, participant-as-observer, the majority of the data collected is of a qualitative nature.

4.2 Research Process

There are three stages involved throughout the research (presented in Figure 4.1). Every stage gradually contributes in answering the research question and at the same time incrementally addresses the research objectives.

The research will fall into three stages: understanding the background, theory building and theory verification.

Stage 1: Understanding the background of reverse and closed-loop supply chains and PMS

This stage is important to ensure that the research is adequately based on existing theory. This involves the acquisition and synthesis of knowledge on two broad areas: reverse and closed-loop supply chains; and performance measurement in supply chain management. The first stage begins by laying out the problem area to identify the research gaps. Then, research objectives and research questions are developed. The research methodology is also selected at this stage.

Stage 2: Theory building - Framework development

The second stage, which is the theory development phase, focuses on the deduction of a typology that embodied the findings of previous research of PM in forward supply chain which will cover process methodologies, the characteristics of performance measures and appropriate dimensions of performance. The theory is then used in developing a conceptual framework to link the strategic objectives in handling product returns to the type of product returns and the recovery network.

Stage 3: Theory verification- Case studies and Survey Questionnaire

The third stage marks the start of the empirical work and is composed of case studies involving UK manufacturers and retailers who actively practise reverse or closed-loop supply chain activities. Semi-structured interviews are conducted with five companies to investigate the factors envisaged in the selection of strategic objectives in managing RSC. The interviews involved one key informant from each of the case study companies as the main contact person and the person who allows overall access within the company.

Then, a questionnaire survey is constructed to examine the use of PMS in RSC and its practice in industry. Nine companies are contacted and contributed by answering the questionnaires that include open-ended questions.

The empirical findings from the interviews and questionnaires are analysed qualitatively and the framework of PMS for RSC is reviewed. Then, the effects of the revised framework on the concepts within the discipline are recommended.

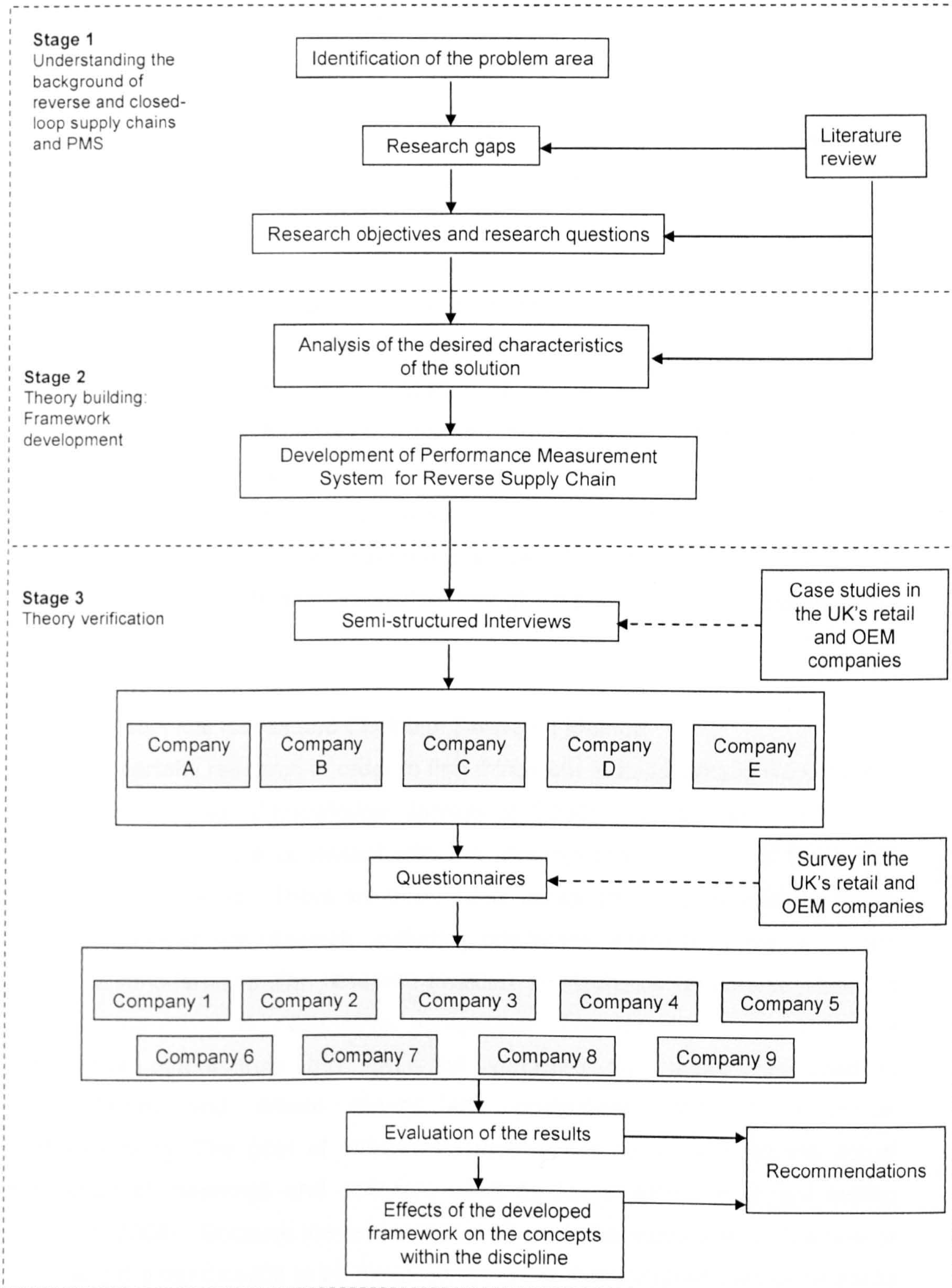

Figure 4.1 Overview of the research process

4.3 Rationale of the Research Approach

In this section, the research strategy is justified. The choice of research must consider the type of research question, the influence of the researcher (philosophical issue) and the choice of research method.

4.3.1 Characteristics of the Research Problem

This research aims to understand the performance measurement in a reverse supply chain. It is hence a descriptive study, as distinct from those studies which attempt to provide a normative indication of how a performance measurement system should be developed and practised. The limitations inherent in the existing reverse supply chain management where only the importance of PM in achieving an effective RSC are highlighted without any approach found for a systematic PMS for RSC design. This research captures the empirical evidence of the decision maker's beliefs and experience through sequential, rational and analytical processes.

4.3.2 Philosophical Issues and Choice of Research Method

People undertake research in order to find things out in a systematic way, thereby increasing their level of knowledge (Jankowicz, 2000). Researchers need to use methodologies that are consistent with the assumptions and aims of theoretical view being expressed. There are three major perspectives of research traditions used in management research, including positivism, interpretive research, and critical postmodernism. The research tradition in which the researcher sees the world is according to interpretive perspective. The focus of the interpretive perspective differs from the focus on variables and hypothesis used in postpositivism and critical theory and postmodern thought in critical postmodernism. The goal of interpretive research is to understand the actual production of meanings and concepts used by social actors in a real setting (Gephart, 2004). Because the research questions in this study start with a how or what, and the topic needs to be explored, it means that variables cannot be easily identified and theories need to be developed. This research involves going out to the setting or field of study, gaining access, and gathering material, providing a narrative of people's view of reality, and it relies on words and talking to create texts (Creswell, 1998). The research methodology used was based on empirical and field-based methodologies. Empirical data is used in this research to help in theory verification.

4.3.3 Research Strategies in Descriptive (Empirical Studies)

The term "strategies of enquiry" is used to categorise research strategies which help researchers move from a particular paradigm and research design to the instruments for the collection of empirical materials (Denzin and Lincoln, 1994). Case studies, experiments and surveys are the main strategies of inquiry used in descriptive design research. Examples of research conducted in PMS design in supply chain management are analysed in Table 4.1 below, which highlights the use of case studies, survey and; both case studies and survey which adopt combined qualitative and quantitative methodology.

Table 4.1 Examples of strategies employed in performance measurement research

Research strategy	Researcher(s)	Investigation area	Subject of research	Methods of data collection
Case studies	Gaiardelli *et al.* (2007)	Integrated Framework for after-sales network performance measurement	Two Italian car manufacturers	Interviews, questionnaire
	Roth (2001)	Performance measurement framework targeted to knowledge reuse and invention in new product development	Four companies (ranging from 45 to 7000 employees)	Interviews and questionnaires
	Harrison and Godsell (2003)	Performance measurement in customer responsive supply chains	Four companies	Interviews
	Hudson *et al.* (2001)	Performance measurement systems for SMEs	Eight SMEs (ranging from 12 to 240 employees)	Interviews
	Schmitz and Platts (2003)	Performance measurement in the automotive industry	Five vehicle manufacturers	Interviews and questionnaire
Survey	Cantu (2006)	Performance measurement model Linking Supply Chain Measures with Financial Performance		Survey
	Rodrigues *et al.* (2004)	Performance measurement in integrated logistics	Executives from Council of Logistics Management	Mail survey
Case studies & survey	Saad & Patel (2006)	Performance measurement in the Indian automotive sector	Indian auto assemblers and auto component manufacturers	Interviews and questionnaire survey

The case study and survey approach was selected based mainly on the following arguments:

1) Single approach, involving just case study or just survey research, is not suitable for the research problem.

This research needs to investigate the problem and strategy in developing PM for RSC and CLSC. Therefore, case study is the method best suited to address the particular research interest. The research, however, also needs a far larger sample to show the performance attributes and performance metrics used according to the characteristics of RSC and CLSC possessed by each company.

2) A combination of case study and survey approach is suitable for the research problem.

The research utilised a case study approach that focused on the accumulation and interpretation of qualitative data. Case/field study is one example of an alternative research paradigm known as interpretivism and uses both quantitative and qualitative methodologies to help understand trend (Meredith, 1998). The nature of this research which is relying on exploratory data makes the case studies approach appropriate. The case studies are used to investigate RSC and CLSC in their natural setting. It is also to act as a method to describe performance measurement of reverse supply chains phenomena and use to validate the related variables depicted in the conceptual framework. The survey is designed and carried out to support the case studies as it provides a rapid and beliefs of the population at large through the use of a representative sample (May, 1997).

4.3.4 Case Study Research

A case study is an empirical enquiry that investigates a contemporary phenomenon within its real life context; when more than one source of evidence is used; and when the investigator has little control over events (Yin, 1994).

4.3.4.1 Strengths of Case Study Research

Three advantages of the case study approach are outlined by Benbasat *et al.* (1987). First, the phenomenon can be studied in its natural setting and meaningful, relevant theory generated from the understanding gained through observing actual practice. Secondly, the case method allows the much more meaningful question of *why*, rather than just *what* and *how*, to be answered with a relatively full understanding of the nature and complexity of the complete phenomenon. Finally, the case method lends itself to early, exploratory investigations where the variables are still unknown and the phenomenon not at all understood. These factors are important for this research because the study requires empirical data from companies in the related business scenario to investigate actual practice towards effective management. Case studies are normally used to explore new processes and behaviours (Hartley, 1994). Case studies can also facilitate rich conceptual or theoretical development and this can be achieved using qualitative and quantitative data collection methods towards providing the researcher with an understanding of the social phenomenon in which the study is made (Yin, 1994).

4.3.4.2 Limitations of Case Study Research

Case study research does not employ large sampling procedures that are a rigorous, representative of a well-specified population towards generalizability of the findings (Aldag and Stearns, 1988). The research method also cannot produce information that goes beyond the original model which cannot account for possibly crucial variations related to context, and that the researcher who adopts the method risks producing reliable but unimportant 'so what' results (Bailey, 1992). Other concerns include the abstract and remote character of key variables, the lack of comparability across studies and the difficulty to understanding, interpreting the results because of the high level of complexity (Benbasat *et al.,* 1987, p. 369).

4.3.5 Further Justification of Research Strategy

A series of other decisions made for the research strategy must be justified:

1) Why multiple case studies

The evidence from multiple cases is often considered more compelling, and the overall study is therefore regarded as being more robust (Herriott and Firestone, 1983). Stake (1995, p. 85) suggests that single cases do not provide as a strong base for generalizing to a population of cases as other research designs. Yin (1994) argues that a single-case design is appropriate under three main circumstances: the case is critical in terms of testing a well-formulated theory, the case is unique (the phenomenon is not likely to be present in several cases), or the case is revelatory (the phenomenon has previously been inaccessible). Since neither of these circumstances is present in this research, the multiple-case design is likely to be most appropriate. Multiple cases may reduce the depth of a study, especially when resources are limited, but at the same time increase external validity and help guard against observer bias.

2) Why UK companies?

In 2002, returns are reported one to five percent from total UK retail sales (CILT UK, 2004). If the middle figure is adopted (2.5 %), the total returns amount to £5.75 billions of goods in retail industry. This situation opens the opportunity for researchers to investigate the effective RSC management practised by successful retailers, logistics providers and manufacturers. In addition, the take-back regulations on end-of-life products in the UK are fully applied to the UK market such as WEEE Directive (from 1 July 2007), Packaging & Packaging Waste Directive (from 2003) and ELV Regulations (from 2003) (Department for Business and Innovation Skills website). European Union (EU) Consumer Policy which are used in the UK empower consumers with the right to return any items bought in any type of shops, from corner-shop to website, on terms which highlights fairness and openness. Recycling is also a very vigorous activity in the UK where 17% of 30.5 million tonnes of waste in 2003/04 was collected for recycling (Defra.gov.uk).

4.4 Data Collection

When collecting data in case studies, Eisenhardt (1989) emphasises the importance of well-defined focus and research questions. Without an appropriate focus, the researcher is likely to become overwhelmed by the volume of potential data.

4.4.1 Triangulation

Triangulation is the application of different research tools to the same stakeholders which can significantly improve the quality of the data, solutions and findings of the research work (Jick, 1979). In the following sections, triangulation of data collection methods and data sources is explained:

1) Triangulation of data collection methods

The method of data collection used was a combination of methods to study the same issue, which is better known as triangulation (Jick, 1979). This method is used as an operation management research in an applied discipline, where the knowledge would emerge not only from analysing evolution and trends in publication, but also comes from the real-life practice of industry and services. In addition, with the rapid growth of competition between companies at the international level in achieving low cost production with time reduction, new challenge and problems are created. Therefore, investigation on the present manufacturing and service organisations has to be carried out. The first method is by a literature review on the two main areas; reverse and closed-loop supply chains and performance measurement systems of forward supply chains. This has provided the basic knowledge on the two subject areas. The second data collection method was semi-structured interviews from the operation managers at a number of manufacturers and retailers who are responsible for reverse supply chain activities in their company. The third method used was questionnaires sent to a number of companies, targeted to managers who directly administer reverse supply chain management in their company.

2) Triangulation of data sources

Triangulation of data methods is required to support a finding by showing that independent measures of it agree with it or, at least, do not contradict it (Miles and Huberman, 1994). In this study, while interviews are carried out on related managers, documentation on process guidelines, manuals and worksheets are studied.

4.4.2 Interviews

1) Rationale

The field-study type of interview is used in this research. It is used to investigate the meaning of a specific concept (Flynn *et al.*, 1990). In this type of interview, it is sometimes depicted as a semi-structured interview. A semi structured interview is where questions are specified by the interviewer, but he or she is more free to probe beyond the answers in a manner which would appear prejudicial to the aims of standardization and comparability (May, 1997). The questions which are arranged in a particular order are asked, starting with more general questions. Further questions are asked according to the answers of respondents.

2) Selection of Respondents

In selecting the case companies for this research, the population is selected from cases that represent the different types of companies identified by conceptual research and which can be considered typical of each company type (Eisenhardt, 1989). The selection is purposeful, not random. The sampling criteria include the job description of the respondents which must be directly involved with decision makings of reverse supply chain management in each of the company. The job position of respondents who were involved in this research includes Quality Managers, Logistics Managers, Supply Chain Managers and Returns Managers.

3) Interview Procedure

The interview script (Appendix 3) was constructed based on the literature review of RSC and performance measurement in FSC. All the research questions regarding the RSC activities and towards examining the strategic objectives were used based on characteristics of product returns and characteristics of disposition option used. The process is started with preliminary contacts to obtain agreements to participate in the research, and suitable personnel were identified. Also, the aims of the research were clarified and the date for the company visit was agreed upon. Semi-structured interviews were conducted during the visits and the researcher also had the opportunity to inspect other material such as company documentation. The interview lasted two to three hours, and for each company, one interviewee is used. The interview conversations were recorded with the agreement of the interviewees and each interview was transcribed later for analysis.

4.4.3 Questionnaires Survey

1) Rationale

To further validate the framework, questionnaires are sent out to a number of identified managers and department heads who are directly involved in product returns management. The use of the questionnaire is selected to match the third aim listed by Babbie (1973) which is to have a description of events or opinions and/or their distribution. Unlike in other types of study, here, the aim is not that of testing, or building, a theory. It is more towards descriptive purpose, and specifically to help in bringing the concepts and variables mentioned in the framework into better focus. In other words, this questionnaire has been employed as a research instrument to support and complement the conceptual analyses and cases conducted in this study. As a whole, this study should be considered as qualitative and interpretative.

2) Selection of Respondents

Nine companies were contacted for the questionnaires where seven manufacturers and two retailers are involved. The rationale for the selection of this sample was that the companies involved deal with product returns and they are actively seeking strategic improvements in their RSC and would be most likely to view PM as a strategic improvement tool.

3) Questionnaire Procedure

The questionnaire guideline is designed based on the constructs in the previous literature review and the questionnaire structure is presented in Appendix 1. To ensure the reliability and the validity of the responses, the questionnaire was sent to four academicians in the Operations Management division and three managers working in the supply chain and logistics department from three companies for review. After some modifications, the questionnaire was sent through email and once the responses were received, they were analysed qualitatively.

4.5 Data Analysis

1) Interview Data Analysis

The type of data analysis performed in this research is based on Eisenhardt (1989) which includes both within-case and cross-case analysis. First, each case is analyzed as a closed entity. This is done mainly in order to become thoroughly familiar with each case. The within-case analysis facilitates the unique patterns of each case to emerge before it is pushed to generalized patterns across cases. Secondly, after within-case analysis, cross-case analysis is conducted in order to find patterns that apply over single cases. The idea of cross-case analysis is to find accurate and reliable theory that would fit as closely as possible with the data obtained from several cases. The comparison of the findings with extant literature is carried out where it involves identifying the similarities and differences between findings and literature as well as identifying possible explanations for these.

2) Questionnaire Data Analysis

Although the questionnaire has been used as a research instrument, this research cannot be regarded a nomothetical (see for example Neilimo and Nasi, 1980). This is mainly because the questionnaire was carried out to collect primarily qualitative and descriptive data on the present state of measurement practices rather than to collect quantitative data enabling identification of cause-effect chains and statistical generalizations.

4.6 Reliability and Validity

In order to conduct research in operations management (OM), the researcher must incorporate real world data into the research and all research is based upon theory (Flynn *et al.* 1990; Voss, 2002). This research deals with the exploration of existing theory and helps to better structure the theories in light of the observed results. It can be concluded that the research has managed to achieve this but the next question is how reliable are the results? To answer this, a validation approach was adopted. The reliability and validity measures conducted in this research are based upon the methods suggested in the case study approach. To ensure validity in case studies, Yin (1994, p.33) proposes a number of tactics associated with construct, internal, and external validity. In short, construct validity is promoted by using multiple sources of evidence, by establishing a chain of evidence, and by having the key informants to review the draft case study report. Internal validity is built by doing pattern matching, explanation building, and by conducting a time-series analysis whenever possible. External validity can be improved by conducting several case studies, that is, by following replication logic in case studies. To demonstrate reliability, the operations of a study such as the data collection procedures should produce the same results whenever repeated. This can be done by using case study protocol and developing a case database. Since these issues are relevant in this research, each of the issues is briefly reviewed or discussed in terms of the purpose and realization of this study based on problems addressed by Leonard-Barton (1995) concerning retrospective case studies (see Table 4.2).

Table 4.2 Discussion on the issues in multiple site retrospective case studies

Research activities	Issue
	1. Data gathering
Efficiency	Semi-structured interview platform. The structure of the interviews was communicated to the respondents in advance.
Objectivity	Data triangulation whenever possible: company documentation, feedback round.
Pattern recognition	Information on performance measures and the factors affecting them cumulated along the interviews: this enabled a gradual recognition of issues regarding PMS
	2. Establishing validity
External validity	External validity is promoted by the definition of population or target group in which the results (the constructed framework) are applicable.
Internal validity	Cause-effect relationships are not of primary interest here. Pattern matching as a method of analysis is still applied to some extent. (Internal validity is a concern only for causal studies (Yin, 1994)).
Construct validity	The use of multiple sources of evidence and multiple cases are the core means to secure construct validity. Also the feedback round with the interview manuscript was intended to improve the validity of the findings.

. 4.7 Summary

In order to answer gradually the research question and to address incrementally the research objectives, this research is carried out in three stages: background, theory building, and theory verification. The nature of the research is qualitative and exploratory. This allows the researcher to identify gradually the reverse and closed-loop supply chains and performance measures approach, in a manner in which data collection and interpretation are intertwined and iterative. The case study approach is chosen because it allows investigating in depth the reverse and closed-loop supply chains and performance measures in supply chain management. The selection of UK companies is justified by the existence of product take-back regulations and consumer policies which resulted in a high number of product returns from consumers. The respondents are Quality Managers, Logistics Managers, Supply Chain Managers and Returns Managers.

Detailed information is collected using a variety of data collection procedures (semi-structured interviews, questionnaires, and support documentations). The semi-structured interview is used to collect in-depth data while the consistent use of an interview guide increases the comparability of the data that makes it easy as a result of questions in the guide. The questionnaire is constructed to include open-ended questions to have description of reverse supply chain and the practice of performance measures. It is more towards descriptive purpose, and specifically to help in bringing the concepts and variables mentioned in the framework into better focus. The quality of the research is confirmed based upon the reliability and validity measures used in the case study approach.

This chapter described and justified the research method. The next chapter proposes a framework for PM in reverse supply chains, which involves three levels; procedural framework which includes step-by-step procedure in designing a PMS, structural framework to select strategic objectives based on the characteristics of RSC involved and also a list of performance attributes and performance metrics towards achieving an effective RSC

Chapter 5

Performance measurement in reverse and closed-loop supply chains

In this chapter, three levels of performance measurement dimensions are proposed for a reverse supply chain. These levels are created to provide two important elements in PM: structural and procedural elements. The first level consists of a five-step procedure which encapsulates the start-to-finish guide towards a performance measurement system for reverse and closed-loop supply chain. Then, the second level follows with a proposal of a framework model to make a suitable selection of strategic objectives in selecting the appropriate performance attributes according to the identified characteristics for the reverse and closed-loop supply chains in place. The third level is developed to propose a list of appropriate performance metrics to address the performance attributes selected in the second level.

5.1 Introduction

Product returns in a reverse supply chain must be managed strategically as the challenges are not the same as in a forward supply chain. The results of the interviews indicate that every company realises the importance of performance measurement in managing product returns. Though some of the performance metrics used are usually regarded as the same as those used in monitoring the performance of a forward supply chain, the biggest challenge in managing product returns - which is the level of uncertainties - should be addressed. Therefore, it is important to identify the characteristics which influence the selection of performance measures for a reverse supply chain.

The framework model proposed in this chapter adopts Folan and Browne's recommendation of PM development typology (the framework was introduced in the literature review) which includes two elements: procedural element and *structural* element (Folan and Browne, 2005) . *Procedural* element in PM defines the step-by-step method of how to design a PM. *Structural* element on the other hand highlights the administrative and selection elements of the PM process. For the PMS of RSC presented in this chapter, it comprises a five-step procedure which is defined as the procedural element and the framework model in selecting strategic objectives is designed as the structural element. The list of performance metrics is provided at the end of the chapter to complete as additional PM tools. These two elements are considered to envisage a PMS for RSC.

5.2 Level 1: Five-step procedural framework

In designing a performance measurement system, a complete structure is central to capture the most important and meaningful elements in achieving an effective performance measurement.

The following five step procedure may help companies to track and improve performance of their reverse logistics operations. The steps include: (1) setting the strategic objectives; (2) collecting proper data; (3) defining a set of simple measures; (4) analyzing the reverse supply chain operations; (5) making informed decisions based on (3) and (4).

Set strategic objectives

There are several possible strategies for dealing with product returns; the best strategy may depend on the type of return and the stage where the product is in its life-cycle, or it may be a compromise of several goals or views. In many companies, there tends to be an immense focus on minimizing cost. Guide and Van Wassenhove (2003) point out that a too- narrow focus on costs may result in a slow and fragmented process with many hand-offs between different parties. They propose to focus on maximizing value recovery, which forces companies to look at returns from a business perspective instead of treating returns as a waste stream. Other strategic objectives include maximize reuse; minimize landfill; maximize speed; reduce the number of (unwanted) returns and maximize the availability of wanted returns (e.g. in a reuse scenario), including complying with environmental regulations.

Collect appropriate meaningful data

Sometimes it is not immediately clear what primary data to collect. The following list may not be exhaustive but provides an overview of the data which we think may be essential to analyze the reverse supply chain operations and to define appropriate metrics to enable informed decision making: the return reasons (why are the products returned?); the return volumes / rates; the location of the returns; the quality (and history) of returned product; the timing of the returns and life-cycle aspects (when are products returned and what stage of their life-cycle are they in?); timing of returns through all reverse logistics processes (when are returns received and dispatched at each stage?), routing information (how are returned products processed and through what stages?), flows, capacities and processing times for each stage; the (residual) value of the returned product and its time sensitivity (does value erode over time or not?); cost information (cost of collection, testing, repair, refurbishment, recycling, landfill, re-marketing and re-distribution); revenue information (e.g. revenue from selling refurbished products on the market); market data (sales potential of refurbished products, likelihood of cannibalization of new product sales when selling refurbished products).

Define a set of specific measures to track performance and set targets

There are many metrics which can be defined to measure an organisation's operational performance, but we think that a limited set of measures can be used to capture the key characteristics of the reverse supply chain operations. To facilitate the selection of appropriate metrics, we propose an (initial) conceptual framework in Level 2. This framework has two main dimensions: key characteristics on product returns, and information about the recovery process.

Analyze the reverse / closed-loop supply chain according to the measures defined

With proper metrics defined and data collected, one can start to analyze the reverse supply chain operations. A recommended approach is to look at the entire system in terms of flows and bottlenecks (Guide *et al.*, 2005). The key to successful reverse supply chain management is then to try to remove the system bottlenecks. Each reverse supply chain activity (acquisition; reverse distribution; test, sort, disposition; recondition; remarket) may become a system bottleneck. As bottlenecks require special attention, it is recommended to monitor them closely and to define specific metrics to track performance improvement. In implementing new performance measures, trial programs can be practised where an identified action is applied to a certain process in a specific length of period. Any non-useful or meaningless performance measures need to be closely observed, along with out-of-control measures.

Informed decision making

Some reverse logistics activities will function well and do not need special attention. It will be sufficient to monitor their performance over time to make sure that everything stays that way. For other activities (e.g. bottlenecks) some metrics may be out of target. Management can allocate more resources and define improvement projects to resolve these situations. Temporary action variables or specific measures may be necessary during the improvement project.

5.3 Level 2: Structural framework model

The framework in Figure 5.2 is developed to summarise the whole concept to approach the performance measurement for reverse and closed-loop supply chains. The objective of the framework is to capture the appropriate strategic objectives according to the characteristics of returns received and the recovery or disposition channels chosen. The framework is developed to capture the most important features that affect the operation of the reverse supply chain, and hence, are important for the measurement of its performance. The design of the framework includes the following highlights:

5.3.1 The importance of segmentation

Segmentation is needed to select clearly the most appropriate performance measures to achieve effectiveness in a reverse supply chain.This is because the flow of returns can include a mixed type of products from different range or life-cycle stages, and every company should tactically process each return to retrieve the most benefits from the returns. Therefore, the framework acts as guidance towards recognizing strategic objectives to be used towards selecting appropriate performance measures which will give meaningful results. There are four dimensions which act as the pillar of the framework (please refer to Figure 5.1) which are divided into two columns of category:

- Product Returns
- Recovery Options

In the Product Returns column, two characteristics are identified to influence the selection of strategic objectives:

- Time sensitivity
- Desirability

In the Recovery Options column, two characteristics are distinctive:

- Recovery Process
- Reverse Supply Chain Structure.

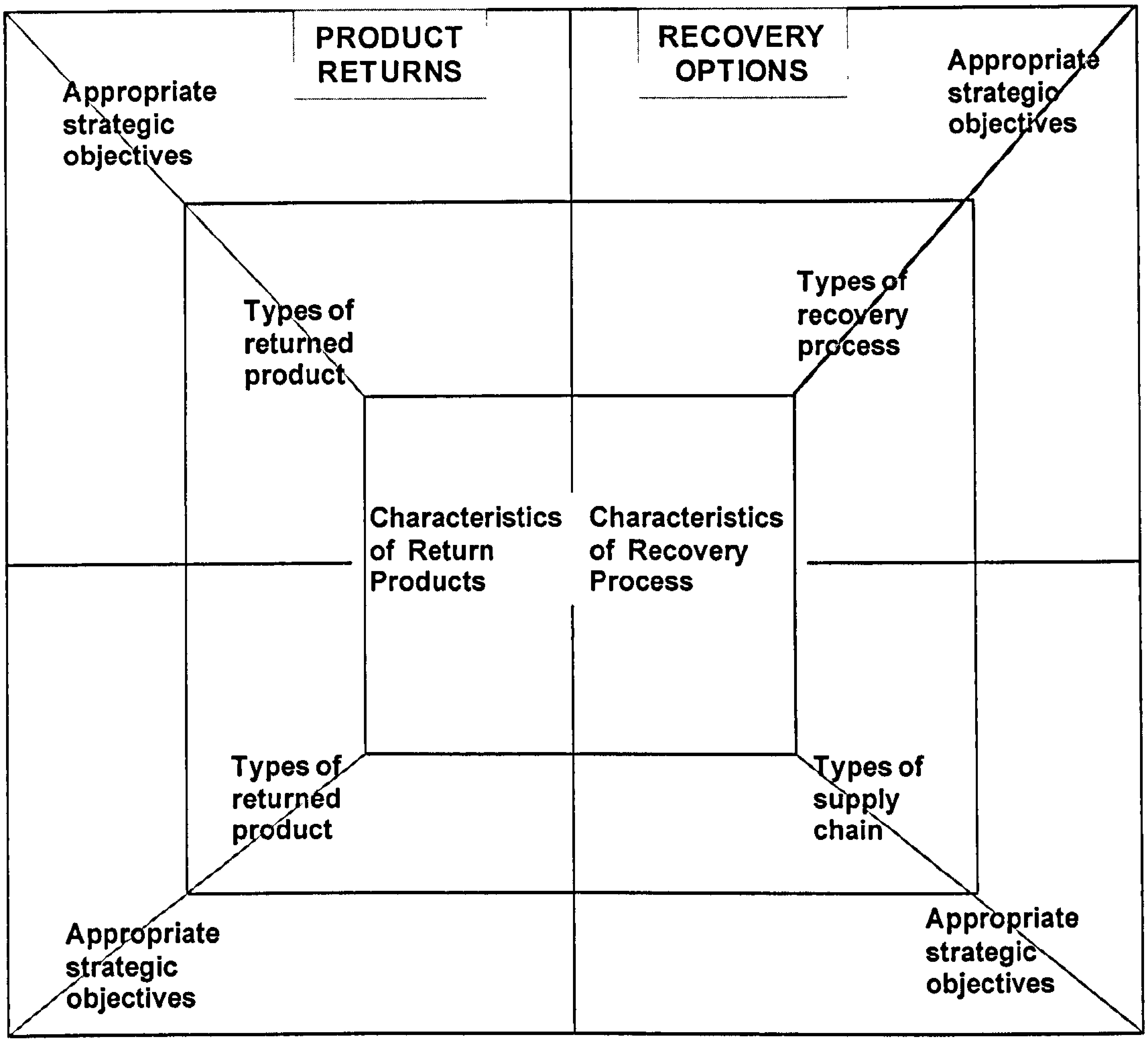

Figure 5.1: The basic structure of the framework

Each element belonging to the characteristics mentioned above is recognized and laid out in details. Then, the strategic objectives appropriate for the elements are identified and linked to each element as illustrated in Figure 5.2. All types of the mentioned dimensions will be discussed in detail below and all the key words used in the framework are further elaborated in the following sections.

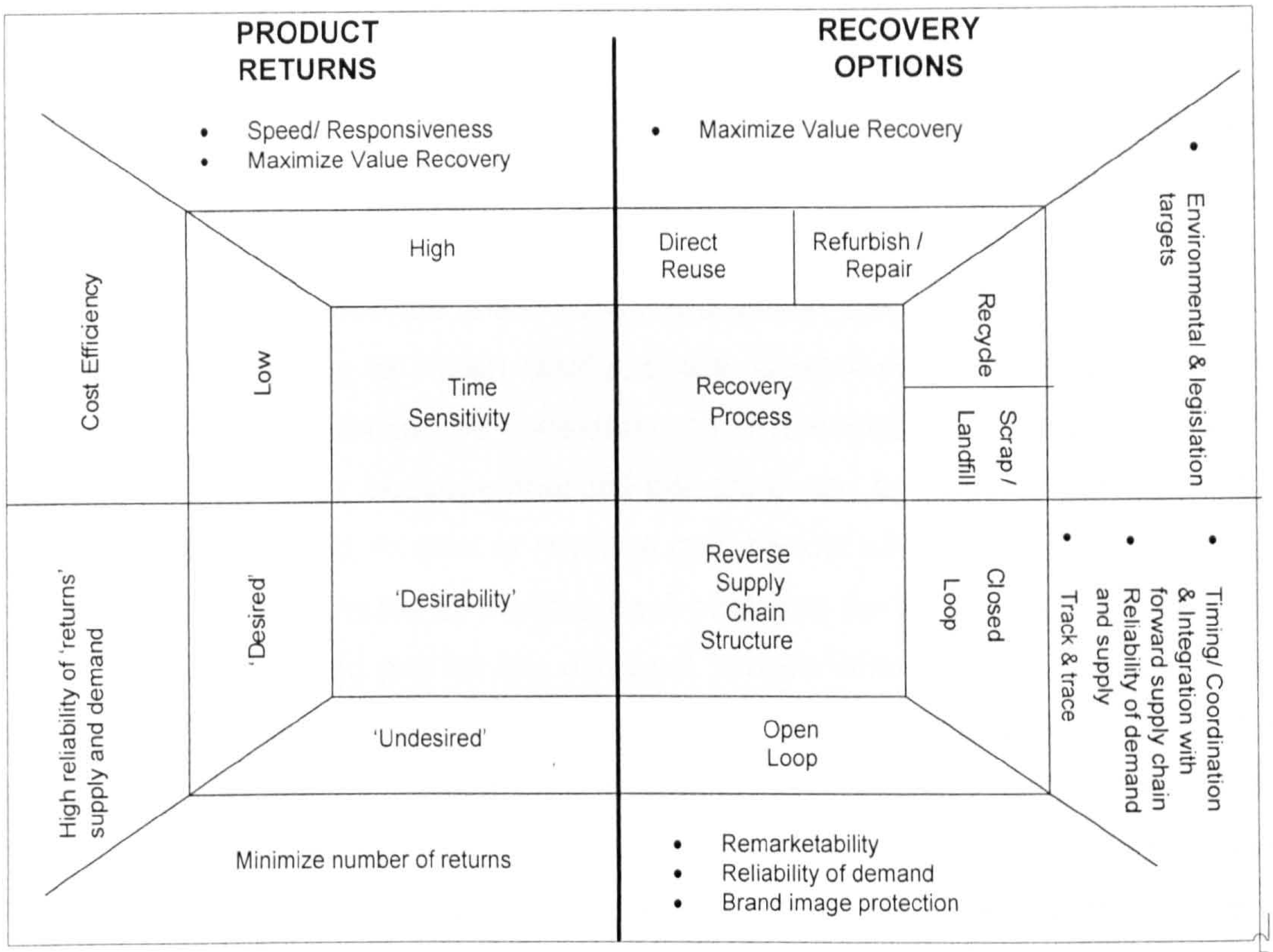

Figure 5.2 - Structural framework of performance measurement (PM) for reverse supply chain (RSC)

5.3.1.1 Characteristics of Returned Products (1): Time sensitivity

In Fisher's taxonomy of strategic design choices for forward supply chains (Fisher, 1997), products are characterized as either functional (predictable demand, long life cycle) or innovative (variable demand, short life cycle). He argues that functional products demand cost-efficient supply chains, whereas a supply chain for innovative products should focus on responsiveness and speed. Blackburn *et al.* (2004) extend Fisher's framework to reverse supply chains, and propose the concept of time-sensitivity to decide how to design the reverse supply chain. High time-sensitive products (e.g. consumer electronics) lose their value rapidly. Obviously, time related metrics are of crucial importance for high time-sensitive returns, because the longer the returns are tied up in the system, the more value is lost. The main characteristic of responsive products is that their life-cycle is short which increases unpredictability. To avoid elevated loss of product value, time to re-market these types of returned products has to be minimized. The reverse supply chain should be responsive, and the overall focus should be to maximize value recovery. When time-sensitivity is low or when the returns have lost most of their value (e.g. end-of-life returns), speed is not important. This type of products is labelled as functional products where they have stable, predictable demand and long life-cycles. The focus for this type of products is to have the physical costs as low as possible. In that case, the overall focus is cost efficiency and economies of scale.

Time-related metrics are also more important in the aftermarket / repairable service parts industry or when products are leased/rented instead of bought. Indeed, repairable parts can be considered as time-sensitive products (even when their life-cycle is long), because financial penalties may be involved when a part is not replaced / repaired on time or revenue may be lost when repair takes too long. An example can be found in the overhaul business for jet engines. Airlines can either buy engines and pay for the overhaul service when due, or they can lease the engines and pay the manufacturer a fee for every hour the engine flies. In the latter case, they don't incur extra costs for overhauls. The key metric that is used in the jet engine overhaul business is turnaround time, which is the total time taken to collect the engine from the customer site, to do the repair and overhaul and to deliver it back to the customer. The dimensions on the time senstivity are summarised as below:

Characteristics	Strategic objectives
Low time-sensitive (functional) returns	• Minimize overall cost
Highly time-sensitive (responsive) returns	• Increase speed to remarket • Maximize value recovered

5.3.1.2 Characteristics of returned products (2): Desirability

Some returns are more desired than others. Desired returns also involve addressing the effect of take-back regulations to manufacturers and this become unavoidable to any companies involved. This is particularly true for end-of-use and end-of-life returns. Acquisition of returns which enter closed-loop supply chains are very much desired such as re-usable packaging, refillable containers, repairable spares whereas returns from overstocks, convenience returns and defects should be avoided as much as possible. A key objective for the unwanted returns is to minimize their volumes. By systematically keeping track of the main reasons that products are returned, one may be able to eliminate some of the root causes of why products are returned. For the 'wanted' returns one may try to ensure that there is a smooth, constant supply flow so that their processing or integration with the forward supply chain can be managed easily.

Some companies actively source end-of-use / end-of-life products, and recondition and re-introduce them into the market. One example is the case of mobile phone refurbishment discussed in Guide and Van Wassenhove (2003). The key parameter which determines the acquisition price of old mobile phones is the quality of the products. In aerospace, engine manufactures actively buy back surplus jet engines from airline operators. The main driver for this effort is again purely economical; to make profits by turning these engines into overhauled parts to be used into the company's engine repair and overhaul operations, or by selling the overhauled parts in the open market. When surplus engines are bought back, one key performance measure is to check the reliability of the documentation that comes with these engines. The history of service and overhaul and the amount of time it spent in the air are key data in determining the value of a used engine. The dimensions on the desirability can be summarized as below:

Characteristics	Strategic objectives
Desired returns	• Maintain high reliability of returns' supply and demand in terms of volume, timing and quality
Undesired returns	• Minimize the number of in-flow returns

5.3.1.3 Characteristics of Recovery Options (1): Recovery process

Direct recovery involves as-good-as-new products that can be fed directly into the market through reuse, resale and redistribution. Another type of recovery may involve reprocessing, including repackaging and all the recovery options described in the earlier chapter. Key objectives can be maximizing value recovery or revenue from selling refurbished products which can involve minimizing overall cost, but if any investment along the recovery process can facilitate increased revenue from the remarketing, cost should not be the main focus. Reliability is obviously an important performance metric because returned products are to be re-introduced into the market, and this will directly involve protecting the brand image. The two other recovery options mentioned are recycle and landfill, both of which are more associated with a disposal process. Potential key objectives here are minimizing overall cost and compliance with environmental and legal targets. The dimensions on the recovery options can be summarized as below:

Characteristics	Strategic objectives
Direct reuse Refurbish / repair	• Maximize value recovery
Recycle & Landfill	• Minimize cost • Compliance with environmental and legal targets

5.3.1.4 Characteristics of Recovery Options (2): Reverse supply chain structure

Reverse supply chains can operate in an open or closed loop. Closed loop supply chains may be more difficult to plan and manage than open loops. The re-introduction of returned products in the forward chain may lead to disruption and bullwhip effects, if the two flows are not closely coordinated or if e.g. the availability of returns is ignored in the production planning. On the other hand, if the reverse supply chain operates in an open loop, new outlets (or markets) need to be created to sell / dispose returned products. Disposition decisions can depend on the life-cycle, and that flexibility in outlet selection is important. In addition, with new market segments being opened, cannibalization of new product sales may be an issue. The dimensions on the reverse supply chain structure can be summarized as below:

Characteristics	Strategic objectives
Closed-loop	• Good timing and coordination & integration with forward supply chain • Reliability of supply and demand • Good track and trace system on physical product and information related to all activities
Open loop	• Remarketability • Reliability of demand • Brand image

The framework was constructed to assist in the identification of appropriate performance metrics and put them in priority order according to the strategic objectives of a reverse supply chain.

5.3.2 Positioning the cases in the conceptual framework

The dimensions described in the above sections were used in the construction of the framework to assist the identification of appropriate performance metrics and put them in priority order according to the strategic objectives of a reverse supply chain. Therefore, a company can easily link its type of returns and disposal or recovery process to the characteristics associated to each dimension in the framework. Each characteristic then leads to the strategic objectives which are formulated to bring maximum benefits to the company from the returns managed.

5.3.3 Identifying the effective measures for each type of return

When strategic objectives have been recognized, the performance metrics can be selected from the list provided in the third level.

5.3.4 Using the measures in the process stages

To calculate the performance measured for tactical and operational levels, each process stage and bottleneck are analysed to apply the appropriate performance measures which can be decided by the managers involved.

5.3.5 Differences of performance measurement in forward supply chain and reverse supply chain

The implementation of performance measures in a forward supply chain of the returned product might comprise the same performance metrics used in the reverse supply chain. The comparison between the two parts of supply chains, however, is not a constructive evaluation because the data compiled from the result do not necessarily contribute toward formulation of the same performance target. One perspective of the framework is to emphasize that achieving the right strategic objectives can help to identify meaningful performance metrics.

5.4 Level 3: List of performance attributes and performance metrics for reverse and closed-loop supply chains

Performance management system design involves collecting information and measuring how effectively an organisation manages its supply chain. Therefore, when an organisation has selected the appropriate strategic objectives which correspond to its type of returns and type of recovery option, data is collected to measure the performance indicators involved. For this purpose, the following sections are dedicated to develop and relate performance metrics with the performance attributes viewed to be significant in reverse and closed-loop supply chains perspectives. Each of the performance attribute chosen is defined specifically for performance measurement in a reverse chain context and supported with background assessment and all relative performance metrics. The use of performance attributes is to mirror SCOR practices where it is used to associate with process element in the supply chain involved. Each performance attributes is then supported by fundamental performance metrics. As described in Chapter 3, performance metrics is a definition of the measure, how it will be calculated, who will be carrying out the calculation, and from where the data will be obtained (Neely *et al.*, 1995). Performance attributes are defined as characteristics of a supply chain used as a measure which can act as review to compare between other supply chains (SCOR version 7.0).

The measurement of performance metrics listed below may be applied at different stage of process along the supply chain at different frequency per period of time. This is because similar to the performance measurement used, the performance measurement system may be unique to each individual organisation, reflected by the type of returns it receives and its recovery option chosen.
Performance metrics listed below are used as an additional comprehensive PM tool to facilitate the following PM contexts:
i) quantitative and qualitative perspectives
ii) levels of management (strategic, tactical, operational)
iii) internal and external perspectives.

It should be noted that all the performance metrics should be measured as quantitatively as possible, even though qualitative measures are involved, in order to avoid subjectivity. The quantifying process is used to consider measures that are based on observable or determinable quantities. Exceptions are given to 'existence' type of measures, where instead of collecting a set of data for a period of time, the measure is prepared by ensuring the data is obtained and made available.
The list of performance metrics listed below also takes into consideration the mixture of strategic, tactical and operational level PM. This is also parallel with SCOR model where different hierarchy of metrics are created (Level 1, Level 2, Level 3) to fulfil the needs of hierarchical process elements. Level 1 Metrics are primary, high level measures that may cross multiple SCOR processes. Level 2 and Level 3 are lower level measures related to a narrower subset of processes. The performance metrics listed for this RSC PMS, however, is not categorized

according to specific hierarchical levels, as different industries may utilize different hierarchy characteristics.
The requirement of addressing internal and external environment is also considered in listing of performance metrics below. This perspective is regarded in SCOR model where five attributes are grouped into Customer-Facing (external) and Internal-Facing categories.

The following section is dedicated to address the importance of performance attributes appropriate for RSC and CLSC. Each performance attribute is classified with its own definition, background and performance metrics (data collected required). This section is concluded with a table (Table 5.1) to summarise the performance metrics proposed for each performance attributes discussed.

5.4.1 Costs (Efficiency)

Definition

The costs associated with any process measured, involving variable and fixed costs.

Background

In almost every supply chain cost is considered as the highest priority measure. It is also listed as one of the two most important internal performance attributes in SCOR model. In reverse supply chains, the cost of operating returns is frequently monitored at every process stage to capture the process that has the highest impact on profits. Generally, reverse logistics is divided into five stage of processes as mentioned in Chapter 2. For each stage, the challenges vary between different types of businesses as described by Guide and Wassenhove (2003). The variance of level of difficulty in terms of planning, controlling and managing are distinctive as the result of the management activities, and the focus on these common processes is not the same for all closed-loop supply chains. Therefore, when an organisation has identified which process causes the bottlenecks along its reverse supply chain, more focus on setting up performance control is needed.
Other than costs involved in all the related process to recover the residual value, indirect cost may occur from the result of value erosion of the returns. The erosion of product value that relates with time or depreciation rate is obvious for time-sensitive returns. The classification of the return products mentioned is dependent

on the basis of their demand patterns in the forward chain (Fisher, 1997); functional and innovative products. The life-cycle of a functional product is normally much longer than the life-cycle of an innovative product, which makes the latter a time-sensitive product. Therefore, if it is a time-sensitive return, then, all the time it spends along the reverse supply chain is cost-related. This means that the timing for every process involving a time-sensitive product needs to be measured. This measure is called value erosion. The loss of asset value over time on returns is classified as avoidable by Blackburn (2004). To study the value erosion for returns, one project is conducted by Guide *et al.* (2005) with Hewlett-Packard's remarketing group where the project has recognized the importance of the value of time in time-sensitive returns and its impact on profitability. In maximising the recovery value, HP managers are being recommended not to delay the recovery/repair process on the used notebooks. With efficient early sorting in-house and avoiding direct delivery to outsourced repair centre, the savings can reach up to $147,000 per month from the monthly flow of 1,000 notebooks.

Another indirect cost that needs consideration in a reverse supply chain is the cost of Information and Communication Technology (ICT) installed internally and externally to support a reverse supply chain. An implementation of a new ICT system can be very expensive but the cost should be applied to the cost and time savings made and value recovered throughout its use. Returned products from the waste stream have no direct cost for obtaining the products; however, there are logistics costs associated (Guide and Wassenhove, 2001). In addition, the remanufacturing cost of a used product is inversely related to the cost of acquisition since the quality of the used product will determine the amount of material replacement and labour content, among others. For a reverse supply chain, the inventory cost contributes a huge amount of direct cost percentage besides the logistics cost .Nonetheless, it is vital to identify which stage of process along the reverse and closed-loop supply chains that contributes the highest cost. To achieve effective cost measurement, performance of a reverse supply chain should not be based on financial measures only. Meaningful results can be achieved by comparing cost data with the amount of value recovered from the returns and also the potential indirect gain towards the company's long term mission such as in achieving a good environmental image.

Data collection

What is measured?

1. Product acquisition cost
2. Reverse distribution/ transportation cost
3. Cost for testing/ sorting
4. Repair/refurbishment cost
5. Remarketing/ redistribution cost
6. Inventory cost
7. Land filling/ scrapping cost
8. Value erosion cost (loss of value because of delays)
9. Incentive alignment cost
10. Penalty cost (e.g.: repair is over due date, quality issues occur after repair)
11. Residual product value/price + overall cost of scrapped return products
12. Inventory level (overall and every stage)

5.4.2 Value recovered (Value recovery/ Revenue issues)

Definition

The revenue obtained from managing and disposing the product returns. This can be accessed from the process of:

- Sales of refurbished or as-is product returns
- Sales of components retrieved from reclamation process
- Reuse of components/parts/packaging from reclamation process
- Service charge from product life-extension programs
- Recycling of valuable materials

Background

Most of the business organisations will have the economic gains as first priority in measuring the performance of reverse and closed-loop supply chains. Even though there are regulations that force companies to manage their product returns, the final value recovered from the returns is closely monitored. Nevertheless, there are many companies who actively acquire their end-of-use and end-of-life products to reclaim functional parts and modules for spares inventory. For companies in the repair and maintenance industry, used spare parts which are properly refurbished to the usable standards can achieve as much as one third from the cost of a new part. Recycling is also an attractive option to retrieve valuable material for production of new products.

Data collection

What is measured?

1. Revenue from reselling repaired products in value-recovery
2. Percentage of returns entering different recovery options (reuse, repair, refurbish, recycle, scrap & landfill, etc.)
3. Number of products enter the wrong disposition route
4. Cost avoidance by reusing refurbished parts/products in the forward supply chain
5. Cost avoidance by recycling materials
6. Number of times products are reused

5.4.3 Flow & Time related measures (Responsiveness)

Definition

The time taken to complete a process. This includes all the activities related to the reverse supply chain starting from product acquisition to remarketing.

Background

The total time to process returns is not widely measured because usually many activities are outsourced to other parties involved and this results in lack of visibility. For the service and maintenance industry, however, time plays an important part in measuring the whole reverse supply chain performance since every product in service is 'on-loan' to the overhaul and maintenance provider, and the continuation of the product use is stopped. If the product value is very high, it can in fact be a liability to the service provider as security is needed to protect the product and sometimes the 'technology' it carries. Total recovery process time is also an important performance measure for any reverse supply chain that deals with time-sensitive products such as highly innovative or seasonal products.

In order to reduce the return rates, the reason behind every product return must be examined. Therefore, all related data regarding incoming product returns must be measured and analysed towards achieving every strategic objective in RSC and CLSC including what and why products are returned.

Data collection

What is measured?

Flow measures:

1. Return rates by product line/ product category
2. Return rates by returns' reason
3. Return rates by channel partners/ region/ location
4. Return rates by return policy (impact of change on return policies)
5. Return rates by quality
6. Return rate variability

Time related measures

1. Total lead time (time from product being returned until final disposition is reached)
2. Lead-times for each processing step
3. Lead-times variability
4. Compliance with due dates
5. Inventory levels of returns at each stage
6. Inventory at risk (to become obsolete/ write-off)

Erosion of value

1. Percentage(%) of decrease in value over time

5.4.4 Quality related measures (Reliability and Accuracy)

Definition

The level of conformance to standards

Background

Reliability must reflect how stable and consistent a process or a system should be. When the reliability of a monitored process is high, then it is easy to forecast future operations. In a reverse supply chain, a company should measure the reliability of the volume, the timing and the level of quality of the incoming returned products according to the type of the final disposition route of the returns. For reverse supply chains which remarket refurbished products back into the primary market, the level of quality of the products has to match the quality of new products and it is a vital performance measure. Especially for closed-loop supply chains, the reliability of the in-flow returns is the key factor in generating an efficient supply of refurbished products to the destined market. If the returns are sold into a secondary market, however, with all identification of the manufacturers or retailers erased, then the merchandise is priced according to the quality which is assessed from the aspects of functionality, cosmetic damage or the life-cycle stage in the market. For disposal of end-of-life products which usually involve recycling and land filling, quality measures of incoming returns might not be needed at all. Product returns are shown to have a distribution of nominal quality (Krikke *et al.*, 1999). By identifying the different levels of average nominal quality and the associated acquisition cost, a company may be able to distinguish what minimum level of quality is needed for reuse and still be economically attractive.

Data collection

What is measured?

1. Product returns volumes (by category, by channel partners)
2. Number of faulty/ badly damaged returns
3. Number of no-fault-found returns
4. Percentage of refurbish/ reuse/scrap
5. Percentage of defects
6. Failure rates (all at testing, quality inspection stage)
7. Number of complaints
8. Customer complaints resolved
9. Level of quality of refurbished products

5.4.5 Traceability

Definition

The necessary record taking of product's use and any refurbishments, repair or upgrading work done on the product.

Background

This metric is usually required for maintenance and repair operation and also model upgrade works. When a product is in the service provider facility, it is practically on loan and every part dismantled for service must be recorded in a proper manner to ensure two important issues; no parts have gone missing and the part's exact original location on the main module or product. This measure is also required for reverse supply chains that involve expensive, high technology and complex products such as aircraft engines and data processors. For repair and maintenance works, the history of previous service carried out on the product is related to the condition or the level of quality of the product. Though some products can go through a series of testing to assess the functionality, certain products - for example parts in a turbine of an aircraft engine - do have limitation on numbers of usage. Therefore, record taking on the number of use and all information related is necessary and the accuracy of the database system is vital. Further, the records are essential for the repair and maintenance, service and use history in supporting the acquisition of used products for spares or refurbishment activities.

Data collection

What is measured?

1. Number of components before repair & overhaul
2. Number of components after repair
3. Number of components/parts lost
4. Number of refurbished/as-is-returned products through each market/ disposition channel
5. Number of rotation of reuses per period of time
6. Location of product at which date/what time
7. The length of loan period (for product on lease)
8. The condition of product at which date/what time (over a period of time)

5.4.6 Coordination

Definition

The interaction between players along the reverse supply chain which channel positive impacts in achieving the objective of the whole reverse supply chain

Background

Coordination can be achieved when all process stages, functions (internally) and players (externally) are clear, with the strategic objectives set and information flow along the supply chain not distorted. In the reverse or closed-loop supply chain, the type of coordination needed becomes clear between retailers and their suppliers. Agreements on how the returns should be managed and which party should bear all cost related to returns have to be made clear. There are suppliers who are willing to offer good credit terms for the retailer to sort out any no-fault-found upfront before the returns are sent back to them. Any agreements on returns are expected to be included in the earliest business arrangements with any new supplier. In a forward supply chain, coordination is the main factor in managing suppliers more effectively and it should also be operated to settle any issues for returns.

Data collection

What is measured?

1. The existence of return agreements in business contracts with each supplier/ vendor
2. Product returns level at each process level
3. Length of time the product returns spent during in-use
4. Number of services completed along the products' life-cycle
5. Inventory level of 'third-party' players
6. The number of documentations of specification regarding level of product quality required, delivery requirements, etc.

5.4.7 Flexibility

Definition

The ability to source various ways in disposing (reuse and remarket) the returns including recognising the available options to dismantle or reuse and finding the possible channels to remarket. All options chosen should be at minimum cost and maximum value recovered.

Background

This measure is important for companies who choose to dispose their returns in an open loop supply chain. As in forward chain, flexibility is the solution for dependency on suppliers to be in the stronger competitive position. Third parties like jobbers and recyclers are at the receiving end of open loops where product owners outsource to remarket or disposing their returns. Flexibility required in this context includes different categories of disposition methods and market potential.

Data collection

What is measured?

1. Reusability of parts/ products (product modularity/ durability)

2. Reusability of materials
3. Feasibility in recycling/ repair options
4. Number of outlets (market segments) for selling returned or refurbished products

5.4.8 Green image (Environment & Sustainability)

Definition

The environmental measure within the business organisation. Sustainability is generally defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs.

Background

Even though imposing a green image to customers is not the main business driver of reverse logistics, it is important to measure its performance. There are two main reasons; firstly, customers are more attracted to buy products from companies that pay attention to and care for the environment, and secondly, there are regulations that force companies to take back their end-of-use and end-of-life products. Returns which are entering open-loop disposition option can impact the environment. For example, disposal of end-of-life returns to landfill will need some control to ensure responsible disposition is carried out. Another form of disposition can come from the scrap resulting from the cannibalization process of returns. Cannibalization is a process where functional parts and components are disassembled and taken from one item and used to repair or rebuild another unit of the same product (REVLOG, 1998). The components and parts also can be sent for recycling to retrieve valuable materials. The unwanted parts and components may be sent to recycling or land fill sites.

Besides the disposition process, another recovery activity which can be associated with the environment is during reverse distribution. The most obvious example is the emission of CO_2: this is produced during the process of transporting the returns and refurbished products and is an important consideration.

At the strategic level of management, environmental concern can be highlighted by imposing the effort to eliminate or minimise waste which can come in terms of energy used in remanufacturing/repair/refurbishing and in terms of by-products, in terms of scrap resulting from the process of product cannibalisation, by-products from manufacturing of new products, and also in terms of waste from end-of-life and end-of-use manufacturing streams. In the European Union, the existing regulations on product take-back do not cover all types of industry. The impact of the regulations concentrates on products such as end-of life vehicles (End-of-Life Vehicles - ELV), electrical and electronic equipments- WEEE), hazardous substances (Restriction of Hazardous Substances - RoHS) and packaging and packaging waste (Packaging and Packaging Waste). Nonetheless, companies in other industries should consider measuring the level of green image presented to the customer to ensure that customers can perceive their commitment in looking after the environment. For example, Company A (from the case studies above) is not bounded by any regulations saying that they have to take back their end-of-life products. Nevertheless, the company has moved one step further by co-operating with another business giant in the same industry to initiate a program in looking at how to properly dispose of and reuse their end-of-life aircrafts. There is also consideration of eco-design or design for environment practices incorporated in the program. Its purpose is to identify the appropriate product design to ensure that less energy is needed to dismantle and complete the recycle process. It is also to reduce the need to use non-sustainable virgin materials and non-sustainable energy for new production. Another activity that supports the sustainability effort is the reuse of by-products from component production by recycling them into virgin material. Recycling can avoid the use of energy to convert ore to pure material and when the recycling is done locally, high emission of CO2 transportation can be greatly reduced.

Data collection

What is measured?

1. Number of regulatory compliance
2. Number of environmental certifications/ awards achieved
3. Number of environmental initiatives/ programs involved/ developed
4. Volume entering landfill
5. Volume of non-biodegradable/ non-recyclable materials used
6. Fraction of materials reused/ recycled
7. Physical quantities of materials used in production process (energy, water, raw materials, etc.)
8. Result from production process in volume (consumer products, emissions into the environment in the form of air pollution, liquid effluent, etc.)
9. % of reduction of consumption of rare material/ non-renewable energy

10. % of reduction in the use of hazardous materials/ products / process
11. Number of positive reports in the media

5.4.9 Market cannibalization

Definition

Market cannibalization is defined as the decline of product or service sales due to the introduction of another product or service that is a substitute (Kerin *et al.*, 1978).

Background

This situation can occur when used products are available in the same market as new products, and the former is offered at just a fraction of the price of the latter. It is also regarded as a marketing stigma when used and refurbished products enter the secondary market with lower prices than newly manufactured products. The resale value of the products in this channel is considered to be a challenge to the new product sale and might result in degrading the brand image of the manufacturer. The concern about these consequences is mentioned in the study carried out on the disposition and refurbishment processes of notebook and desktop PC returns for Hewlett Packard (Guide *et al.*, 2005) and the investigation of the effect of used, older model automobiles sales on the sales of current models (Purohit, 1992). Market cannibalization is also listed as one of the unresolved issues which need further understanding in CLSC research (Guide and Wassenhove, 2006). Furthermore, Ferguson and Totkay (2005) examine the internal cannibalization effect of remanufactured products on an OEM's new product sales. They show that an independent entrant could make profits even though a monopolist OEM may not find it more profitable to remanufacture, in part because the OEM incurs an opportunity cost when selling remanufactured products while also selling a new product. By including this opportunity cost, the authors show that the OEM may choose not to remanufacture, allowing the entrant the advantage. The measurement of cannibalization effect is more to support one-off programs in identifying the effect of used and refurbished products to the volume or the sales price of new product sales. Besides providing information to determine whether the disposition route used/taken is functioning well or managed properly internally and externally, the performance measurement is useful in determining whether choosing appropriate secondary channel can actually result in an enhancement effect, rather than the cannibalization effect, to the sales figures in the forward channel.

Data collection

What is measured?

1. Volume of sales per market (primary and secondary) per period of time
2. Percent volume of new products (of the same product with the returns) sold to the total volume of its family sales for an entire sales period
3. Percentage volume of new products (of the same product with the returns) product family sold of the entire sales volume of the brand for an complete sales period
4. Percentage volume of company's entire sales of the total market share for a complete sales period
5. The number of remarketed returns coming back as second-time returns

5.4.10 Industry clockspeed

Definition

The rate of product and process innovation in an industry (Fine 1998, 2000).

Background

This performance attribute is suggested to be used at strategic level and to be considered right at the start of the forward chain. The objective is to predict how long a product will spend its life in the market and to foresee qualitatively the period of each life-cycle stage along the introductory, growth, maturity and decline stages. Therefore, the period when the product is at its highest value can be identified and manipulated when it enters the reverse chain. The data gained from this measurement is very useful to support the decision on the total time target to remarket and also the most profitable type of disposition route. The requirement of such decision making is not expected to be done on a specific time basis, so this performance attribute should not have a regular time frequency. The measurement might be needed when a new product is launched in the forward chain, or a sudden increase in returns' volume is received from a particular product model or range.

Data collection

1. The fraction of total revenue derived from new products (i.e., introduced within the preceding twelve months)-an indicator of product innovation
2. The total duration of the product life-cycle (i.e., product life)
3. The rate of decline in the prices of input materials

The following list presented in Table 5.1 summarises the performance metrics suggested for each performance attribute for RSC and CLSC as discussed earlier.

Table 5.1 Performance attributes and performance metrics for RSC and CLSC

PERFORMANCE ATTRIBUTES	PERFORMANCE METRICS
1. COSTS •Overall direct cost	•Product acquisition cost •Reverse distribution/ transportation cost •Cost for testing/ sorting •Repair/refurbishment cost •Remarketing/ redistribution cost •Inventory cost •Land filling/ scrapping cost •Value erosion cost (loss of value due to delays)
•Indirect costs	•Incentive alignment cost •Penalty cost (e.g.: repair is over due date, error occurs after repair) •Cost of customer help-lines and technical support implementation •Cost of information and communication technology (ICT) support installed
•Cost of obsolescence •Capital tied up in system	• Residual product value/price + overall cost of scrapped return products •Inventory level (overall and every stage)
2. VALUE RECOVERED	•Revenue from reselling repaired products in value-recovery •Percentage of returns entering different recovery options (reuse, repair, refurbish, recycle, scrap & landfill, etc.) •Number of products enter the wrong disposition route •Cost avoidance by reusing refurbished parts/products in the forward supply chain •Cost avoidance by recycling materials •Number of times products are reused
3. FLOW & TIME RELATED MEASURES (RESPONSIVENESS) •Flow measures	•Return rates by product line/ product category •Return rates by returns' reason •Return rates by channel partners/ region/ location •Return rates by return policy (impact of change on return policies) •Return rates by quality •Return rate variability

PERFORMANCE ATTRIBUTES	PERFORMANCE METRICS
•Time related measures	•Total lead time (time from product being returned until final disposition) •Lead-times for each processing step •Lead-times variability •Compliance with due dates •Inventory levels of returned at each stage •Inventory at risk (to become obsolete/ write-off)
•Erosion of value (Lost of value over time)	•Product returns value per one period of time
4. QUALITY RELATED MEASURES (RELIABILITY AND ACCURACY) •Flow of product returns (consistency/stability) •The impact on returns volume and quality (by change of return policies, improvement of customer support) •Quality of incoming product returns	•Product returns volumes (by category, by channel partners) •Number of faulty/ badly damaged returns •Number of no-fault-found returns •Percentage of refurbish/ reuse/scrap
•Quality of refurbished products	•Percentage of defects •Failure rates (all at testing, quality inspection stage)
•Customer satisfaction	•Number of complaints •Customer complaints resolved
5. TRACEABILITY (before and after return stage), repair/overhaul/high technology •During process	•No. of components before repair & overhaul •No. of components after repair •No. of components/parts lost •Location of product at which date/what time •The length of loan period (for product on-lease) •The condition of product at which date/what time (over a period of time)
•'Closing' loop	•No. of refurbished/as-is-returned products through each market/ disposition channel •Number of rotation of reuses per period of time
6. COORDINATION •Incentive alignment - with different parties -with different internal functions (Debo, Savaskan, and Van Wassenhove, 2003) •Information flows -to reduce bullwhip effect -decrease total supply chain cost (Lee, Padmanabhan and Whang, 1997)	•The existence of return agreements in business contracts with each supplier/ vendor •Product returns level at each process level •Length of time the product returns spent during in-use •No. of service done along the products' life-cycle •Inventory level of 'third-party' players

PERFORMANCE ATTRIBUTES	PERFORMANCE METRICS
7. FLEXIBILITY •Product/component durability (modularity	•Reusability of parts/ products (product modularity/ durability) •Reusability of materials •Feasibility in recycling/ repair options •Number of outlets (market segments) for selling returned or refurbished products
8. GREEN IMAGE/ ENVIRONMENTAL PERFORMANCE AND SUSTAINABILITY	•No. of regulatory compliance •No. of environmental certifications/ awards achieved •No. of environmental initiatives/ programs involved/ developed •*Physical quantities of materials used in production process (energy, water, raw materials, etc.) •*Result from production process (consumer products, emissions into the environment in the form of air pollution, liquid effluent, etc.) •% of reduction of consumption of rare material/ non-renewable energy •% of reduction in the use of hazardous materials/ products / process
9. MARKET CANNIBALIZATION •Absolute volume analysis •Market share analysis •Market size analysis (Srinivasan et al., 2006)	•Percent volume of new products (of the same product with the returns) sold to the total volume of its family sales for an entire sales period •Percent volume of new products (of the same product with the returns) product family sold OF the total sales volume of the brand for an entire sales period •Percent volume of company's total sales of the total market share for an entire sales period •The number of remarketed returns came back as second-time returns
10. INDUSTRY CLOCKSPEED - measured in forward chain (Mendelson and Pillai, 1999)	•The fraction of total revenue derived from new products (i.e., introduced within the preceding twelve months)-an indicator of product innovation •The total duration of the product life-cycle (i.e., product life) •The rate of decline in the prices of input materials

5.5 Summary

This chapter has provided a proposal for designing a performance measurement for reverse and closed-loop supply chains. The PM is divided into a three-level framework. First, a five-step procedural framework is suggested as a systematic approach towards implementing an effective performance measurement, starting from setting up strategic objectives to using the evaluation of the information gained in corrective-action process. The second level presents a structural framework model which is provided to establish the appropriate strategic objectives which will lead to maximum value recovery or minimum overall cost, depending on the type of product returns and the type of recovery options used. In the framework, a segmentation concept is used and the need to use the concept in achieving the identified strategic objectives. The final level comprises the list of performance metrics which are considered to be useful in measuring performance of reverse and closed-loop supply chains. The performance metrics are grouped into ten different performance attributes and each attribute is explained in detail to show the relation of its use towards achieving an effective performance measurement system.

The next chapter presents the empirical works performed for the research which emphasises two methods: case studies and questionnaire survey. At the end of the chapter, the key findings from the empirical works are discussed in detail.

Chapter 6

Empirical results

Chapter 6 comprises the key empirical findings made in the study. As discussed in Chapter 1, the empirical part of the study consists of a study of five companies and a survey conducted within the UK companies. This chapter is divided into three parts. Part A (6.1) deals with the case studies. Part B (6.2) deals with the questionnaire survey. The final part (6.3) discusses the key findings from both empirical works. It should be noted that the names of the studied companies are not published because of confidentiality reasons.

6.1 Case study

6.1.1 Objective

As there is little evidence about how performance measurement is practised in reverse and closed-loop supply chains, empirical studies are needed to review the issue. For this purpose, an interview was used to explore the subsurface of the following interests in detail:

i. The strategy of managing reverse supply chain
ii. The factors affecting the selection of strategic objectives

6.1.2 Background and method

Five companies have been selected for the above purpose. Each company can be briefly described as a multinational company with more than 1000 employees. The first company (Company A) is a global power systems company providing power for land, sea and air, with leading positions in civil aerospace, defence, marine and energy markets, and the interview examines the aerospace maintenance, repair and overhaul operation at Facility N. The second selected company (Company B) is in IT infrastructure and personal computing business, and the research investigates how returned laptops are dealt with. Both third and fourth management companies are high street retailers. The third company (Company C) sells a very wide range of products, from home furniture to toys and the fourth company (Company D) concentrates on outdoor leisure products, bicycles, car parts including car accessories and enhancement products. For both companies, the interview examines the management of all types of returns from customers. The last company (company E) is in the information technology and communication business. The interview concentrates on the end-of-life products acquisition and disposition, which involve both material recycling and product dismantling for spare parts. As the majority of the companies have not yet allocated specific personnel to manage their returns issues, the responsibility is given to various job positions including program leaders, quality managers and logistics managers and these personnel are approached to assist with the interviews. Only one manager interviewed holds the post of Returns Manager, which is solely dedicated to manage product returns issues, and he reports directly to the Quality Manager. The five companies are selected to seek characteristics of different types of customer returns in a range of industries. The number of interviews with each company varied from one time to three times, depending on the amount of information gained from each meeting. Each interview lasted about two hours and was conducted at the companies' premises where the managers work. Because of the nature of the interview objectives, a semi-structured interview method is used (see; Westlander, 2000). As it is qualitative information which the research is seeking, all conversation is recorded and transcribed for further analysis.

6.1.2.1 Company A

The first company (Company A) is a global power systems company providing power for land, sea and air, with leading positions in civil aerospace, defence, marine and energy markets. The case study examines the civil aeroplanes maintenance, repair and overhaul operation at Facility N. At the end of 2008, Company A employed 38,900 permanent staff in over 50 countries with its turnover reaching £55.5 billion and 59 percent came from services. Operations in Facility N concentrate on the company's global component repair services which specifically provide a service to repair and overhaul. Two main operations are investigated in this case study. The first activity is where aeroplanes' whole engines, modules or parts are received from flight operators and after the service and overhaul operations, they are sent back to the customers. The second activity is where Company A buys back surplus engines owned by flight operators for the purpose of taking the engines apart for useful parts, called part cannibalization.

The first activity is a type of product life extension program, which involves products such as jet engines, airframes, and railroad locomotive engines, and is among the earliest remanufacturing programs that involve very expensive industrial goods. The life-cycle for each civil aeroplane engine is 25 years. Currently, Company A has the capability to overhaul 40 engine types that come from a range of Original Equipment Manufacturers, OEMs. Customer satisfaction is sought through high quality, fully serviced or repaired aeroplane engines in terms of parts or modules delivered between the agreed time-frame. In order to provide a wide coverage of repair and overhaul service, Company A leverages its network, composed of four repair centres through out the UK. For engine service and overhaul, each engine has a specific term time. Term time is the phrase that is given to indicate the period of time taken to service an engine, starting from the point where the engine is sent to Company A from the customer's site, to the point where the fully serviced engine is delivered back to the customer. The length of this term time is different for different types of engines. For example, for Type T and Type RB engines, the term time is 63 days. All Type A models take 15 days to be completed.

To achieve their annual business target which is to carry out repair and overhaul service on 196 engines, the following key objectives are identified:

a) Deliver 100% quality level on all repaired and overhauled engines
b) Meet the Turn Round Time (TRT) of the repair and overhaul process agreed with every particular engine owner
c) Maintain high reliability of delivery
d) Achieve lowest overall operations cost

The performance attributes observed are:

a) Time (days taken to deliver): Turn round time – cost according to the number of days taken to complete the whole process
b) Parts existence (number of parts per engine at dismantle point and at the building point)
c) Resource utilisation
    - Labour
    - Machine (e.g. test bed)
    - Capacity (space to dismantle, build)
    - Energy
d) Flexibility
    - Source of part : new parts or pool from used parts inventory

- Movement of manpower to support any process stage at different process area

e) Quality

- The use of test bed

f) Cost

- Labour
- Material
- Total operating cost

The second activity involves acquisition, repair/overhaul and reselling modules or parts from used engines. This activity is carried out at a different operating division from the previous activity described above. This activity involves acquisition of engines or parts from airlines operators who sell the engines to release inventory to improve their cash flow. There is a time where there would be a large number of engines still in use for flying the aeroplanes, but some are just surplus to requirements which will come on to the marketplace. Company A will be looking at buying back these engines with the view of taking the engine apart, overhauling the useful parts and refitting them to engines which are still flying and still need engine overhaul process in-house. Any excess material needing to be scrapped is disposed through a third party company which Company A partners and who will sort it into the different types of metal which will then go for recycling.

The main objective of this particular activity is purely economical. The output of this activity is either sold back in open markets or used in the repair and overhaul of engines (first activity). In the first activity, when the engine is in need of a part replacement, overhaul operations still need to pay the full catalogue price which is the same as an independent overhaul shop. There is no discount obtained. If an overhauled part is used, however, it is going to cost 25% to 35% less than a new part. For Company A, it can definitely make a profit by supplying a used part, where the cost of buying the surplus engine and overhauling the parts will only form two thirds of the selling price, which makes the profit one third. Furthermore, by supplying a cheaper part than a new one, Company A passes the cost reduction to its customers when overhauling engines. The customer who owns the engine sees the savings and this will help to put Company A above its competitors. Furthermore, sometimes there is a shortage of new parts and if Company A do not use overhauled parts, they will not be able to build an engine in the middle of an overhaul process. Therefore, the overhauled parts are useful for back-up inventory.

For instance, the despatching of one engine which costs $2 million was stopped because there was a shortage of a $4 seal which new production has been discontinued.

The performance attributes used are identified as the following:

- Marketability (meeting supply and demand)
- Quality of the incoming parts and also the outgoing overhauled parts
- Number of quality documentation met (for e.g. ISO4001)
- Lead time (Turn Round Time-TRT)

6.1.2.2 Company B

Company B offers consumers a wide range of products and services from digital photography to digital entertainment and from computing to home printing. The company employs 172,000 employees worldwide and in 2007, generated over $104 billion turnover. The survey concentrates on the refurbishment of returned laptops. The life-cycle of a typical laptop is 6 months making the product range's obsolescence rate very high. Returns are received from customers as convenience returns when they change their minds or as defective returns. There are also channel returns, usually from overstocks or stock adjustments. The last category is demonstration returns.

These returns are periodically collected by resellers and they will be shipped to the returns and manufacturing site. Workers at the facility will inspect the laptops upon arrival and decide on their disposition which could be:

- Direct storage in the warehouse
- Low-touch refurbishment
- High-touch (technical) refurbishment
- Scrap

All used products undergo technical testing and repair as necessary. Then, unrefurbished laptops are stored in the warehouse then delivered to an outsourced repair centre (ORC). After the refurbished laptops are received from the ORC, low-touch refurbishments are carried out and labelled as refurbished products inventory. Obsolete and unrepairable returns are sent to the technical value solutions and take-back operations division to be sold as is to brokers or to be scrapped. The process's final stage is selling the refurbished products, mostly through auctions and catalogue sales to specialized partners.

Company B's strategic objectives in refurbishing and disposing of its laptops returns are as below:

- Protect brand image

  Company B requires that all refurbished products be brought to like-new condition. This is reflected when, after refurbishment is completed on the laptops, Company B tests them and sells as quality 1 with a warranty. Any failed laptops are sold as quality 2 without a warranty.
- Optimized value recovery

  All the laptops are sorted and refurbished as soon as the laptops enter their facility and all factors which impact on profitability are considered.

The performance attributes observed are:

- Quality of incoming and outgoing products
- Total time taken to refurbish and remarket
- Total cost involved
- Total revenue from reselling refurbished laptops

6.1.2.3 Company C

This company is a high-volume retailer that sells 18,000 general merchandise products for the home from over 700 stores throughout the UK and Republic of Ireland. In 2008, its turnover was £4.2 billion and the company employed 34,000 people across the business. In terms of value, Company C receives bad product returns of about 8% of the total sales annually. Company C applies a 30-day return policy where the shop will take back any product in resalable condition with money back or it will be replaced with another product. Outside the 30-day rule, only broken products will be accepted back. There are two major types of product returns received: home-delivered returns with very high value and store returns. For domestic sourced products, all returns will be sent back to the supplier. Any excess stock or damaged stock are built into pallets, sent back to, or collected by the suppliers and full credit is received. For products sourced from the Far East or Eastern Europe which involves 35% from total products, any returns are sold to jobbers and this provides 11% return of the cost price through jobbing. If any product returns prove not economic to job-off, the returns are put into the skip. There are, however, a number of suppliers who required special arrangements. Some suppliers request that their products should be sorted at Company C to screen out any damaged returns, therefore only good product returns are sent back to the supplier. This request is to avoid the damaged returns from acquiring logistics costs. In this case, Company C will carry out the refurbishment on the damaged returns and less than 10% of product returns are refurbished. In return, it will receive better trading terms from the involved suppliers.

For Company C, the biggest problem is having a very wide range of items; the cheapest is priced at £3.50, up to the most expensive at £1500. Therefore, the volume of products handled by the retailer is very high and as it is selling products from catalogue pages, product returns are expected as there is a very limited display of products in-stores. Therefore, its main strategic objective is to drive the number of returns down to the lowest level, and in 2006 its target is to achieve 250,000 units of returns.

In looking at the retailer's strategy in managing its product returns, the following approaches are carried out:

- Provide technical helpline for televisions, ipods and a number of other electronic and electrical products which have a high number of returns. This is to give customers detailed information on the use of their purchase as one main reason for return is lack of knowledge in operating and using the products.
- Data collected on the returns received from customer are compiled and developed into a key performance indicators (KPI) pack. This pack is delegated to other related departments such as distribution, home delivery stores and contact centres, under a program team to drive actions from all the internal parties involved.
- Agreements with suppliers are made to ensure they take away any surplus stock at the end of each catalogue. Every year, Company C releases two seasons of catalogues. This is to avoid any build-up of old stock in Company C.
- 'No-fault found' returns are not welcomed by suppliers and cause problems in supplier-retailer relationships. Trials on different length of returns policy are carried out to solve this problem. In approaching this issue, Company C uses a third party to carry out market testing to compare their products with other competitors'.
- Try as much as possible to clear product returns in-store rather than let it into reverse flow, to avoid the cost of putting them on trucks. Usually the returns will be re-distributed across the retailer's largest stores.

- Work with supplier to ensure the quality delivered on each product meet customers' expectations.

Company C tracks its reverse supply chain's performance by measuring its volume and value of returns according to the following categories:

- return's channels: 2-man delivery, 1-man delivery and store returns
- store/branch
- areas and regions
- types of breakages
- hazardous and toxic returns
- supplier
- old /new returns : old returns are products that have arrived and sitting in DC more than 60 days but have not been sent back to the supplier.

6.1.2.4 Company D

Company D is a retailer that sells over 10,000 different products, ranging from car parts and cycles to the latest in-car technology, child seats, roof boxes and outdoor leisure and camping equipment. In 2008, the company owned 466 stores across the UK, Republic of Ireland and other European countries and employs approximately 10,000 staff. It is reported to achieve £797.4 million as revenue in 2008. Approximately 0.5% to 1% of sales volume came back as returns, which is equivalent to 4% to 5% of the total amount of sales value. Company D has two types of suppliers for its merchandise: local suppliers and Far East suppliers. Returns from locally-sourced products are sent back to the supplier. Products sourced from Far East countries go through different disposition routes. High value products, for example satellite navigation systems, are sent to a third party partner and undergo sorting and repair. All products for resale are checked for de-branding before they enter secondary markets and 60%-70% from the total returns are resaleable. All the earnings are divided between Company D and the partner with 70% going to Company D and 30% going to the partner. Less expensive returns of products sourced from Far East, such as introductory price radios, cheap DVD players, tents and spanners, are sold to jobbers. The products are mixed into jamboree boxes and the jobbers will buy the boxes from Company D. Depending on the quality of each returned product, there are three types of disposition methods used by the jobbers:

- Refurbish

- Recycle for valuable materials e.g. aluminium and plastic granules
- Direct re-sell – with de-branding process required

Company D focuses on the avoidance of all types of returns as the main key objectives in handling its return products, especially on no-fault-found returns from customers. This objective is shared with its partners especially with the suppliers therefore they can contribute towards the implementation of technical help-lines. Company D also makes sure there are clear agreements with suppliers regarding returns to avoid any misunderstanding along the process of handling returns from customers, as any reduction in product returns will benefit both parties.

There are a number of strategies practised to manage product returns effectively.

- Implementation of technical help-lines for in-car technologies.
- All return products entering secondary markets are de-branded to avoid they re-enter the primary market as a 'second-time' return (fraud).
- In-house repair for any bicycles returns. Company D sells over one million cycles every year and cycle specialists are hired to ensure that all repair works are completed in-house as soon as possible. To achieve the shortest lead-time, any shortage of parts is solved by cannibalising other stock to make sure that the product that the customer brought back goes back to the customer in the shortest time.
- Quality of all cycles is 100% achieved.
- 40% of the products that were coming back were under £15 retail. It is estimated to cost about £5 to bring back a unit on a lorry processing through DC. Therefore, Company D tries to clear these products in store by applying up to a 50% discount. Any damaged returns are written off by store managers, with the exception of health, safety and environmental critical items.
- In the case of in-car technology products, quality is checked by the staff in store who received the product directly from the customer. Every piece that comes back goes to a bench where the inspector examines whether all components and accessories are complete. Then the product is re-boxed, palletised and returned to the supplier. This checking is done particularly on expensive products (e.g. in-car technology) and if there is any missing component, be it SIM card, charger or mounting bracket, this will be charged by the supplier. The in-store checking effort has reduced

incomplete returns from 15% to 2.4%, and 95% of product returns sent back to supplier are boxed up.

Company D's effort to avoid customer returns has successfully reduced returns by 38% in 2006. Company D uses the same set of performance measurement as FSC with the addition of the following performance metrics:

- Value recovered – 25% to 30% of total cost of returned products is incurred through repair work and resell where jobbers can only give 5%-10% of the product cost.
- Lost in transit - In 2005, product returns with £890,000 in value are reported lost in transit from stores to DC. This happened when the amounts booked out by stores do not match the amount receipted by DC. Therefore, Company D believes it is important to monitor this issue.

6.1.2.5 Company E

Operating in over 170 countries around the world, Company E is the world's leading provider of communication services solutions which include networked IT services, local, national and international telecommunication services and higher value broadband and internet products and services. It generated £8.48 billion in 2007-08 as its annual revenue and employed a workforce of 18,000.

The case study concentrates on the recycling activity of end-of-life products such as telephones, fax machines, cables, switches and telegraph poles. Over 100 million tonnes are collected and recycled annually. Company E is bounded by the WEEE directive which requires manufacturers in the European Union to collect and recycle electronic waste from home and businesses.

Company E sell out pay-phones, alarm systems and networking equipment which involve high value equipment. There are, however, some products which are rented to customers such as telephones, fax machines and modems. The life-cycle of the products involved is between 2 years and 15 years but the average is 5 years. From the total products reclaimed from customers, 80% of the volume comes from low value products (telephones, fax machine, modem) which cost from £10 to £100, and 20% comes from the high value products (networking equipment and alarm systems) which are in the cost range from £800 to £1000.

At the acquisition stage, Company E hires specialized skips, and places them at local recycling centres where they are specifically for electronics equipment. This effort is dedicated for accumulation of end-of-life cheap products. Then, a third-party acting as a recycler collects the products and they are sorted for recycling or scrapping if there is no residual value. Products liable for recycling are weighed and go directly into granulator, smelter and refinery to separate the different types of materials. The extracted pure materials are sold to steelworks and metal companies. All these activities are carried out by the recycler and from all the earnings of the materials' sale, Company E will get a small fraction by prior agreement with the recyclers involved. Each recycler, however, is required to supply information on the recycling facts and figures, for example, total weight of products received, total weight of material extracted etc.

In the case of higher value products, these are collected from the customers' site or they can be delivered to Company E's facilities. All rework, refurbishment and parts cannibalization works are carried out in-house. Rework and refurbishment activities are completed on alarms systems and parts cannibalization involves the extraction of circuit boards from networking equipments.

The main strategic objective is to have fewer product returns going to landfill. In handling its end-of-life product returns, the most problematic issue is to handle the customers' inquiries regarding the return of their products, especially old telephones to Company E. As a result, 50% to 60% of the products are returned directly to Company E and do not go straight to the recycler. This affects logistics and labour costs.

Company E emphasises that the level of accuracy of the information submitted by recyclers regarding the recycling activity is very important. By carrying out audits on the recyclers' sites, it makes sure that the materials that they claim recovered and recycled are properly recorded. This has been open to abuse in the past. The recycling process must also adhere to the legislation as faulty recycling can damage Company E's image since the recyclers can link their business with Company E.

At the moment, Company E concentrates their performance measures into the following metrics:

- Total weight sent to recyclers
- Weight of recycled materials, total and fraction according to each type of material
- Weight of return products sent to landfill

The cost of the whole activity is not tracked yet but it is still seen as an important set of data which is under consideration.

6.1.3 Results

As expected, all interviews have supplied valuable information towards answering the research focus. In conclusion, the interviewed managers agreed that the performance measurement system plays a key role in achieving effectiveness in their reverse supply chain operation. All managers quoted performance measurement metrics in the forward supply chains which are used to measure the performance of their reverse supply chains. As the interview proceeds, however, it transpires that though the same metrics are used between the two supply chains, the processes being measured are different because of the different reverse supply chain processes. The most significant finding is that the strategic objectives set for managing customer returns are totally different from strategic objectives set up for the forward supply chain. As performance measures are developed to reflect the strategic objectives in achieving organisational goals, the results discussed in this chapter will not include all performance metrics used by each company at operational level but will emphasise the strategic objectives used in solving every issue in each of the reverse supply chains of the companies. To systematically understand the strategy used by every company, the results are presented according to a number of defined factors. These factors are significant to the research because companies start the selection of performance attributes and metrics from recognizing their strategic objectives in managing product returns. There are two main factors learned; recognize the characteristics of the in-flow of returns according to the type of product returns and type of reverse supply chain operated. Then, segment the product returns according to the characteristics learned. Along the supply chains, performance measures are placed specifically for each process involved.

6.1.3.1 Recognize reverse supply chain characteristics

Product returns can enter the reverse supply chain with a mix of quality levels. There are certain characteristics of the return, however, which can help to identify the most effective way to remarket or to dispose of the returns.

Though there are similarities in the nature of business among the companies interviewed, type of returns and type of reverse and closed-loop supply chains differ from one company to another. With examples from five companies investigated, they can be recognized according to these characteristics:

6.1.3.1.1 Type of product returns

It is widely known that sorting is an important part of the reverse supply chain in order to determine the quality of the returns. The level of quality is then dictates which disposition route should be adopted. Nevertheless, even at this stage, all companies agreed that very high costs have been incurred as a result of logistics and labour costs, and it is very difficult to get the value recovered even to cover the overall costs. Therefore, considering the following two main characteristics of returns can lead to effective returns management which emphasizes minimisation of cost and maximum value recovery.

1. Time-sensitivity factor

It is apparent from these interviews that the returns are treated according to the level of urgency with which a return should be processed. The urgency factor depends on the life-cycle span and the effect of a postponement strategy on variable cost. For Company A, two types of processes are discussed. The first one involved maintenance, repair and overhaul of civil aeroplane engines. This is an example of a closed-loop supply chain, and the customer will be given an overhaul schedule for every new engine or aeroplane bought. The life-cycle for each civil aeroplane engine is 25 years. Therefore, the overhaul facility in Company A will also have a schedule which lists the details of each incoming engine to be serviced for every 10 years of the engine's life. Clearly, product life extension programs like this which generally involve expensive industrial goods such as jet engines, airframes, and railroad locomotive engines, is a desired returns to OEMs as it generates income every time overhaul work is carried out. In 2005, 59% from annual sales of Company A came from services. As suggested by Blackburn *et al.* (2004), two main categories specified by Lee (2002) can be used to manage effectively commercial returns; cost-efficient and functional products. Though jet engines value does not erode rapidly with time when they are not in use, they are specified as time sensitive during the repair and maintenance processes. An engine sent to a service and repair facility will become an urgent and critical item. This is for two main reasons; firstly, every airline obviously aims for full utilization on every engine they own, and secondly, if the customer is left with only one spare engine and it experiences an unexpected incident resulting in an idle aircraft - normally termed as Aircraft on Ground (A.O.G). Therefore, the whole maintenance process will have to meet the schedule agreed with the owner of the engine. This is a crucial entity to both parties; the customer and the overhaul facility, because if the overall time taken is longer than the scheduled time targeted, a monetary penalty will be charged to Company A, and apparently, labour cost, holding inventory cost, handling cost and other direct costs will be liable to the overhaul facility. On average, Company A is charged US$3000 per day for late delivery per engine and every penalty quote is agreed between two parties. The complete overhaul time will include the moment the engine is sent to the service facility to the point when the fully serviced engine is returned to the customer.

There are two main factors affecting the complete overhaul time; first is the type of engine, and second is the process involved. Each type of jet engine has a specific overhaul time. For example, in Facility N, engines type E1 and E2 are expected to take 63 days to complete, compared with engine T1 that will only take 15 days. Facility N carries out engines' overhaul from other OEMs and they also carry different overhaul times; EV engines need 35 days, but ET engines mostly require up to 45 days to overhaul. The calculated overhaul time varies from one type of engine to another as the overhaul process will depend heavily on the engine's structure because of the dismantling process. The overhaul process is mainly divided into three phases; dismantling; inspection, cleaning and repair; and re-build. The overall process starts with a high level decision meeting to assess what type of overhaul is needed, where the repair or service will be carried out, which vendor or supplier will be selected to carry out the repair work and what is the target overhaul time to be achieved. During the dismantling process, the engine will be stripped according to two levels, module level and part level. Module is a term used for every large assembly of components and several modules are needed to build up an engine which carries its own individual identity and service history. In Company A, for an average turbofan engine, there are eight basic modules consisting of 2 turbines, a compressor, a compressor rotor, a compressor case, an intermediate case, a gearbox and pressure system (Figure 6.1). There are three levels of service and inspection; Level 1 is on one module only; Level 2 is done on some modules and Level 3 is on all modules.

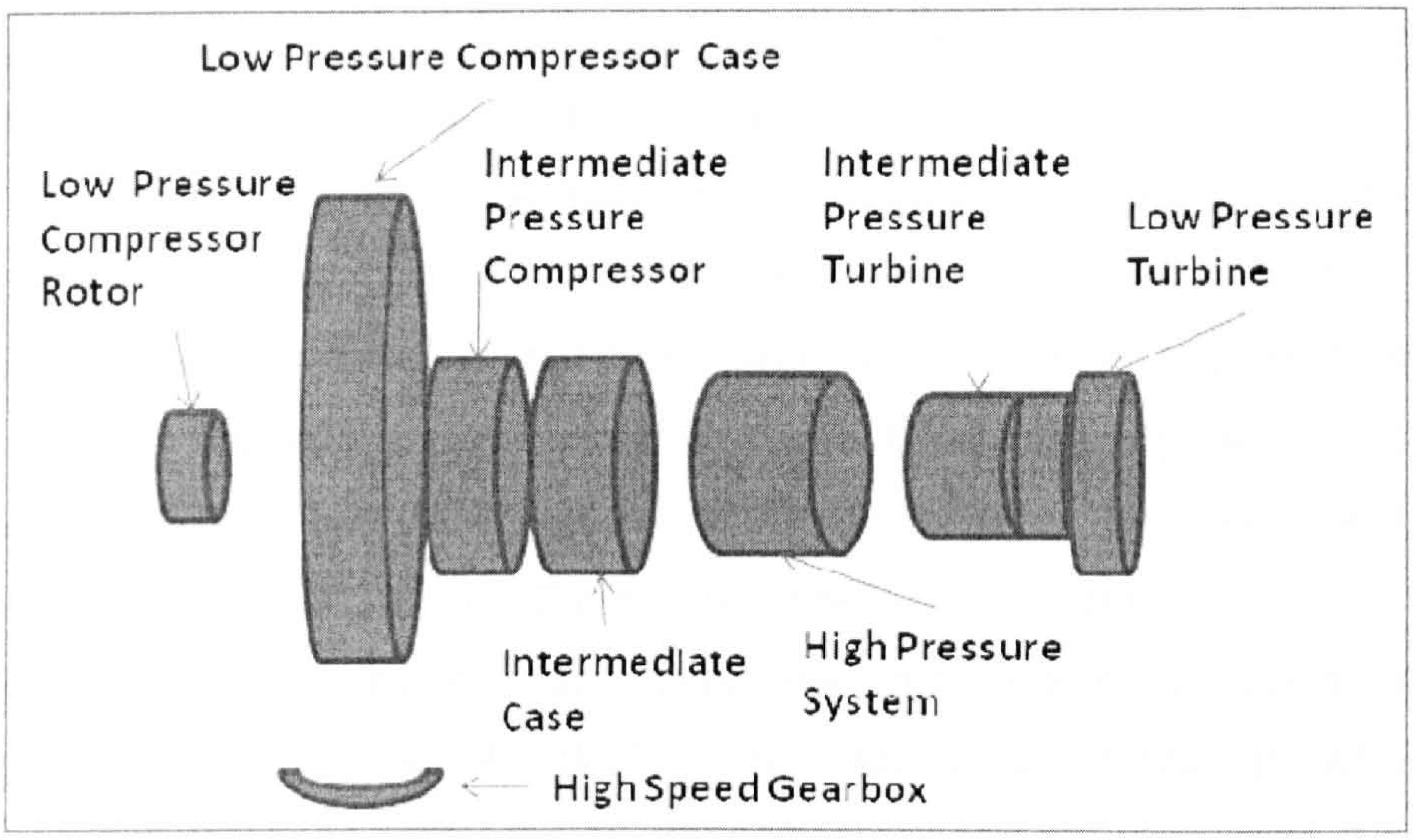

Figure 6.1 : Basic layout of turbofan engine modules

If a Level 2 service is carried out on the high pressure system module, it will involve taking off first the two turbines, then the compressor motor before getting to the high pressure system. This sequence forms a standard dismantle combination and there are alternative combinations that can be applied in order to reach the same module. If an engine has extra modules or a different layout of modules, then there are different combinations that need to be followed. The parts dismantling system contributes to different length of overhaul time for each incoming engine. Facility N and other overhaul facilities for Company A have their own engine streamer with process gates that any particular engine goes through to achieve a certain term time for the customer.

The second factor is established by some stages along the process of the service and maintenance. If the engine requires repair work, it can be done in the overhaul facility or sent to a qualified repair vendor. For Facility N, there are more than 230 companies in the vendor's network for Company A. Nonetheless, the engine will first be dismantled in Facility N before the required module or part is sent to the chosen vendor. If there is a delay in the repair work carried out by the vendor, Facility N will need to bear the consequences as it still has the sole accountability for a product that goes into that network for repair. Any company acting as vendor in the network will also have agreements with Company A especially in deciding the monetary penalty charged for late repair on the product sent to them. Another alternative available to Facility N other than waiting for the product to be repaired by the vendor is for Facility N to buy a new product. This helps to meet an urgent requirement from the customer, but the cost will usually be three times higher than the repair cost. At this stage, Company A will need to consider the repair-versus-buy strategy. Facility N also experiences logistical delays between them and their vendors. Before a product is sent for repair, purchase order documents will be prepared to list the details of the product, the instructions of repair, the price and the time allocated for the vendor to complete the repair. Once the product is sent to the vendor, the vendor will have to inspect the documents and he is given 24 hours to accept the work. Documents are needed to accompany the product when it is shipped to overseas vendors for customs purposes. The accuracy of these documents is vital as any incorrect information will lead to delay.

In the case of company B, returned laptops are time-sensitive products, because of their short life cycle as a result of high-speed technology growth in the electronics industry. The total time in processing the laptops is crucial in deciding the final market value of the refurbished laptops. For retailers such as Company C and D, with highly time-sensitive products such as electronic and high technology products, a tight contract between suppliers and the retailer is needed to ensure that when those products are returned by customers, prompt collection is arranged. This is in order to avoid loss of value in transit and in storage.

Although returns from customer will be collected or sent back to the suppliers as soon as possible so not to lose any of the product value and to reduce holding costs, when returns from functional, long-life cycle products such as tools and basic furniture are involved, Company C's strategy is just to minimise cost and maximise any possible gain. If suppliers do offer a disposition incentive, and give their approval for the returns to enter the secondary market, then the returns are sold to brokers who will sell them through other channels. Therefore, the pallet size for functional returns will be larger than time-sensitive products pallet size. Pallet size is determined by the number of products mounted on one pallet. This is supported by Beullens, Van Oudheusden and van Wassenhove (pg.132)(2004) where in achieving efficient routing, a postponement strategy is practised by delaying returns collection, and this does not affect the cost for processes further down the reverse logistics network. This strategy cannot be used for returns with a high depreciation rate.

Factor	Type of product returns	
	Time sensitivity of product returns	
Category of product returns	High time-sensitivity	Low time-sensitivity
Characteristics	•Short life-cycle span •Postponement increases variable cost •Example: electronic, software	•Long life-cycle span •Example: functional products such as tools, furniture
Strategic objectives	•Maximise speed/responsiveness •Maximise recovery value •Minimise risk of obsolescence	•Cost efficiency

Figure 6.2: Strategic objectives selection method using time-sensitivity factor

The identified strategic objectives used by the companies are illustrated in Figure 6.2 and related to the characteristics of the returns under the time-sensitivity factor. The strategic objectives are elaborated further as below:

Speed/Responsiveness – ability to achieve the shortest time to remarket and delivery to customer

Recovery value - maximise the value recovered from the returns

Risk of obsolescence - ability to forecast the shelf-life as accurate as possible

Cost efficiency - minimise the total cost incurred in retrieving the value

2. 'Desirability' factor

The term desirability is generally understood to mean how much value is gained from return-on-investment made in managing returns. As defined in Chapter 2, returns may be initiated by the brand owner or natural flow generated by returns policies and convenience returns. As long as the returns have the potential to bring economic benefits to the supply chain owners, companies will regard these returns as desired. Though some companies have to deal with unwanted returns that involve high logistics, storage and labour costs, other indirect gains can be expected such as green image, brand image and technology protection. These other possible gains are usually under long term programmes, therefore they are likely to receive lower priorities than economic gains.

a) Desired returns

The main motivation in managing product returns is when economic advantage is possible. For Company A, maintenance and repair work will generate continuous economic gain and the success of the whole closed-loop supply chain will depend on the on-time delivery records which will build the reputation for the repair and maintenance facility. In Company A, there are a number of repair facilities around the world and the customers can, at any stage, choose at which repair facility they want their engines to be serviced. At Facility N, Company A have the capacity to overhaul 200 engines annually, from 40 engine types which come not only from Company A, but also from other jet engines' OEMs. Between facilities, they need to meet certain turnover targets and to compete against each other to achieve the highest turnover possible. Facility N's biggest competitor will be Facility H in Hong Kong. Although it does not have as many customers as Facility N's, Facility H operates with a similar size of workforce, and it carries out the overhaul on the same type of engines as Facility N but they pose an attractive example because they have a far shorter overhaul time than Facility N's overhaul time, i.e. by 10 to 15 days. This advantage is results from the fact that Facility H is facilitated with their own test bed whereas Facility N has to rely on their service providers for a test bed, which limits the total time use. Another Company A's overhaul facility, Facility S, which is situated in South East Asia, also has the reputation of achieving an overhaul time less than 60 days. That achievement is the result from having close relationships between a small number of customers, where the overhaul facility has the ability to spread its assets (e.g. engines, modules or parts) between the customers. For example, one part of an engine can be replaced with another part from a different engine from a different customer. This is not an easy prospect when there are a lot of customers per overhaul facility and a customer will only accept parts from a small number of engines from other airlines, which are usually detailed in the contracts between the airlines and the overhaul facility. There are certain reasons why parts of engines from certain airlines will not be accepted by other airlines and these reasons are not disclosed in the contracts, but the name of airlines or engine manufacturers are clearly stated. Therefore, in handling a large number of customers, a repair facility will be in a fixed position by many of the contracts. Therefore, when compared with Facility N which handles a much larger number of customers, Facility S can keep a pool of inventory which they can move around among a small number of customers who do not specify restrictions about other companies' parts in their engines. When a part is sent for service or repair, the longest time is taken by the repair process, which is given 21 days from the total 63 days of total overhaul time. The repair work will either be carried out at the vendor's facility or completed in-house. When there is a similar fully serviced part on the inventory, it will be used to replace the missing part in the engine. The part in use can be owned by the repair facility or owned by another airline, but is available as a spare. Therefore, the build process does not have to wait for the part to be sent out for repair to be carried out and sent back to the overhaul facility. The waiting time will reduce the total overhaul time by more than 15%. In this context, the number of contracts between the overhaul facility and the customers is the key issue to allow the overhaul facility to use parts from other airlines already in their repair process.

In service and maintenance processes, replacement of parts and components is usually needed when the originals have achieved maximum number of uses, do not meet safety standards or they are simply faulty. Replacement parts usually come from new products manufactured in-house, new products sourced outside the company or from surplus new stock. Surplus new stocks are parts taken from engines bought from other airline companies, and these engines are originally kept as spares. Each dismantled part then undergoes refurbishment and serviced according to the part's standard. All decisions on using any type of replacement parts will need approval from the customers. Other than new surplus stock, another source is from the used parts market. Repair facilities will use this market to find parts which are still refurbishable, or parts which are no longer manufactured. The parts sourced in this way will undergo the same refurbish process as parts sourced from new surplus stock. Normally, the parts cost from this type of market will be 1/3 of the total parts price sold to customer. The other 1/3 is the refurbishment cost and the last 1/3 forms the profit. Replacements using parts that are sourced from refurbished and surplus new stock bring down the parts' cost 1/3 cheaper than new manufactured parts. The cost saved is shared with their customers and this make the option to reuse refurbished parts very attractive. Unfortunately, the supply for refurbished products is not stable and depends on availability in the market. This uncertainty in incoming volume is one of the major issues in the reverse supply chain. One more disadvantage for this buy-back operation is for critical parts which have certain usage limits: they have to come with documents that detail the usage history of the part. Parts for aerospace service need to go through stringent parts conformance control and all refurbished parts need to achieve the same quality standards as new manufactured parts. Therefore, the accuracy of the information in the documents is crucial to determine the quality of the part. To ensure the accuracy of the documentation, it must be recorded according to the right system and at the right timing. The sourcing of the parts reaches airline companies around the world and each airline company has its own information recording system, sometimes recorded in their native language. This inconsistency occasionally means that the test and sorting processes take longer.

b) Non-desirable

Mainly, there are three reasons that companies manage product returns; environmental regulations, economic gains and green image. For Company E, a large percentage of product returns are managed to comply with WEEE regulations. Company E rents out products such as telephones, fax machines and modems to its customers, and there are products sold to customers such as pay-phones, alarm systems and networking equipment. The products can also be grouped into two categories; low value which fall in the price range of £10- £100 and high value which starts from £800, up to £1000 per unit. Low value product ranges are from telephones, fax machines, modems and pay phones. High value products are from alarm systems and networking equipment range. Company E receives in excess of 100 million tonnes end-of-life products per year, and in handling these returns the sole target is to process as much as possible with the lowest cost achievable. To reach the targets, they make sure that the customers do not come across any difficulties in sending back end-of-life products to Company E. The efforts including hire skips in recycling centres around the country specifically for electronic equipment and setting up environmental helpdesk lines. The returns are sent to a selected recycler in bulk: the recycler reports to Company E on the amount of the material reclaimed from the recycling process and pays the Company based on weight per tonne material. Company E will keep a record of the amount of material gained from the recycling process and monitor the recycling process performance according to the amount retrieved. Used and faulty telephones returned by customers carry a very low value when new and there are costs to maintain customer help lines, collection points at a number of locations throughout the country and the use of a third party provider in handling the collection, recycling and disposal which must be provided by Company E. Although the recycled materials are sold, the value gained is not significant and does not cover the overall operating cost. Therefore, this type of product returns is categorised as undesirable by companies. The pressure to meet regulations requirement in taking back and manage end-of-life and end-of-use products leaves companies no option but to be ready to deal with the returns.

For retailers, returns are also very much undesired and unwanted because of the cost related to logistics, sorting and other indirect costs. They are, however, bound by returns policies which protect customers' rights which are also an important factor in giving a sense of assurance to customers. Customers' returns are not avoidable and more lenient return policies contribute to sales increments. In managing product returns, it is obvious that the first objective of both retailers is to drive returns to nil. High street retailers like Company C and Company D claim return products as undesirable and the number one problem in their business. With lenient return policies in place, however, they can strategically encourage sales. Company C agrees that a customer can return a product within 30 days for any reason, including change of mind, and a full refund is given. After 30 days, returns can only be made on broken items.

There are two main challenges in managing returns for Company C. Firstly, Company C handles a very wide range of products starting from bulky home and garden furniture to fine jewellery. The diversity of products offered to their customer reaches 80,000 products. Therefore, any member of staff on the front line of receiving returns does not posses all the detailed product knowledge. The level of functionality of each product return which is claimed as defective cannot be checked or tested in-store and each return is labelled with the reason given by the customer for the return to the store. This situation is clearly causing a mixture of good and bad returns to supplier and contributes to the second challenge - high volume returns. The annual number of returns received by Company C is very high, amounting to 15 million products. This number of returns is, however, only a small fraction of sales of £3-4 billion annually. In conclusion, a high volume of returns is the result of easy acceptance of reported-defective returns by customers and also simply because of the high number of sales.

In dealing with the returns for Company C, one key point is trying to 'dispose' the returns as soon as possible, while the value is still not affected by time, and trying to 'shorten' the route of disposition for lowest logistics and handling costs. In the meantime, to reduce the number of returns, the number is monitored closely according to the branch locations and condition of returns; defective, damaged or no-fault (good) returns. Trials on the impact of the length of returns policies on good versus bad returns percentage are also being practised. While soaring percentage of good returns received from newly-launched products which require understanding to operate, effective helplines are offered and information on products is printed clearly on products' catalogues. The number of RTM (agreements between suppliers and Company C) needs to be improved as, without RTM, the destination of returns will not be standardised and will need to depend on the quality and quantity of the returns. The routes taken include: send for repair, exchange with new or full refund, depending on the judgment of the personnel who handles the returned item. From the store, the broken product will be sent back to a regional distribution centre and immediately sent to a centralised returns warehouse. There are programs devised to investigate the reason for returns and to act on the root causes. The level of communication with the suppliers is also increased as it helps to decrease the cost of handling returns at the retailers' sites and also helps the suppliers to retrieve the optimum value from returns. This will systematically sort each return from the point it enters the retailers' site according to the requirement of the suppliers, and there is a certain stock level that will trigger the suppliers to collect the returns form the retailers' site. Suppliers also need to work closely with the retailers to understand the root cause of returns and provide enough support to persuade the customers to return products to the correct location. This will reduce the time taken for the product to reach the supplier and drive down the product's loss of value, especially for time-sensitive goods such as high technology electronic products.

Figure 6.3 relates between the characteristics discussed above with the strategic objectives used.

Factor	Type of product returns	
	Desirability	
Category of product returns	Desired	Undesired
Characteristics	•Profitable •End-of-life & end-of-use products under returns' regulation	•Non-profitable and cost generator
Strategic objectives	•Maximise reliability of returns supply •Maximise the number incoming product returns with high quality	•Minimise the amount of product returns •Minimise total cost

Figure 6.3 Selection of strategic objectives method using desirability of product returns factor

Reliability- Ability to handle/forecast variations in quantity, quality and timing of the incoming returns (supply)

Quality- Ability to drive the quality of incoming returns to the level required

Quantity- Minimise the amount of returns to achieve zero customer returns

6.1.3.1.2 Type of disposition route (supply chain characteristics): Open loop or closed-loop

As described in Chapter 2, returns in reverse supply chain can be repaired or refurbished and reused in the forward chain, which forms a closed-loop supply chain. If the retrieved returns do not flow back into the forward chain, the whole supply chain will remain open. Next, this section will review the key performance measures used in managing returns which rely on the types of supply chains involved. As discussed in the earlier chapters, there are five stages composing a reverse supply chain, and this section will look at methods the five companies employ for the last three stages which involve disposition options such as repair and overhaul, refurbish and reuse, dismantle and reuse, remanufacture, remarket, recycle and landfilling.

1. Open loop

For retailers such as Company C and Company D, product returns are clearly managed by the open-loop concept where either the products are returned back to the original supplier or sold to a third party to be marketed into the secondary market. In measuring the performance of returning returns merchandise to their suppliers, the length of time setting in their facilities is tracked to formulate the cost involved in holding the returns. One more important measure used is the rate of non-defective return product sent back to the supplier. This is crucial to maintain good relationships with suppliers, as product returns that have no quality problems are not happily accepted by the suppliers. Company E also practises an open loop supply chain where their end-of-life telephones, fax machines and cable poles are sold to recycling operators by weight. The payment received will depend on the amount of materials derived from the recycling activities where the materials are considered sold to the recycling operators. In 2007, between 400 and 500 tonnes of end-of-life products were recycled, the majority of which comes from cables, switches and telegraph poles. In the case of Company E, the main performance measure used is the number of end-of-life products reclaimed from the market/public and the number of products sent out to recyclers every quarter calendar year. The results will, however, be cross-checked with the production data of each particular product model. The return figures for low production and discontinued products are not expected to achieve as much as the return number for active and high production goods.

In disposing of returns - especially end-of-life returns - Company A is taking a pro-active role by teaming up with two other giant companies in the civil aerospace business. This is in order to establish an association in finding the appropriate technology in landfilling parts and materials from end-of-life aircrafts. Company A believes that by doing so, they are being environmentally friendly and introducing sustainability. This is also regarded as a wise step to avoid new regulations from being implemented.

2. Closed-loop

There are several types of closed-loop supply chains as described in Chapter 2. For Company A, overhaul service is an attractive after-sale activity because of its continuous economic benefits. After-sale service is a popular example of a closed-loop supply chain where every engine sold is accommodated with an overhaul schedule. One more activity that can be classified with the closed-loop supply chain is acquisition of used parts from the open market. Majority of the parts were originally manufactured by Company A and they are favoured by customers who owned the engines and original parts are much preferred. Besides used parts in the open market, Company A seek to buy parts, modules or even whole engines from commercial airline operators where they may want to diminish spare engines inventory for cash inflow. Any parts, modules or engines acquired are inspected, cleaned and refurbished according to their standard to ensure they reach the same quality as new parts. Quality plays an important part in this product acquisition.

Using product returns as spares for in-repair jobs is also practised by Company B and Company E where product returns are dismantled for parts to be used as spares. Figure 6.4 shows the relationship between the characters discussed above and the strategies used.

Factor	Type of reverse supply chains	
Category of reverse supply chains	Open loop	Closed-loop
Examples of activities	•Retail returns (directly return to supplier) •Material recycling •Refurbishment/repair for secondary market	•Part/component cannibalisation for spares •Maintenance, repair and overhaul activities •Refurbishment for primary market
Strategic objectives	•Maximise flexibility •Maximise remarketability •Maximise reliability of demand	•Maximise timing/coordination & integration with forward supply chain players & process stages

Figure 6.4 Strategic objectives selection method using type of supply chains (open/closed-loop) factor

Flexibility – ability to meet different requirements from new player, process or market

Remarketability- ability to find final destination for refurbished returns

Reliability of demand - ability to forecast the demand in the market

Timing - ability to achieve coordination and integration between players in the supply chain by ensuring each process stage meets the targeted time allocation

6.1.3.2 Segmentation of reverse supply chain

Segmentation concept is identified as important to be implemented in processing and disposing or in remarketing returns according to the calculated costs and benefits of the characteristics discussed above. The concept is more obvious for companies who deal with a wide range of products in their return streams. Analysis of the reverse supply chains of five companies shows that early segmentation is practised to achieve maximum benefits, and segmentation can be applied from the point at which the returns are received or collected from the customers to the point of disposition or remarketing. Company D segments the reverse supply chain according to the quality and reclaimable residual value of the returns and Figure 6.5 addresses the segmentation of returns' disposition routes.

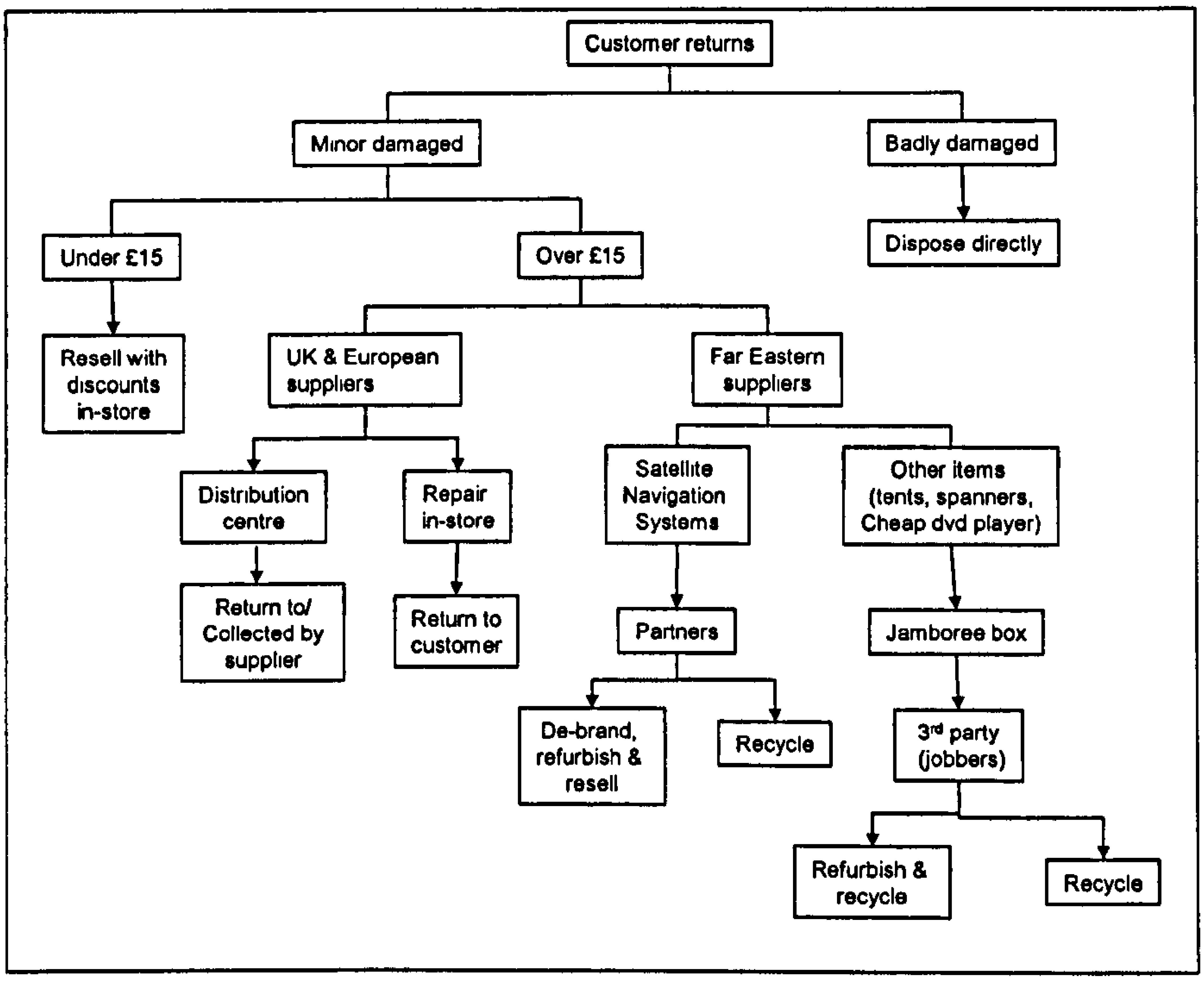

Figure 6.5 Segmentation of product returns' disposition route for Company D

When a product is returned to a store, it will be inspected for damage. If the product is 100% free from any damage, the product will be either returned to the customer or, if it was returned for a refund, it will be resold in-store. Any badly damaged returns will be regarded as a write-off directly in-store. In the case of cheap returns, however, which are classified as products priced under £15, any minor damage such as light scratches or small dents, Company D keep the returns in-store and re-sell them with price reductions. These returns are put in a clearance area and the store manager has the authority to use his discretion to apply discounts up to 50% off the retail price. By doing this, Company D calculates that it can avoid £5 to £7 for each return which would involve the logistics and administrative costs in order to bring back a return to its supplier. These procedures are practised on all ranges of products, except for products under the categories of health and safety and environmentally critical such as aerosol cans and bicycle helmets. It is not legal to resell these types of returns even if they have minor damage, and are required to be disposed of properly.

Returns with a retail price above £15 are divided into two main categories. For products manufactured in the UK and in European countries, any minor damaged returns are either repaired in-store or sent to Company D's distribution centre. The route taken at this stage depends on the returns agreement with each of the product suppliers. The collection frequency also differs between suppliers. For high technology products which are time-sensitive, initiatives are taken to encourage suppliers to collect these returns as frequently as possible. Particularly for satellite navigation systems which carries about 70% of total returns coming back through the distribution centre in terms of value, there is a supplier who collects its returns once a week, and others can collect every four weeks. Beside the value erosion issue, high value returns needs tight security, which can involve high variable cost. As for products sourced from Far Eastern suppliers, the returns are not sent back to the supplier because of very high logistics costs and are disposed of according to the value of the product. For satellite navigation systems, all returns are sent to a third party who acts as a partner to Company D. Before the returns are refurbished and resold, the brand name on the returns are taken off the labels and erased from the software installed in the systems to avoid re-entry into the supply chain. Faulty returns and non-refurbishable goods are sent for recycling. Other items such as tents, spanners and cheap DVD players, are sold to jobbers, mixed in big boxes called jamboree box. These returns also have to be de-branded and refurbished before being resold in the secondary market. Non-functioning returns are sent straight for recycling.

Besides receiving returns generated by the return policies, retailers such as Company C are bound by WEEE regulations because some products that they buy come directly from factories in the Far East and this activity categorizes them as a manufacturer. Return policies also have to be met to adhere to customer rights. Though there are other types of returns such as returns from stock re-distribution, staff shop surplus damaged and surplus stock as a result of the arrival of the new catalogue, the biggest concern is returns from customers. For Company C, customers' product returns amounted to 8% in 2006 from £3-4 billion sales. From the total returns amount, Company C acquires a bad returns amount of £15 million. Customers are given 30 days to return an item, which should be in new, unopened-seal condition. After 30 days, an item only can be returned if it is broken. There are three types of products return streams; product returns in stores, product returns by two-man delivery and product returns by one-man delivery (Figure 4.6). The normal practice for any returns in stores is that any cosmetically damaged returns are sold with discounts in-stores. Goods with other damages that only affect the outer packaging are re-packed under product recovery programs and resold as new products in-store. Products returned with a serious damage claim are sent directly to a regional distribution centre and then transported to a centralised returns warehouse. For domestically sourced products, the returns either need prior sorting or direct collection by the suppliers or transported to the suppliers' sites, depending on the RTM agreement. For direct return to suppliers, customer returns labelled as damaged stocks are built into pallets and are collected by or sent to suppliers for full credit. There are exceptional cases where certain suppliers may require sorting to be done to screen out no-fault-found returns and this requirement is included in the RTM agreement. Under this type of agreement, Company C sorts out returns with no-fault found and resells them in-stores which means only defective returns are sent back to their suppliers. In return, better trading terms are received from the associated suppliers. In the case of suppliers without an RTM, their product returns mostly are collected directly from centralised returns warehouse.

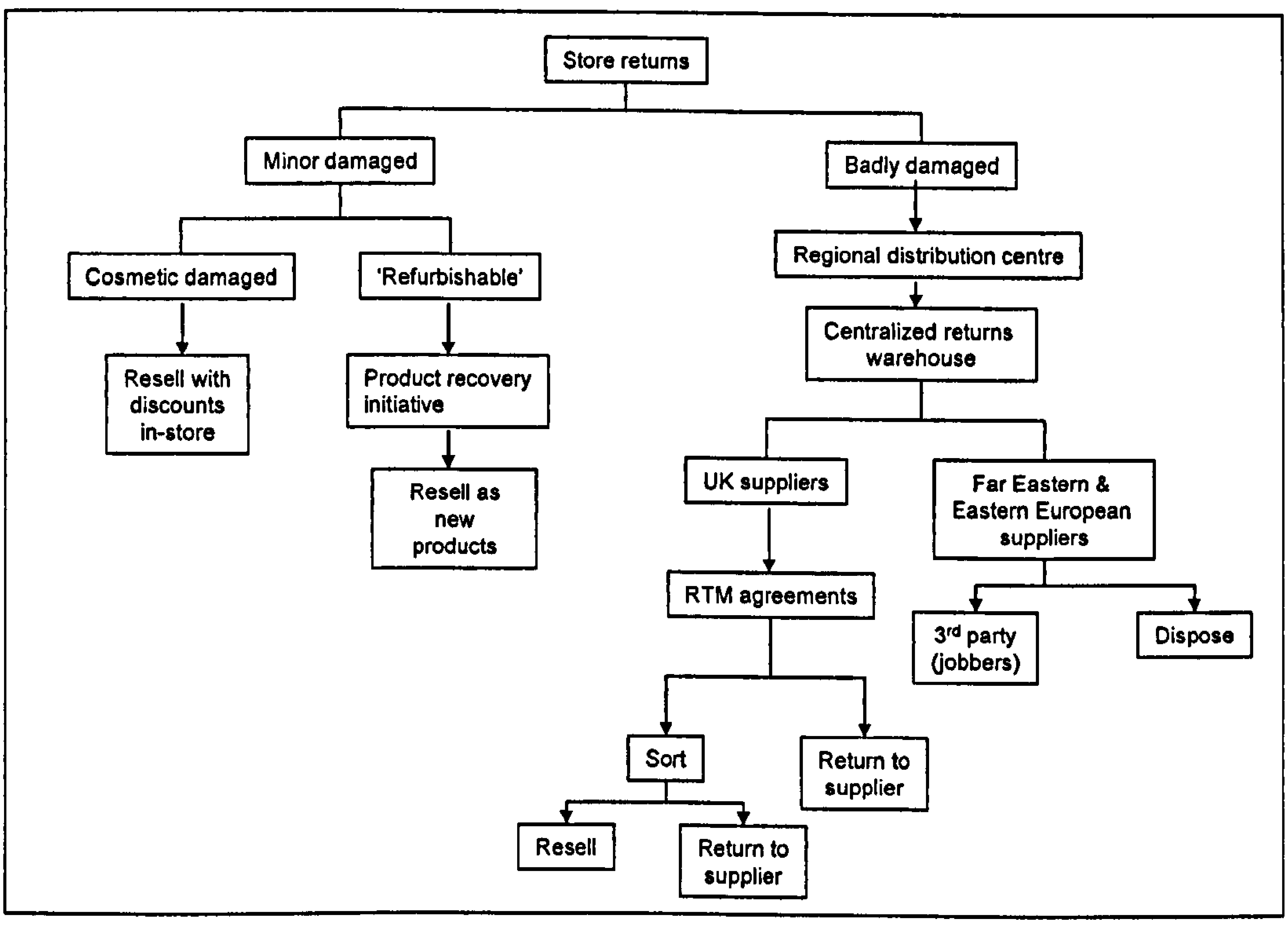

Figure 6.6 Segmentation of product returns' (store returns) disposition route for Company C

Other routes are used for exported products. Company C sourced products from domestic suppliers and also sourced from suppliers from the Far East and Eastern European because of the low production costs. In 2006, 35% of total products were imported from these regions. The route taken to dispose of these imported products will need to consider logistics and labour cost as the returns will not be sent back to the supplier. The option taken is by jobbing off, which involves a third party, called jobbers who will buy the returns in boxes, take off the catalogue number from each product before reselling them in local markets at a far lower price than the cost price. For dysfunctional returns, direct disposition are carried out according to the proper procedures.

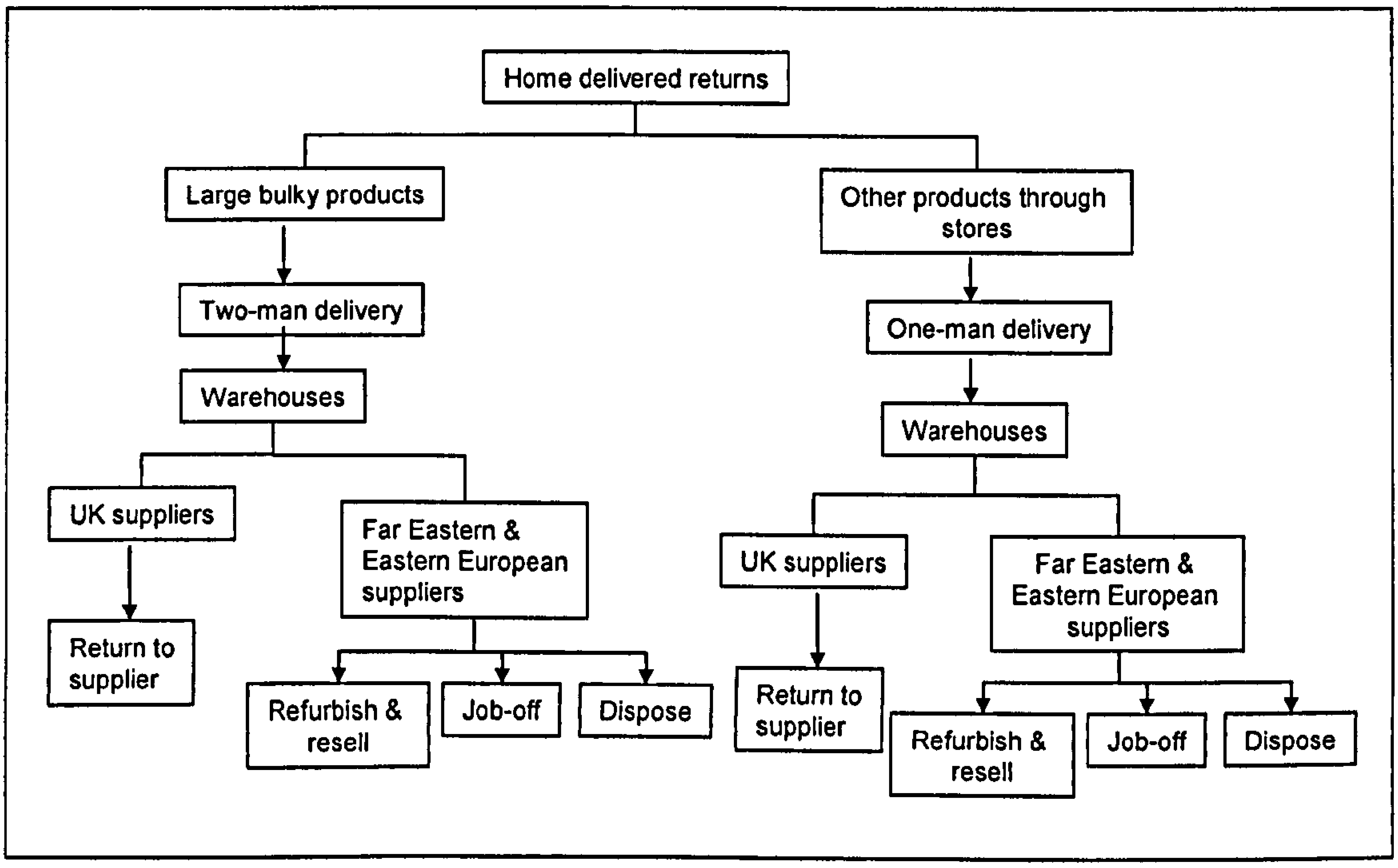

Figure 6.7 Segmentation of product returns' (home-delivered returns) disposition route for Company C

For home delivered products (Figure 6.7), the two types of delivery also have different routes of disposition. For one-man delivery returns, two warehouses are dedicated for this type of returns. The returns from a two-man delivery will be sent to three other warehouses and this type of returns consists of bulky items that can only be bought home-delivered such as sofas, beds or large televisions. It is called a two-man delivery as it needs two men on the truck because of the size of the items. Domestically sourced product returns are then collected by suppliers but returns from selective suppliers are refurbished in the warehouse which again depends on the RTM agreements. Any returns which are originally sourced from the Far East and Eastern Europe are separated and are not sent back to the suppliers. For high value returns particularly, Company C refurbish and resell but the percentage of this activity is too small, less than 10% of total returns from same stream. If the condition is recoverable, the recovery process is carried out in the warehouses and the refurbished products are put back into stock. The majority of exported returns are sold to jobbers and will enter secondary markets. All the returns have the catalogue numbers stripped off to ensure each particular product does not enter the reverse supply chain again. All dysfunctional returns are properly disposed of. All returns from the two-man delivery route acquire the highest reverse cost where only 11% of the cost price is covered.

For in-store product returns, the returns are sent to a regional distribution centre, and to a centralised returns warehouse. Cosmetically damaged returns will usually be recovered in-store by repairing the packaging and replaced on the shelves. Minor damaged returns such as small scratches or dents will be cleared by offering them at discounts in-stores. The strategy being practised is trying to keep and clear as many returns as possible in stores to avoid incurring any logistics and labour costs. This strategy is still under trial but so far, the results are good. This strategy is extended to warehouse product recovery where the same process is carried out on products that have internal warehouse damage and the recovered products are put in reverse flow directly. Products classified as staff shop surplus damaged will go through the same route.

6.1.4 Summary

The findings from the case study are summarised as follows:

- Type of customer returns and type of supply chain envisage the characteristics of a RSC.
- Strategic objectives for a RSC are selected according to two characteristics of product returns; the time-sensitivity factor and desirability factor.
- The strategic objectives are also selected based on whether the product returns are managed in open loop system or closed-loop system.
- Early segmentation of product returns must be considered to achieve maximum benefits from the product returns received.

The summary is described further in Figure 6.8 and Figure 6.9 below.

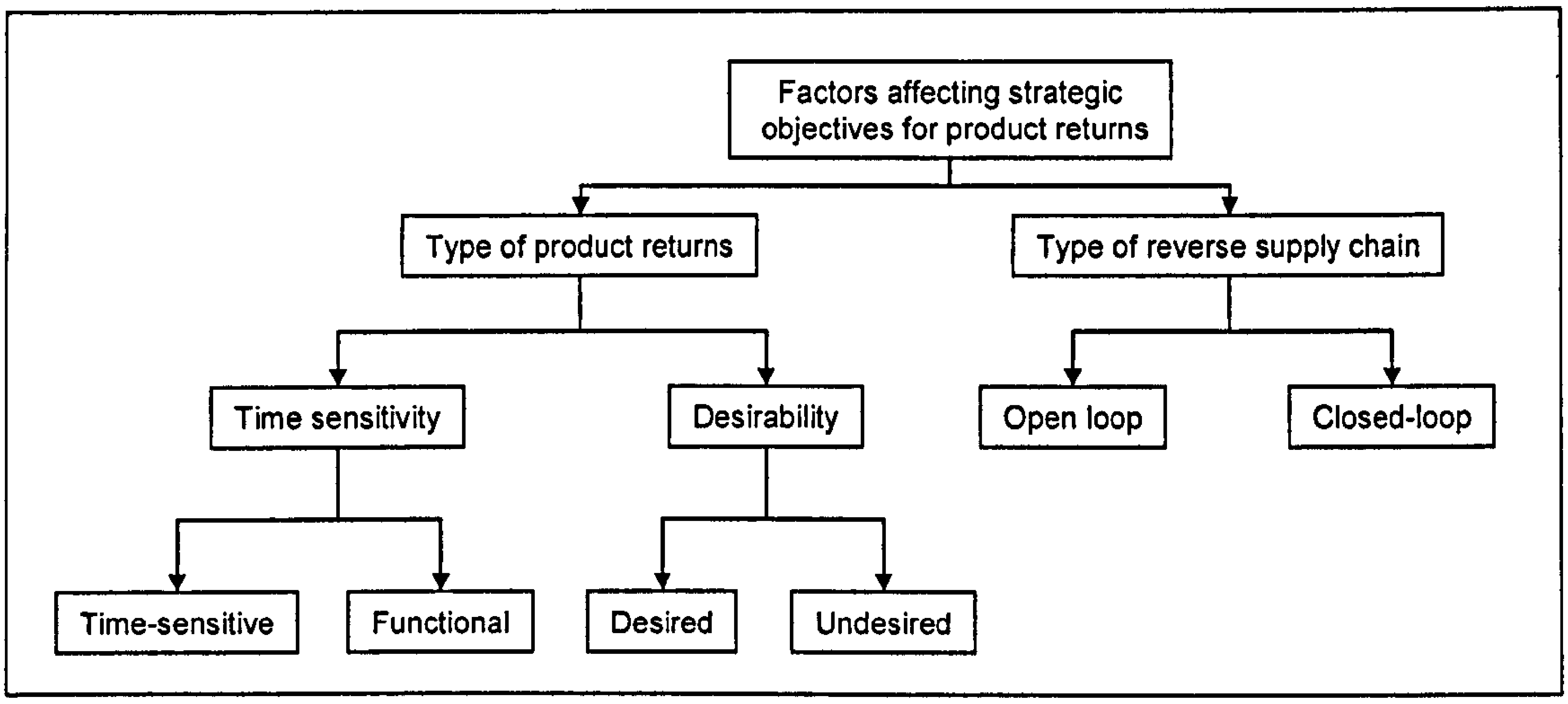

Figure 6.8: The breakdown of customer returns and reverse supply chain

Case companies	Type of product returns				Type of reverse supply chain		Strategic Objectives	Note
	High time-sensitive	Low time-sensitive	Desired	Undesired	Open loop	Closed-loop		
Company A *Refurbish/ Repair*		✓	✓			✓	•Minimise total lead time •Minimise total cost •Maximise reliability of demand •Maximise remarketability	•Due to financial penalty from product owner (customer)
Company B *Refurbish/ Repair*	✓			✓		✓	•Minimise total lead time •Maximise value recovered •Maximize quality of refurbished products	
Company C *Direct Reuse*	✓	✓		✓	✓		•Minimise number of returns •Minimise total cost	
Company D *Direct Reuse*	✓	✓		✓	✓		•Minimise number of returns •Minimise total cost	
Company E *Recycle*		✓		✓	✓		•Maximise number of returns •Minimise total cost •Maximise accuracy of information received	•Due to compliance with WEEE regulation

Figure 6.9: The strategic objectives used by each case company when compared with the types of product returns and type of reverse supply chain owned.

6.2 Questionnaire Survey

6.2.1 Objective

The objective of this survey is to establish response from a wider sample to seek further insights into the following research interests:

i. Difficulties in measuring performance of RSC
ii. How a PMS for RSC is designed and practised
iii. The effectiveness of existing PMS in improving RSC performance

iv. The differences between PMS in RSC and FSC

6.2.2 Background and method

The survey was initiated with a literature review of the field of RSC and CLSC performance measurement, and also using the data gained from the case studies conducted previously. The research questions were sufficiently clarified for the design of the questionnaire (see Appendix 1). After a few iterations regarding the design of the survey, the questionnaire was pre-tested with the assistance of five fellow academicians in supply chain management and three managers who were directly involved in product returns management in their company. These evaluators were asked to complete the questionnaire and to evaluate the applicability and understandability of the questions. The pre-testing brought out only minor development needs in the questionnaire. After some modifications, the questionnaire was sent to respondents in May 2008. The questionnaire was developed using SurveyMonkey.com online survey service and was sent through individual emails which included a link to a website which contains the questionnaire (Web questionnaire).

The questionnaire was sent to 1000 email addresses of UK retailers, distributors and OEMs which includes a wide range of industries. The contact email addresses of the companies were obtained from their official enquiries website. When there was no specific email address for enquiries, a general enquiry form was used and sent through the website.

Responses were obtained from 14 companies. That corresponded to a response rate of 1.4%. From the total responses, five are unusable which brings the final sample of this research to just 9 companies. The poor response rate is deduced to be affected by the following reasons:

1) The research tried to get appropriate contact lists from logistics and supply chain associations in the UK, but unfortunately they do not offer their database up for sale. Therefore, the research used each company's website to access the contacts information. By using these general enquiry email addresses, the questionnaires did not reach the appropriate person in the company who could answer the questions (product returns manager, supply chain manager, operations director) so were not considered relevant.

2) The potential respondents were reluctant to participate because they were put off by the questionnaire's title (Performance Measurement in Reverse and Closed-loop Supply Chains) believing that the survey might try to access their current companies' operations performance.
3) Survey might not be the best research method for this research giving the reasons that companies receive many requests for research studies and not willing to answer another questionnaire.

As mentioned in Chapter 4, however, a survey was initially conducted to collect qualitative and descriptive data on the present state of measurement practices rather than to assess quantitative data enabling identification of cause-effect chains and statistical generalisations. Therefore, the nine responses received are still regarded as highly informative and will be analysed and regarded as indicative where they provide useful information towards supporting the case studies' results. As the result of the survey indicates, the research needs a much larger study in order to ratify the findings.

The questionnaire consisted of 33 questions in total including 5 open-ended questions. The questionnaire was 12 pages long and it was outlined into five main sections. The first section provided the background of the survey, and the researchers involved. The second part dealt with the general information regarding the companies' profile. The third section of the questionnaire was dedicated to assessing the characteristics of the company's reverse supply chain including type of product returns, type of disposition used and the level of difficulty when dealing with each of the reverse supply chain activities. The importance of segmentation and strategic objectives used in handling product returns is also highlighted in this section. The fourth section underlined the performance metrics used to address specific performance attributes for RSC and CLSC. The respondents' opinions on a number of statements regarding PM in RSC and CLSC were also included in this section. The questionnaire is concluded in section five with optional questions asking for the respondents' contact details.

Among the responses received, 7 were manufacturers and 2 were retailers. The questionnaire focused on RSC and CLSC in the UK realising that the respondents might be working for multi-national companies. As the reverse supply chain is a new practice in organisations, it is interesting to know which position in a company will take on this job description. Among the respondents, there are Operations

Director, Supply Chain Manager, Returns Managers, Commercial Manager, Third Party Contract Manager, Reverse Logistics Manager and Services Vice President. The findings are summarised in Appendix 2 according to individual responses.

6.2.3 Results

The survey provides useful insights into answering the research questions. Each of the questionnaire responses was analysed separately as each company deals with a different type of business; resulting in receiving different types of product returns thus adapting a different mix of disposition channels. The following section is prepared to discuss the findings and locate its contribution to the research. Whilst the case studies are carried out to address the third part of the research questions which concentrates on the methods and development of a PMS for RSC and CLSC, this survey is designed to assess the current practices of PMS in RSC and CLSC and the differences between the PMS for the FSC and the PMS for the RSC and CLSC.

6.2.3.1 Difficulties in measuring and managing the performance of RSC

Three out of nine companies do not know what data to collect in measuring their RSC performance. This can be related to the reason that all three companies do not have a clear procedure in planning and managing their RSC, and rate their current RSC performance from very poor to average. Two of the companies feel that the product returns are not important as their products are in the forward flow which signifies that product returns are not perceived as a potential gain, economically or in portraying a green image. These two companies, one of which operates a £500 million turnover annually, realise that they experience severe system bottlenecks and believe that their disposition channels are not contributing towards the maximum value recovery from the product returns. There is no regular internal discussion or meetings, which indicates that RSC performance is not given serious attention. This shows that even though companies receive a high number of returns, managing RSC is still a new practice and companies are still working on effective ways of managing it.

The majority of the companies who responded to the survey (five out of eight) face the problem that their channel partners (suppliers, distributors, logistics provider, etc.) fail to understand all issues related in the RSC. In this situation, it is difficult for them to operate based on the same objectives in achieving performance targets. Nevertheless, three companies have established some efforts in terms of programs and discussions to train their channel partners in this regard.

Every respondent is asked what the most difficult RSC activities are to manage. Then the problematic activity is linked to the performance metrics mentioned in the later part of the questionnaire. This is to locate whether the problem is properly addressed and monitored through the implementation of PMS. Among the highlighted issues mentioned by the respondents are:

- difficulty in deciding on the disposition route to match the quality and condition of the product returns
- fear of the grey market effect which may lead to brand damage
- product routing problem - the combination of delivery of products to customer/retailer (forward flow) and the collection of product returns
- debranding activity for remarketing deflates the value of product which affects the maximisation of yields from the product returns, for the brand owner and the remarketing partner
- record takings accuracy issues from the channel partners (in the respondent's case: retailers)
- Refurbishing process difficulty to fulfil the requirement on tight specifications of products, in terms of cost and remarketability

The issues listed above are not usual in the FSC, and companies struggle to overcome these drawbacks in achieving an effective RSC and CLSC. Therefore, the problem must be reflected in each of the company's PMS to monitor systematically the raised issue. The survey results show that only performance metrics used in the FSC are implemented in the companies' RSC PMS. No specific performance metrics are addressed to solve each particular issue and at the right process stage. Though the questionnaire allowed the respondents to select related performance metrics grouped under five major performance attributes based on SCOR model, the respondents were given extra space in an open ended type of question. This was where they could suggest or mention specifically any performance metrics used in their RSC without having to relate to the performance attributes' list. No extra suggestions, however, were received.

6.2.3.2 The methodology of measuring performance in RSC

Specific PMS frameworks are not investigated by this survey because the results of case studies show that all companies do not apply any of the PMS frameworks available in the literature (discussed earlier in Chapter 3, for eg. Balanced Scorecard, Performance Measurement Matrix, Performance Prism etc.) . Their common practice in their FSC is to set up strategic objectives, and follow by identifying the related process stage affected: then performance metrics are selected to measure the performance at every stage, and also to address the performance of the overall FSC. A review period is set up to assess the RSC performance, and an improvement strategy is then developed according to the results of the review. This method is used in RSC PMS.

Therefore, the survey investigated the companies' strategy in setting up their strategic objectives. One of the prominent strategies concluded from the case studies is segmentation of product returns. In the survey: segmentation is defined as 'splitting the return streams in different categories and setting different objectives for each category'. Multiple choice-type of questions are used to investigate this subject. Almost all the companies (eight out of nine respondents) segment their product returns.

This has shown that segmentation is an important element in setting up RSC PMS, as product returns flow can consist of a mixture of different levels of product quality, different stages of life-cycle and product value. Proper selection of segmentation is also important to ensure that correct selection of performance metrics is used. For example, the RSC which consists of return products with a high obsolescence rate (time-sensitive products) needs to measure total lead time taken from the product acquisition stage to remarketing point. Each stage's lead time also needs to be measured to identify any bottlenecks.

6.2.3.3 The effectiveness of existing PMS in improving RSC performance

One out of nine companies rated its effectiveness of PMS for its RSC as very poor, contributing to a very poor RSC overall performance. Three companies rate themselves as average, three as good and one as very good. These responses directly related to their overall RSC performance. Therefore, companies are still in the improvement stage in terms of their PMS for RSC.

6.2.3.4 The differences between PMS in FSC and PMS in RSC

The majority of the companies (six out of nine) reported that they use the same strategic objectives for their FSC and RSC. Only four companies, however, specify that the same key performance indicators are used for both supply chains. Seven companies recognize that their RSC shows more variability compared with forward flows and eight of them realise that their RSC needs more points of control. It is not very surprising that the companies see no difference as the strategic objectives selected by companies in the questionnaire such as minimise cost, maximise profit, minimise lead time, minimise landfill, and minimise inventory are commonly associated with FSC. The nature of the perceived strategic objectives of RSC did not indicate very clearly that the requirements that arise from the product returns variability would strongly affect the formulation of objectives. Change that sentence. Other strategic objectives listed, such as maximise value recovery, minimise the number of (unwanted) returns, maximise the number of (wanted) returns, maximise number of reuse, comply with environmental regulation and improve green image, are not applicable and not used in FSC, but they are still selected. These strategic objectives are a critical part of the appraised and reviewed at regular intervals parallel to the variability of the volume, quality and timing of product returns entering the RSC. In this context, the survey results suggest that the companies perceive that there is no difference of strategic objectives between their RSC and FSC. The research believes, however, that besides applying the same strategic objectives of FSC, the strategic objectives exclusive to RSC must be recognized properly according to the characteristics of the product returns and the type of disposition channels used. Therefore, the performance metrics used must correlate with the strategic objectives used as PM should support and be aligned with the strategic objectives of an organisation. The PM, at best, determines the given objectives and communicates about them. When comparing the RSC performance metrics with the important perceived strategic objectives of RSC, it is possible to analyse how the performance attributes actually align with the given objectives of RSC. The lists of selected performance metrics are clearly related with RSC activities and Table 7.16 presented below indicates the most frequent selected performance metrics for each performance attributes from all the respondents (frequency ≥ 3).

Predictably, though companies indicated that they used the same performance metrics for both RSC and FSC, most of the performance metrics selected above are only applicable for product returns and this is summarised in the table below:

Performance attributes	Performance metrics
Cost-efficiency	•Reverse distribution/ transportation cost •Cost for testing/sorting •Repair/refurbishment cost •Remarketing/ redistribution cost •Inventory cost •Land filling/ scrapping cost
Value recovery	•Revenue from reselling repaired products •% of returns entering different recovery options (reuse, repair, refurbish, recycle, scrap & landfill, etc.) •Cost avoidance by reusing refurbished parts/products in the forward supply chain
Returns flow& time related	•Return rates by product line/ product category •Return rates by return reason •Return rates by channel partners/ region/ location •Return rate quality
Quality	•Quality of incoming returns •Accuracy of credit issuance •Accuracy of reverse distribution/ transportation •Accuracy of repair/ refurbishment operations •Customer satisfaction •Customer complaints resolved
Flexibility	•Reusability of parts/ products (product modularity/ durability) •Number of outlets (market segments) for selling returned or refurbished products
Environmental & Sustainability	•Level of compliance with environmental regulations/ targets •Waste reduction

The results bring to the indication that companies are eager to measure more obvious attributes such as cost-efficiency and quality when dealing with product returns. Clearly, these performance attributes are used in FSC and they are important sets of measures when companies put minimization of product returns as the priority strategic objective. The collection of data on other performance metrics associated with RSC activities can actually identify which stage of process affects the product returns value, and at which stage the whole RSC might increase the value recovery. Examples of such performance metrics are as follows :

"% of returns entering different recovery options (reuse, repair, refurbish, recycle, scrap & landfill, etc.)"

"Return rates by return reason"

"Cost avoidance by reusing refurbished parts/products in the forward supply chain"
"Reusability of parts/ products (product modularity/ durability)"
"Number of outlets (market segments) for selling returned or refurbished products"

Though the performance metrics do not relate to the statements regarding the differences between RSC and FSC, the survey indicates that PMS in RSC still can apply the same set of strategic objectives and performance metrics from FSC. Additional measures must, however, be implemented to adapt to the variability of RSC in terms of volume, timing and quality.

6.3 Discussion of key findings from case studies and questionnaires survey

The following section is dedicated to a discussion of the key findings of the research conclusions from the empirical results. The discussion is based on the following research questions constructed in Chapter 1 of the thesis.

i) How do companies measure and manage the performance of their reverse supply chain activities?

- Are companies having difficulties with measuring the performance of their reverse logistics operations? What are the problems?
- Do they have specific systems or frameworks in place? What is their methodology?
- Is the system/framework in practice working properly?
- What needs to be changed in future? What will be the key challenges?

ii) Are performance measurement systems in reverse supply chains different from performance measurements systems in forward supply chains?

- If yes, in what aspects?
- Should there be any differences? In what aspects should they be different and why?
- What does the literature say and what is the current situation practised by companies?

iii) What should companies do to ensure that their performance measurement systems are adequate?

- What should be the appropriate framework/methodology of performance measurement system for reverse supply chains?
- How important are life-cycle aspects?
- Should performance measurement systems for reverse supply chain be different for different products or sectors?

6.3.1 How do companies measure and manage the performance of their reverse supply chain activities?

Are companies having difficulties with measuring the performance of their reverse logistics operations? What are the problems?

From the survey it shows that only one company has achieved very good performance with its RSC performance where the rest of the companies still need more attention to RSC management. Though six out of ten companies treat product returns as very important to their company, the performance of RSC is still on average. Therefore, without understanding their RSC problems, the companies still do not know what and which process to measure. Among the problems mentioned are:

- difficulty in deciding on the disposition route to match the quality and condition of the product returns
- fear of the grey market effect which may lead to brand damage
- product routing problem - the combination of delivery of products to customer/retailer (forward flow) and the collection of product returns
- debranding activity for remarketing deflates the value of product which affects the maximisation of yields from the product returns, for the brand owner and the remarketing partner
- record takings accuracy issues from the channel partners (in the respondent's case: retailers)
- Refurbishing process difficulty to fulfil the requirement on tight specifications of products, in terms of cost and remarketability

The problems mentioned above indicate that companies are still working on operational issues in their RSC. The extension into PM of the process involved is seen to be still under development where six out of nine companies use the same strategic objectives for their RSC PM.

Do they have specific systems or frameworks in place? What is their methodology?

From the case study observations, all companies do not apply any of the PMS frameworks available in the literature (discussed earlier in Chapter 3, for eg. Balanced Scorecard, Performance Measurement Matrix, Performance Prism etc.) . Their common practice in their FSC is first by setting up strategic objectives, then follow by identifying the related process stage affected and then performance metrics are selected to measure the performance at every process stage, and also to address the performance of the overall FSC. A review period is set up to assess the RSC performance, and an improvement strategy is then developed according to the results of the review. This method is actually consistent with the Structural Framework, the first part of RSC PMS proposed in Chapter 4.

Is the system/framework in practice working properly?

One of nine companies rated its effectiveness of PMS for its RSC as very poor, contributing to very poor RSC overall performance. Three companies rate themselves as average, three as good and one as very good. These responses are directly related to their overall RSC performance. Therefore, companies are still in the improvement stage in terms of their PMS for RSC. The conclusion is based on the fact that the majority (six out of nine) of the companies are using strategic objectives of their FSC for their RSC, such as minimisation of total cost. The strategic objectives derived specifically to address the characteristics of product returns such as maximization of value recovery, maximise the number (volume) of 'wanted' returns, maximise number of use and minimise the cannibalisation on new product sales effect are not addressed properly.

What needs to be changed in future? What will be the key challenges?

The case study and survey results indicate that measuring the performance of RSC is affected by the variability of the product returns. Inconsistent quantity of incoming product returns affects the forecasting of product acquisition which is shown in refurbishing-for-part-reuse activity.

6.3.2 Is performance measurement in reverse supply chains different from performance measurement in forward supply chains?

If yes, in what aspects?

The results of the survey found that companies do not perceive any difference between the PMS of FSC and the PMS of RSC. Although the majority of companies who responded to the survey experience high variability in terms of quality, volume and timing when dealing with incoming product returns, no reference is made of linking the use of PM with controlling the problematic issues. Clearly, the problems implicated in the questionnaires are not common in FSC. Therefore, companies should have utilized some kind of effort to control the RSC process involved, and PM is an excellent systematic approach.

Should there be any differences? In what aspects should it be different and why?

One obvious result from the survey is that performance metrics selected for RSC PM are measurements exclusively relevant to RSC. A few examples of the performance metrics facilitating RSC are:

> *"% of returns entering different recovery options (reuse, repair, refurbish, recycle, scrap & landfill, etc.)"*
> *"Return rates by return reason"*
> *"Cost avoidance by reusing refurbished parts/products in the forward supply chain"*
> *"Reusability of parts/ products (product modularity/ durability)"*
> *"Number of outlets (market segments) for selling returned or refurbished products"*

What does the literature say and what is the current situation practised by companies?

All of the companies in the case study reveal that no specific frameworks or models are used in measuring the performance of their RSC. Most of the performance measures used are the ones commonly used in FSC PMS such as cost, quality and lead time. With high variability, however, in quantity, price and timing with the product returns received; all the companies realise that it is more difficult to measure the performance and the survey showed that the companies experience high variability of RSC's performance. The highest priority measure is total cost, where product returns are usually undesired and unwanted from customers.

6.3.3 What should companies do to ensure that their performance measurement is adequate?

What should be the appropriate framework/methodology of performance measurement system for reverse supply chains?

As stated in the conceptual framework, the segmentation of product returns is important to help the selection of the strategic objectives. Companies should consider the time sensitivity factor and also the desirability factor of the product returns. Most companies segment their product returns according to the condition or quality, and also the value of the product returns. This practice shows that in addition to the conceptual framework which emphasizes the rate of loss on residual value of the product returns as shown by Guide *et al.* (2005) and Blackburn *et al.* (2004), additional criteria can be used such as level of quality, product returns' value and own brand vs. suppliers' brands. The survey shows all the companies receive 'unwanted' returns, which result from environmental regulation enforcement and also customer return policies. Therefore, all of the responses focus on reducing the total cost, and also minimising the product returns which are as highlighted in the framework.

The framework also needs to emphasize cost minimisation for all aspects. This can be observed on the retailers who deal with both low and high sensitivity product returns. The performance metrics such as cost of acquisition and cost of refurbishment are reported to assist in identifying which process contributes to high operation costs.

The survey also supports the element of remarketability of product returns in the open loop systems. One of the problems reported by manufacturers is to find a secondary market for reduced-quality product returns with a high risk of brand damage. The majority of the companies involved in the research are uncertain of their secondary market in protecting their brand name as high variability of product returns' quality entering the secondary markets. The majority of the companies involved in the research were uncertain that the secondary market was adequately protecting their brand name, because of the broad variation in the products involved.

From the survey results, the majority of the companies do not suggest that they practise different PMS for both FSC and RSC. The same strategic objectives, such as minimising total cost, is reported to be applicable for both of the supply chains.

The *Structural Framework* proposed in Chapter 5 also needs revision according to the results of the empirical findings. The framework should be used with an important stipulation: the quality of outgoing products leaving a RSC or a CLSC should be measured at all the quadrants, except for product returns leaving the RSC as scrap/landfill or sent for recycling, as it is done externally by a third party or it is unnecessary. The survey results show that all companies measure the condition or quality of their product returns at two stage of the process; either during the product acquisition stage or during the refurbishment stage. For example, retailers who decentralise their RSC activities carry out an assessment of each product return as soon as it is returned by customers, and the condition of the product is labelled in store. The quality is categorized as an important factor as it will identify the most appropriate of disposition routes. For companies who refurbish their product returns for remarketing in primary and secondary channels, the quality level of finished products leaving the RSC is vital to meet the quality standards of the destination market. One company in the aerospace industry has pointed out that the quality standard of the secondary market has very tight specifications.

c) How important are life-cycle aspects?

Life-cycle aspects are important to RSC as products returns entering at certain stages of the RSC do not require any RSC activities on the retailers/suppliers part. The *Structural Framework* addresses this issue at the Recovery Process Quadrant where the disposition channels are selected based on the marketability of the returned products. Outdated and obsolete products may require brokers to sell them at a very much reduced price in secondary markets. Returned products at the introduction or growth stage of life-cycle, however, require product information and technology protection and are not passed to any external party.

Empirical observations regarding the impact of product life-cycle aspects on RSC PM indicate that the decision makers or managers understand that the product life-cycle poses a number of long-term challenges that can be answered through PMS. From the case study, a company in aerospace industry takes one step further in teaming-up with manufacturers in the same industry into dealing with end-of-life aircrafts. In the programme, the reusability of aircraft parts is measured, and the amount of recycled materials are recorded and compared with the materials going to landfill. By taking this proactive effort, they might have the opportunity to avoid regulations of enforcement to take back end-of-life products from the market. There are also retailers who decentralised the sorting of their product returns and measuring the number of products which are resold to the customers within a certain amount of lead time. This can help to avoid time-sensitive products from losing residual value while in-transit or while stored on inventory. In order to minimise handling costs incurred in returning a product to the primary market, the amount of time spent in-store is critical. In RSC, product life-cycle concept is used in understanding the supply and demand of refurbished parts in the secondary markets. The sale price of refurbished parts is greatly affected by the life-cycle stage in the primary market.

d) Should PMS for RSC be different for different products or sectors?

The PMS framework proposed in Chapter 4 comprises three levels: *Procedural Framework*, *Structural Framework* and a list of performance metrics. The Structural Framework is designed as guidance for companies to select strategic objectives according to the characteristics of product returns and type of disposition routes. Therefore, the differences between one company and another who are operating with different types of product or in different sectors of industry will have the same type of strategic objectives when they fall into the same quadrant in the framework. Then, when strategic objectives are identified, performance metrics selected based on the explicit strategic objectives should be linked to a specific process owned by each company, as ruled in SCOR model (introduced in the literature review). At this level, each company should have a different set of performance measures to associate with the level of process complexity and the size of product range involved.

The empirical observations regarding this issue indicate that there are differences which present according to different type of return products' characteristics and disposition method. This supports the RSC PMS that the level of performance has to be achieved in a context-specific issue. Original equipment manufacturers do not measure quality for incoming product returns which are going into recycling disposition channel. The volume of recycled material is more important than the level of quality. Quality is, however, a vital measure for companies who refurbish parts or components for use in new products manufacturing.

6.3.4 Conclusion

To summarize the potential trajectory of the product returns performance measurement provided by RSC PMS, certain issues seem evident. Developing more comprehensive PMS requires at least:

- More explicit identification of current practice
    - operation problems in RSC are not associated with PM
    - conceptual frameworks developed for PMS in FSC are not used in practice
    - the strategic objectives for RSC are derived from strategic objectives for FSC
    - In contrast with many industrial practices, the level of PM used for RSC seems to be underdeveloped. It is related to the limited use of strategic objectives specifically to address RSC issues
- More explicit reference to segmentation of product returns
    - Type of product returns according to time sensitivity
    - Type of product returns' desirability
    - Type of disposition channels
    - Type of reverse supply chain operation (open loop or closed-loop)

6.4 Summary

The case studies and survey are set out with the aim of assessing the existence and the design of performance measures in RSC. It is apparent from the results reported above that performance measurement is practised by each company and highly dependent on strategic objectives set for identified streams of returns. The streams of returns are firstly identified and then segmented according to the characteristics of the incoming returns and the reverse supply chains returns used to process the returns. It is vital to recognise these two factors in order to shape the strategic objectives in managing the returns. In dealing with customer returns, the companies interviewed seem to share two main missions; to achieve maximum value recovery or to minimise cost related in managing and disposing of the returns. To achieve one or both of these missions, strategic objectives are designed according to two simple questions: 1) What type of customer returns do we have? and 2) How do we process the return or how do we recover value? For each of these questions two dimensions are observed. Two characteristics of customer returns are found significant in deciding the strategic objectives; time-sensitivity and desirability. In processing the returns, there are also two types recognized; open and closed-loop supply chains. The next chapter highlights the research contribution and suggestions for future work.

Chapter 7

Conclusions and Further Research

This chapter starts with the research background and is followed by the research approach. The research contributions are then discussed according to two main categories: academic and industrial. Next, research limitations are identified and recommendations on future works are listed.

7.1 Research Background

This research set out to improve the understanding of performance measurement for reverse and closed-loop supply chains. The study highlights multiple justifications. At first, it is in the researcher's interest and motivation to investigate in detail the performance measurement of supply chain management. A significant interest of industry and academia in performance measurement for reverse and closed-loop supply chain had also been highlighted at that stage. For that purpose, two chapters of literature was presented. In the first chapter, Chapter 2 examined the research areas governing the reverse and closed-loop supply chain, where it is concluded with the research gaps which include the lack of a process to support supply chain managers to carry out a performance measurement for reverse and closed-loop supply chains. There are three main research questions for this study: (1) how do companies measure and manage the performance of their reverse supply chain activities? (2) are performance measurements in reverse supply chains different from performance measurements in forward supply chains? (3) what should companies do to ensure that their performance measurement is adequate? In Chapter 3, a literature review on performance measurement in supply chain management was discussed to examine the methods used in previous publications in tracking and measuring performance in supply chain management.

Chapter 4 explained and justified the methods used in addressing the gaps mentioned and also the methodologies in order to address the research aims. For this aspect, case study companies showed willingness to be involved in this research and invited the researcher to study the particular projects. Chapter 5 developed and proposed the conceptual framework using the knowledge from the literature which comprises three levels: 1st level presented a five-step procedural framework which encapsulates the start-to-finish guide towards a performance measurement for reverse and closed-loop supply chain: 2nd level established a structural framework model to select strategic objectives for the appropriate performance attributes according to the identified characteristics for reverse and closed-loop supply chains in place: 3rd level is developed to propose a list of appropriate performance metrics to address the performance attributes selected in the second level. Chapter 6 presented the data collected and results from the interviews carried out as the method used in case studies investigations among five manufacturers and retailers in the UK. Each case study company was described in detail and a cross-case analysis was carried out. The data gained from the questionnaires in the survey to support the case studies' result is also reported. Both of the research methods approached contributed to the overview on the current practice of performance measurement for reverse and closed-loop supply chains. The findings are analysed further and the discussion on the key findings of the empirical research was included at the end of this chapter.

7.2 Research approach

This research attempted qualitative and exploratory methods throughout the process. They were identified by the researcher as the best approach in gradually answering the research questions and at the same time incrementally addressing the research objectives in a manner in which data collection and interpretation are intertwined and iterative.

The case study approach is chosen because it allows investigating in depth the performance measurement for reverse and closed-loop supply chains. The selection of UK companies for the case studies is justified by the level of customer returns' associated with the environmental and take back regulations imposed and also the existence of liberal customer returns policy. The respondents involved a range of job positions which includes supply chain managers, program managers, quality managers and logistics managers. Information was collected by manipulating a variety of data collection methods (semi-structured interviews, questionnaire, and archive). As it is known that a case study offers an insufficient basis for generalisation, the findings of this research must be validated through multiple case studies. Three manufacturers and two retailers are involved in the case studies and responses from nine companies are obtained for the survey. Multiple sources of evidence and triangulation of data collection methods are used to ensure reliability of data and rigour of the research.

7.3 Research Contribution

This research's main objective was to understand further the performance measurement for reverse and closed-loop supply chains and develop a framework on how to select the strategic objectives which can drive the selection of most appropriate performance metrics. The contributions of this research can be classified into academic and industrial facets.

7.3.1 Academic Implications

The literature suggested that PM is very important in achieving effective RSC and CLSC. There is, however, no empirical research to address the particular subject. In this research, a detailed process view was mapped on designing and implementing PM for RSC and CLSC. Multiple case studies and a survey are performed investigating the RSC and CLSC practice in five manufacturers and retailers, and identified the selection of strategy objectives for constructing measures which can facilitate finding a balance for the PM.

Despite the efforts from the practical side and from the academic side, the performance measurement proposed has not considered the challenges involving RSC and CLSC. General guidelines are given without taking into account the characteristics and the issues revolving around RSC and CLSC. To address the shortcomings, the primary contribution of this research is the proposed three-level framework of PM for RSC and CLSC. The proposed framework allows the decision makers to identify meaningful performance attributes and performance metrics through a systematic view of the whole reverse and closed-loop supply chains' strategic objectives and characteristics. There are a few suggestions about analytical models to help decision makers in measuring their RSC and CLSC; however, most of these models have limitations. These methods do not address the strategy in selecting the right measures to address the characteristics of each type of supply chain and each type of product returns. The framework facilitates the development of PM for RSC and CLSC in a step-by-step process with a detailed list of performance attributes and performance metrics. Overall, it connects two streams of literature: RSC and CLSC with PM in the supply chain management. First, the framework recommends a *procedural framework* to ensure that the PM is properly developed. It includes the initial development stage, the measuring stage and the evaluation stage of the PM. Secondly, *structural framework* is developed as a guideline in identifying the right strategic objectives according to the type of product returns and also the type of reverse supply chain. The strategic objectives are then directed to the selection of appropriate performance metrics. This level of framework overrules the generalisation of the whole PM framework model to all the RSCs and CLSCs. Thirdly, a list of performance attributes is proposed to address all issues which might govern RSC and CLSC. For each performance attributes, a number of applicable performance metrics are presented. None of the existing analytical models explicitly use this concept in developing, implementing and improving their PM for RSC and CLSC. The previous suggestion in addressing PM in RSC and CSLC do not recognise the various operational steps in designing their framework models.

Case study findings can be seen not only as a part of this primary contribution but also as an independent contribution in itself. The multiple case studies involving five companies collected the desired evidence showing the importance of having the right strategic objectives in order to identify what to measure to improve their process. It is also shown that early segmentation treatment on the incoming product returns can produce positive results. The case studies also showed the applicability of the framework at least within some industrial environments.

The survey results constitute a part of the contribution of this research. The information regarding the present state of PM for RSC and CLSC in the UK in terms of problems encountered, strategic objectives employed and measurement purposes has some novelty value. On the other hand, the survey results indicated and refined the selection of performance metrics applied exclusively to RSC and CSLC.

7.3.2 Industrial Implications

The main contribution from the industrial aspect is in investigating the current practice of PM for RSC and CLSC in manufacturing companies and suppliers. Other companies in different industries can learn from each others' experiences. The framework model suggested in this research can be applied in practice when the other examples of case studies in this research can be connected to their own process. The framework model offers a clear, three levels actions with step-by-step development in achieving a comprehensive yet functional PM development guideline.

In addition, it is difficult to identify the person involved in the company who directly deals with RSC and CLSC activities before the data collection is carried out. The case study and survey results had revealed the job positions of the respondents who are involved in this study. This is very useful information to other companies in assigning the RSC responsibilities to their employees. It also plays a role in giving the overall picture of how RSC and CLSC affect other functions and FSC processes in a company.

As a whole, the research emphasizes the importance of PM towards achieving an effective RSC and CLSC. The characteristics of RSC and CSLC are shown to play an important role in selecting the right strategic objectives which assist in the selection of meaningful performance attributes and performance metrics. As RSC and CSLC are fairly new areas in supply chain management, companies might need to leave out the PM concept in their target to achieve maximum benefits from their RSC and CLSC.

7.4 Research Limitations

One of the limitations regarding the survey is the relatively low response rate. This may have caused a bias in the responses. In other words, more companies with different types of product returns and different RSC activities may not be represented in the survey results. Generalisation cannot be applied using the results gained from the survey where companies' experience in all type of industries cannot be investigated. Another limitation of the survey is related to the use of general email contact from which the questionnaires might not be passed on to the person who specifically deals with RSC and CLSC. More work could be done in using the identified job description owners who are responsible for the activities and the management of RSC and CLSC. Further, the case study of the five companies and a limited number of interviewees provide only a limited empirical context within the ideas presented in this study. With the involvement of the larger horizon into the whole community of the RSC and CLSC which could involve partnering with suppliers, transportation carriers, warehouse operators and other service providers might contribute towards a sufficient volume of information. Lastly, the case studies were not able to provide data on the real time of the PM application in RSC and CSLC and follow each measurement process through all the necessary iterations. This option was excluded because of restrictions on time and company access.

7.5 Future Research

Considering the scope of this research, it is suggested that the following areas should be further explored:

- Further evaluation of the framework is thus needed, involving more industries and more supply chain levels (tactical and operational).
- Different configurations of power, relationships and dependence among actors need to be addressed from both a conceptual and empirical standpoint in order to assess more thoroughly the validity of the framework.
- Each of the performance attributes listed has not been fully tested from an empirical point of view. It would therefore be beneficial to make further case studies in industry to assure their applicability and improve their usefulness as well as studying the limitations.
- A separate study should be carried out to provide a validation study. Because of a lack of time and opportunity this cannot be carried out within the current work and requires a separate study.
- In order to improve the usefulness of the proposed method some statistical studies should be made, which show the nature of a typical PMS used by a manufacturer or a retailer. Though a survey had been adopted in this research, a much higher response rate is needed to capture the appropriate level of generality.
- Finally, the implementation of PMSs for reverse and closed-loop supply chain and their evolution over time should be studied: the adoption of a longitudinal perspective in case research would be helpful to this objective.

7.6 Conclusions

Supply chains today continue to have shorter life-cycle products as a result of high rates of innovation. The increasing number of electronic retailing and catalogue sales fulfil the requirement of home shopping. More liberal return policies have been introduced to protect customers' buying rights and at the same time generate more sales. A growing number of environmental regulations is created which involve a wide range of products. All of these circumstances contribute to the reverse flow of products which require manufacturing organisations to manage strategically and deal with the return flows. As advocated by numerous literatures, the use of PM is an effective way to support and enhance supply chain improvements, and research concerning PM in RSC and CLSC is, therefore, of vital importance. The research aims to investigate the practice of performance measurement in reverse and closed-loop supply chains, how it is developed and the strategies used. The research presents an understanding of PM for RSC and CSLC. Multiple case studies and survey involving manufacturers and retailers provide the empirical evidence for the research. It further aims to configure the differences between PM for RSC and CLSC with PM for FSC. The outcome of the research is a framework model of PM for RSC and CSLC. To conclude, the framework model of PM for RSC and CLSC presented in this research is relevant and important.

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Appendix 1: Questionnaires for survey

Performance Measurement in Reverse & Closed-loop Supply Chains

1. About this research

This research aims to investigate how companies measure the performance of their reverse supply chain activities. The following questionnaire focuses particularly on defining strategic objectives and selecting appropriate metrics for reverse supply chain performance measurement.

We would very much appreciate your participation in this study and we hope you can answer all the questions.We anticipate that completing the questionnaire will take about 15 minutes. We are not looking for company sensitive data, but all information will be treated as confidential. Please feel free to contact us in case you would like any other information, or in case you would like to receive a paper version of this questionnaire.

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2. Company Profile

General information about your company

1. In which of the following channel positions does your company operate?

- ○ Manufacturer
- ○ Retailer
- ○ Service provider
- ○ Other (please specify)

If you are a third party provider, please answer the following questions for one of your companies client.

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Performance Measurement in Reverse & Closed-loop Supply Chains

2. What is your primary business?

- ○ 1) Automotive
- ○ 2) Aerospace
- ○ 3) Machinery, machine tools and instrumentation
- ○ 4) Industrial chemicals
- ○ 5) Iron, steel and construction materials
- ○ 6) Plastic and packaging
- ○ 7) Electrical equipment & electronics
- ○ 8) Pharmaceuticals
- ○ 9) Home and garden furniture and accessories
- ○ 10) Food & drinks
- ○ 11) Clothes, Shoes & Accessories
- ○ 12) Paper products/ carton
- ○ 14) Retail business
- ○ Other (please specify)

3. Please enter the following information:

Turnover in 2007 in the UK (£K)

Number of employees in the UK

Number of employees dealing with reverse logistics issues (in the UK)

4. Please estimate your sales percentage (VOLUME and VALUE) in the following market segments:

(Your answers should total up to 100%)

	VOLUME	VALUE
Low-end products		
Medium-range products		
High-end products		

5. How long is the life cycle of a typical product in your company?

- ○ Less than 6 months
- ○ Between 6 months and 2 years
- ○ Between 2 years and 5 years
- ○ Longer than 5 years

3. Reverse supply chain information

6. How important are product returns in your company?

	Not important at all	Somewhat important	Important	Very important	Extremely important
Importance	○	○	○	○	○

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Performance Measurement in Reverse & Closed-loop Supply Chains

7. Which of the following return streams are the most important in terms of VOLUME, in your company?

	Very Low	Low	Medium	High	Very High
End of life returns	○	○	○	○	○
End of use returns (e.g. leasing)	○	○	○	○	○
Commercial returns from customers (e.g. convenience returns)	○	○	○	○	○
Warranty returns	○	○	○	○	○
Commercial returns from channel partners (e.g. overstocks, channel clearance)	○	○	○	○	○
Maintenance, Repair and Overhaul returns	○	○	○	○	○
Product recalls	○	○	○	○	○
Distribution related returns (wrong/ damaged deliveries)	○	○	○	○	○
Raw material surplus	○	○	○	○	○
Quality-control returns	○	○	○	○	○
Production leftovers/ by-products	○	○	○	○	○

Other (please specify)

8. Which of the following return streams are the most important in terms of RESIDUAL VALUE, in your company?

	Very Low	Low	Medium	High	Very High
End of life returns	○	○	○	○	○
End of use returns (e.g. leasing)	○	○	○	○	○
Commercial returns from customers (e.g. convenience returns)	○	○	○	○	○
Warranty returns	○	○	○	○	○
Commercial returns from channel partners (e.g. overstocks, channel clearance)	○	○	○	○	○
Maintenance, Repair and Overhaul returns	○	○	○	○	○
Product recalls	○	○	○	○	○
Distribution related returns (wrong/ damaged deliveries)	○	○	○	○	○
Raw material surplus	○	○	○	○	○
Quality-control returns	○	○	○	○	○
Production leftovers/ by-products	○	○	○	○	○

Other (please specify)

Performance Measurement in Reverse & Closed-loop Supply Chains

9. Which of the following return streams are easy or difficult to control?

	Easy to control	Intermediate	Difficult to control
End of life returns	○	○	○
End of use returns (e.g. leasing)	○	○	○
Commercial returns from customers (e.g. convenience returns)	○	○	○
Warranty returns	○	○	○
Commercial returns from channel partners (e.g. overstocks, channel clearance)	○	○	○
Maintenance, Repair and Overhaul returns	○	○	○
Product recalls	○	○	○
Distribution related returns (wrong/ damaged deliveries)	○	○	○
Raw material surplus	○	○	○
Quality-control returns	○	○	○
Production leftovers/ by-products	○	○	○

10. Does the value of the returned products erode over time? (the most important product if you have a wide range of products per return stream)

	No erosion	Slow erosion	Fast erosion
End of life returns	○	○	○
End of use returns (e.g. leasing)	○	○	○
Commercial returns from customers (e.g. convenience returns)	○	○	○
Warranty returns	○	○	○
Commercial returns from channel partners (e.g. overstocks, channel clearance)	○	○	○
Maintenance, Repair and Overhaul returns	○	○	○
Product recalls	○	○	○
Distribution related returns (wrong/ damaged deliveries)	○	○	○
Raw material surplus	○	○	○
Quality-control returns	○	○	○
Production leftovers/ by-products	○	○	○

Performance Measurement in Reverse & Closed-loop Supply Chains

11. Which of the following reverse supply chain activities are OUTSOURCED to service providers or carried out IN-HOUSE?

	In-House	Third Party	Both
Product acquisitions (obtaining products from last user or point of return)	○	○	○
Reverse distribution (logistics involved to transport returned products)	○	○	○
Test, sort, and dispositioning (deciding on final destination of returned products)	○	○	○
Refurbishing (recovery process e.g. remanufacturing, repair)	○	○	○
Remarketing (selling refurbished products, development of secondary market)	○	○	○

If you selected BOTH for any of the activities above, please comment.

12. Which of the activities below is the most DIFFICULT TO MANAGE AND CONTROL, and WHY? If you have a variety of returns, you may select a specific product return stream.

○ Product acquisitions (obtaining products from last user or point of return)

○ Reverse distribution (logistics involved to transport returned products)

○ Test, sort, and dispositioning (deciding on final destination of returned products)

○ Refurbishing (recovery process e.g. remanufacturing, repair)

○ Remarketing (selling refurbished products, development of secondary market)

WHY (please specify)

13. Are the following activities carried out either CENTRALISED or DECENTRALISED in your reverse supply chain?

	Centralized	Decentralized (at several locations)
Testing & sorting	○	○
Dispositioning (deciding what to do with product returns)	○	○
Refurbish /repair	○	○

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14. For your company, please estimate the percentage of product returns processed using the following options:
(Your answers should total up to 100%)

	VOLUME (%)
1) Resold as is in the primary market	
2) Resold as is in the secondary market	
3) Refurbished and sold/ reused in primary market	
4) Refurbished and resold/reused in secondary market	
5) Disassembly into parts and good parts are resold/ reused for primary market	
6) Disassembly into parts and good parts are resold/ reused for secondary market	
7) Materials recycling	
8) Scrap and sell to broker	
9) Energy recovery	
10) Landfill	
11) Other	

(please specify)

15. Do you segment your return streams in order to achieve your strategic objectives?
(Segmentation means splitting the return streams in different categories and setting different objectives for each category)

- ○ No
- ○ Yes

16. If YES, what are the criteria you use to segment your return streams?

- ☐ Returns value (high value vs. low value; obsolete vs. active)
- ☐ Quality/ condition of returns
- ☐ Time sensitivity of products (Highly sensitive vs. low sensitivity)
- ☐ Re-marketability (speed to re-enter markets)
- ☐ Own brand vs. other brand
- ☐ Origin of product (local vs not local eg. Far East)

Other (please specify)

Performance Measurement in Reverse & Closed-loop Supply Chains

17. Are there any parts of your reverse supply chain operated as a closed-loop [e.g. returned products are (re-)used for the production of new products]

- ○ No
- ○ Yes

If yes, please comment on the type of your closed-loop

18. What is the impact of environmental regulations (e.g. WEEE, ELV, RoHS, etc.) on your company's:

	Strong decrease	Decrease	No impact	Increase	Strong increase
Return stream volume	○	○	○	○	○
Return logistics cost	○	○	○	○	○
Complexity of supply chain	○	○	○	○	○
Complexity of product design	○	○	○	○	○
Re-usability of products/materials	○	○	○	○	○

19. Please rate the importance of the following STRATEGIC OBJECTIVES for dealing with product returns in your company?

	Not important at all	Somewhat important	Important	Very important	Extremely important
Minimise cost	○	○	○	○	○
Maximise value recovery/profit	○	○	○	○	○
Minimise the number of of (unwanted) returns	○	○	○	○	○
Maximise the number of (wanted) returns	○	○	○	○	○
Maximise speed of handling returns/ minimise leadtime	○	○	○	○	○
Minimise inventory of returned products	○	○	○	○	○
Maximise reuse	○	○	○	○	○
Minimise landfill	○	○	○	○	○
Comply with environmental regulation	○	○	○	○	○
Improve green image	○	○	○	○	○
Expand business (e.g. selling refurbished products in secondary markets)	○	○	○	○	○
Protect brand image/ avoid cannibalisation of new product sales/avoid grey markets	○	○	○	○	○

Other (please specify)

4. Performance Measures

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20. Which of the following METRICS do you currently use to measure the performance of your reverse supply chain operations in terms of COST-EFFECIENCY? Please tick all that apply.

- [ ] Production acquisition cost
- [ ] Reverse distribution/ transportation cost
- [ ] Cost for testing/ sorting
- [ ] Repair/refurbishment cost
- [ ] Remarketing/ redistribution cost
- [ ] Inventory cost
- [ ] Landfilling/ scrapping cost
- [ ] Value erosion cost (loss of value due to delays)
- [ ] Incentive alignment cost
- [ ] Penalty cost (e.g.: repair is over due date, error occurs after repair)

Other (please specify)

21. Which of the following METRICS do you currently use to measure the performance of your reverse supply chain operations in terms of VALUE RECOVERY? Please tick all that apply.

- [ ] Revenue from reselling repaired products
- [ ] Percentage of returns entering different recovery options (reuse, repair, refurbish, recycle, scrap & landfill, etc.)
- [ ] Cost avoidance by reusing refurbished parts/products in the forward supply chain
- [ ] Cost avoidance by recycling materials
- [ ] Number of times products are reused
- [ ] Cannibalisation of new product sales from selling refurbished products

Other (please specify)

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Performance Measurement in Reverse & Closed-loop Supply Chains

22. Which of the following METRICS do you currently use to measure the performance of your reverse supply chain operations in terms of RETURNS FLOW & TIME RELATED measures ? Please tick all that apply.

- [ ] Return rates by product line/ product category
- [ ] Return rates by return reason
- [ ] Return rates by channel partners/ region/ location
- [ ] Return rates by return policy (impact of change on return policies)
- [ ] Return rates by quality
- [ ] Return rate variability
- [ ] Total lead time (time from product being returned until final disposition)
- [ ] Leadtimes for each processing step
- [ ] Leadtime variability
- [ ] Compliance with due dates
- [ ] Inventory levels of returned products at each stage
- [ ] Inventory at risk (to become obsolete/ write-off)

Other (please specify)

23. Which of the following METRICS do you currently use to measure the performance of your reverse supply chain operations in terms of QUALITY related measures? Please tick all that apply.

- [ ] Quality of incoming returns
- [ ] Traceability of product return (history of use/service/repair, location, documentation)
- [ ] Accuracy of credit issuance
- [ ] Accuracy of returns acquisition process
- [ ] Accuracy of reverse distribution/ transportation
- [ ] Accuracy of testing/ sorting/ dispositions
- [ ] Accuracy of repair/ refurbishment operations
- [ ] Customer satisfaction
- [ ] Customer complaints
- [ ] Customer complaints resolved
- [ ] Success of customer helplines & support (in avoiding returns)

Other (please specify)

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24. Which of the following METRICS do you currently use to measure the performance of your reverse supply chain operations in terms of FLEXIBILITY? Please tick all that apply.

- [ ] Reusability of parts/ products (product modularity/ durability)
- [ ] Reusability of materials
- [ ] Feasibility in recycling/ repair options
- [ ] Number of outlets (market segments) for selling returned or refurbished products

Other (please specify)

25. Which of the following METRICS do you currently use to measure the performance of your reverse supply chain operations in terms of ENVIRONMENTAL/ SUSTAINABILITY issues? Please tick all that apply.

- [ ] Level of compliance with environmental regulations/ targets
- [ ] Number of environmental programme/initiatives involved
- [ ] Level of environmental emission
- [ ] Volume entering landfill
- [ ] Volume of non-biodegradable/ non-recyclable materials used
- [ ] Fraction of materials reused/ recycled
- [ ] Waste reduction
- [ ] Number of positive stories in the media

Other (please specify)

26. From the performance metrics you selected from previous questions, please indicate the five most important ones in your environment.

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Performance Measurement in Reverse & Closed-loop Supply Chains

27. Please express your opinion on performance measurement in your forward and/or reverse supply chains by answering TRUE or FALSE to the following statements:

	TRUE	FALSE
1)The strategic objectives for our forward supply chain differ from those for our reverse supply chain	O	O
2)We use different key performance indicators for the forward and reverse supply chain processes	O	O
3)It is more difficult to select appropriate metrics for reverse supply chain operations (compared with forward supply chain operations)	O	O
4)We know what data to collect for effective reverse supply chain performance measurement	O	O
5)There is more variability in our return streams compared to forward flows.	O	O
6)Compared with forward supply chain operations, it is more difficult to set performance targets for reverse operations	O	O
7)We have different objectives, metrics and/or targets in place for different product return streams.	O	O
8)Our reverse supply chain performance shows more variability than our forward supply chain performance	O	O
9)We have clear procedures how we handle returns	O	O
10)We have internal meetings to review and discuss our reverse supply chain performance.	O	O
11)Our channel partners fully understand all issues related to our product returns, and work towards the same objectives	O	O
12)We 'train' our channel partners so that they better understand our issues with product returns	O	O
13)Compared with forward supply chains, reverse supply chain require more points of control	O	O
14)Our disposition decisions give us maximum value recovery	O	O
15)We have no severe system bottlenecks in our reverse supply chain	O	O
16)A closed-loop supply chain would be the best solution to maximize value recovery and avoid channel conflicts	O	O
17)Open-loop reverse supply chains are a greater risk because of possible channel conflicts, grey markets and damage to brand name.	O	O

28. In your opinion, do your closed-loop reverse supply chains require other or different levels of control than open loop systems?

	TRUE	FALSE
Requires more coordination	O	O
Close monitoring for reliability on quality and time on the parties involved	O	O
Proactive acquisitioning	O	O
Better incentive alignment	O	O

Other comments (please specify)

Performance Measurement in Reverse & Closed-loop Supply Chains

29. How would you rate the overall performance of your reverse supply chain operations, and how effective is your current performance measurement system towards improving your reverse logistics performance?

	Very poor	Poor	Average	Good	Very good
Reverse supply chain performance	O	O	O	O	O
Effectiveness of performance measurement systems towards further improvement	O	O	O	O	O

30. If you have any other comments/ideas on performance measurement in reverse and closed-loop supply chains, please specify.

5. Conclusion

Details below are optional. However, any information submitted will help to extend the analysis of the survey.

31. Your position and your division/department (important)

32. Do you wish to receive a copy of the survey results?

O Yes O No

33. Your details

Name:
Company:
Address 1:
Address 2:
Postcode:
Country:
Email Address:
Phone Number:

Thank you very much for your participation.
All information provided by yourself will be treated as confidential and will not be made available to any third party.

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Appendix 2: Survey results

Respondent 1:

This company is a manufacturer of laptop cases and accessories and operates with 65 employees. The respondent is an Operations Director for *Europe, the Middle East and Africa (EMEA)* division. The company operates an open-loop supply chain where 65% of its returns are sold back into the primary market and 25% to the secondary market. It does not require a closed-loop system to achieve an effective product returns management but the company believes that the open loop system presents a higher risk in remarketing the returned products. Remarketing products is a new venture for this company, and it believes that this is the most difficult stage in its reverse supply chain: it is mainly concerned about the products entering grey markets. This company does not have an effective PMS for its RSC and state that it has a very poor RSC performance. It has no coordination with other channel partners, no established effort to train them, and experiences severe system bottlenecks in its RSC. Moreover, this company does not have clear procedures in handling product returns, has no internal discussion about its RSC performance and does not have specific data to measure its RSC performance. The company also has no specific objectives for each of the FSC and RSC, and believes that their disposition decisions do not give maximum value recovery for its returned products.

Respondent 2:

This company is a manufacturer in the cosmetics business. It has 2500 employees in the UK and its UK turnover for 2007 amounted to £626 million. The respondent is a Supply Chain Manager. The company operates an open-loop supply chain where 30% of product returns are resold to the primary market, 30% are resold in the secondary market and another 30% sent to recycling for materials recovery. For the company, closing the loop would be the best solution in maximizing value recovery and channel conflicts. It also believes that the open-loop system is a greater risk compared with the closed-loop system in terms of possible channel conflicts, grey markets and damage to brand name. To change its operation from open to a closed-loop supply chain, the company needs more coordination between all activities and channel partners and also needs to have proactive product returns acquisition. It named the most difficult stage as product acquisition because of complex distribution involving many points of sale by customers, creating difficulty in timings/coordination between physical return and the financial side (credit to the customer). It also has the problem that the channel partners do not understand its RSC issues even though it has make efforts to train its channel partners. The company rate its overall RSC performance as average and the effectiveness of its PMS for RSC as good. The company still do not know, however, what data to collect to achieve an effective PMS for its RSC and still has no clear procedure for handling returns, but the company holds internal meetings to review and discuss its RSC performance.

This company segment their return according to the quality or conditions of the returns. Therefore, it does not have different targets or performance metrics placed for different product streams. It is also confident that it chooses the best disposition recovery channel as it brings maximum value recovery for its product returns. The strategic objectives selected are shown in Table 7.1.

The company also uses the same strategic objectives in FSC and RSC. It does, however, use a different set of performance metrics to measure performance in RSC. This is because there is more variability in RSC, making the selection of performance metrics more difficult. Table 7.2 lists the performance metrics used for its RSC. It states that the two most important performance targets are to be a greener company and improve on timings efficiency and processes for returns.

Table 7.1 Strategic objectives selected

Strategic Objectives	Not important at all	Somewhat important	Important	Very important	Extremely important
Minimise cost				✓	
Maximise value recovery/profit				✓	
Minimise the number of of (unwanted) returns				✓	
Maximise the number of (wanted) returns		✓			
Maximise speed of handling returns/ minimise leadtime				✓	
Minimise inventory of returned products				✓	
Maximise reuse				✓	
Minimise landfill				✓	
Comply with environmental regulation				✓	
Improve green image					✓
Expand business (e.g. selling refurbished products in secondary markets)				✓	
Protect brand image/ avoid cannibalisation of new product sales/avoid grey markets				✓	

Table 7.2 Performance metrics selected

Performance attributes	Performance metrics
Cost-efficiency	•Inventory cost
Value recovery	•Cost avoidance by reusing refurbished parts/products in the forward supply chain •Cost avoidance by recycling materials
Returns flow& time related	•Total lead time (time from product being returned until final disposition) •Leadtimes for each processing step •Compliance with due dates
Quality	-
Flexibility	•Number of outlets (market segments) for selling returned or refurbished products
Environmental & Sustainability	-

Respondent 3:

This company design, manufacture and buy factored Home Appliances for sale to large Multiples and Retailers. It has 1200 employees and has gained turnover of £150 million in 2007. The respondent is a Returns Manager. The company operates on open-loop and closed-loop supply chain where 50% of returns are refurbished and sold in the secondary market, 20% are refurbished and sold in the primary market, 20% are scrapped and sold to a broker; and 10% are resold *as is* in the secondary market. These disposition decisions are identified to give maximum value recovery out of the product returns. For this company, product acquisition would be the most difficult activity to manage and control because it is often difficult to tie up a delivery, install and collect on a warranty exchange where costs associated in 'one-hit' is always higher than a separate delivery and collection. The respondent rates the company to have a very good reverse supply chain performance and also highly effective PMS for its RSC and CLSC. The company has worked with its channel partners towards understanding all issues related to the company's product returns and they work towards the same objectives. The company also does not face any severe bottlenecks in its RSC and CLSC and it holds regular internal meetings to review its performance. It has clear procedures on how to handle its product returns and it recognizes what data to collect for an effective PMS.

This company segment their product returns according to returns value (high vs. low, active vs. obsolete) and returns quality. It uses different strategic objectives and performance metrics for its RSC and CLSC compared with its FSC. Setting PMS for RSC and CLSC, however, is not difficult for this company when compared with setting PMS for its FSC. There is no requirement for more control points and the variability of the product returns does not pose a problem. The list of strategic objectives used is listed in Table 7.3 and the list of performance metrics used is shown in Table 7.4.

Table 7.3 Strategic objectives

Strategic Objectives	Not important at all	Somewhat important	Important	Very important	Extremely important
Minimise cost					✓
Maximise value recovery/profit					✓
Minimise the number of of (unwanted) returns					✓
Maximise the number of (wanted) returns		✓			
Maximise speed of handling returns/ minimise leadtime				✓	
Minimise inventory of returned products					✓
Maximise reuse				✓	
Minimise landfill				✓	
Comply with environmental regulation				✓	
Improve green image			✓		
Expand business (e.g. selling refurbished products in secondary markets)			✓		
Protect brand image/ avoid cannibalisation of new product sales/avoid grey markets					✓

Table 7.3 Performance metrics

Performance attributes	Performance metrics
Cost-efficiency	•Product acquisition cost •Reverse distribution/ transportation cost •Cost for testing/sorting •Repair/refurbishment cost •Inventory cost •Land filling/ scrapping cost
Value recovery	•Revenue from reselling repaired products •% of returns entering different recovery options (reuse, repair, refurbish, recycle, scrap & landfill, etc.) •Number of times products are reused
Returns flow& time related	•Return rates by product line/ product category •Return rates by return reason •Return rates by return policy (impact of change on return policies) •Return rates by quality •Total lead time (time from product being returned until final disposition) •Compliance with due dates •Inventory levels of returned products at each stage
Quality	•Quality of incoming returns •Traceability of product return (history of use/service/repair, location, documentation) •Accuracy of credit issuance •Accuracy of returns acquisition process •Accuracy of reverse distribution/ transportation •Accuracy of testing/ sorting/ dispositions •Accuracy of repair/ refurbishment operations •Customer satisfaction •Customer complaints •Customer complaints resolved •Success of customer help lines & support (in avoiding returns)
Flexibility	-
Environmental & Sustainability	•Waste reduction

Respondent 4:

This company is a manufacturer in the aerospace industry. It has 400 employees and its turnover for 2007 is US$350 million (aerospace industry uses US currency as global standardisation practice). This company operates an open-loop supply chain where 95% of returns are recycled for materials and the rest is scrapped. Refurbishment is its most difficult activity to manage because product returns received are generally not fit for purpose and strict quality rules make product deviation very difficult. This company does not segment its product returns and Table 7.5 shows its strategic objectives.

Table 7.5 Strategic objectives

Strategic Objectives	Not important at all	Somewhat important	Important	Very important	Extremely Important
Minimise cost					✓
Maximise value recovery/profit					✓
Minimise the number of of (unwanted) returns					✓
Maximise the number of (wanted) returns			✓		
Maximise speed of handling returns/ minimise leadtime					✓
Minimise inventory of returned products					✓
Maximise reuse					✓
Minimise landfill	✓				
Comply with environmental regulation	✓				
Improve green image	✓				
Expand business (e.g. selling refurbished products in secondary markets)		✓			
Protect brand image/ avoid cannibalisation of new product sales/avoid grey markets		✓			

Respondent 5:

This company is a retailer. It has 10,000 employees and its turnover amounted to £87 million in 2007. The respondent is a Returns Manager. The company operates an open-loop supply chain where 35% of returns are warranty products and returned to suppliers; 20% are resold in the primary market, 20% are recycled and 20% are sold to a broker as scrap. Any refurbishment is decentralized. This selection of disposition is identified to give maximum value recovery from the product returns. The company recognizes that remarketing is the most difficult activity to manage because it remarkets primarily through third party operations and wants to maximise yield while at the same time trying to protect its Own Brand (OB) product. De-branding protects its image but deflates the value of the product, rendering some products uneconomical for partners. For the company, closing the loop would be the best solution in maximizing value recovery and channel conflicts. It also believes that the open-loop system carries a greater risk than closed-loop system in terms of possible channel conflicts, grey markets and damage to brand name. To change operation from open to closed-loop supply chain, the company needs close monitoring on reliability of quality and time on the channel partners; and proactive acquisitioning. Nonetheless, the total performance of its RSC is rated as good and the effectiveness of its PMS in improving its RSC performance is rated as average. The company has no severe system bottlenecks in its RSC and has a clear procedure in handling returns. It knows what data to collect for an effective PMS and holds internal meetings regularly to access its performance. It also ensures that its channel partners fully understand all issues related to its product returns, and they work towards the same objectives.

The company segments their product returns according to returns value (high value vs. low value; obsolete vs. active), own brand vs. other brand; and origin of product (local vs. not local eg. Far East). It applies different objectives and performance metrics to different product return streams. The company identifies that it is more difficult to select appropriate performance metrics for RSC when compared with the ones for FSC. This is because there is more variability in its return streams compared with forward flows, and RSC require more points of control. The strategic objectives used are shown in Table 7.6 and the performance metrics used are listed in Table 7.7.

Table 7.6 Strategic objectives

Strategic Objectives	Not important at all	Somewhat important	Important	Very important	Extremely important
Minimise cost				✓	
Maximise value recovery/profit					✓
Minimise the number of of (unwanted) returns					✓
Maximise the number of (wanted) returns	✓				
Maximise speed of handling returns/ minimise leadtime			✓		
Minimise inventory of returned products		✓			
Maximise reuse			✓		
Minimise landfill					✓
Comply with environmental regulation					✓
Improve green image				✓	
Expand business (e.g. selling refurbished products in secondary markets)	✓				
Protect brand image/ avoid cannibalisation of new product sales/avoid grey markets					✓

Table 7.7 Performance metrics

Performance attributes	Performance metrics
Cost-efficiency	•Repair/refurbishment cost •Remarketing/ redistribution cost •Land filling/ scrapping cost •Penalty cost (e.g.: repair is over due date, error occurs after repair)
Value recovery	•Revenue from reselling repaired products •Cost avoidance by reusing refurbished parts/products in the forward supply chain
Returns flow& time related	•Return rates by product line/ product category •Return rates by return reason •Return rates by quality •Inventory at risk (to become obsolete/ write-off)
Quality	•Quality of incoming returns •Accuracy of repair/ refurbishment operations •Customer satisfaction •Customer complaints •Customer complaints resolved •Success of customer help lines & support (in avoiding returns)
Flexibility	•Feasibility in recycling/ repair options
Environmental & Sustainability	•Level of compliance with environmental regulations/ targets •Level of environmental emission •Volume entering landfill •Volume of non-biodegradable/ non-recyclable materials used •Waste reduction

The five most important performance metrics in the company's RSC are:

- Returns rate by product line
- Returns rate by reason
- Customer satisfaction
- Cost avoidance by using refurbished parts
- Revenue from selling repaired products

Respondent 6:

This company is a manufacturer of electrical equipment and electronics. It has 35 employees. Though the uses of disposition channels are not stated, this company signifies that its disposition decisions give maximum value recovery. It segments the product returns according to returns value (high value vs. low value; obsolete vs. active), time sensitivity of products (highly sensitive vs. low sensitivity) and re-marketability (speed to re-enter markets). The same strategic objectives and performance metrics are used for all type of return streams. For the company, closing the loop would be the best solution in maximizing value recovery and channel conflicts, grey markets and damage to its brand name. It also recognizes that the open-loop system carries a greater risk in terms of possible channel conflicts, grey markets and damage to brand name. To change its operation from open to a closed-loop supply chain, the company needs more coordination between all activities and channel partners which includes close monitoring for reliability on quality and time. The company also identifies the need for proactive acquisitioning and better incentive alignment with channel partners involved.

Although the company works towards achieving coordination with its channel partners, it still faces the problem where the channel partners do not fully understand all issues related to its product returns, thus do not work to the same objectives. Reverse distribution is named as the most difficult activity to manage as its retailers will always try and add extra products to returned products. Once the products are received, it is very difficult for the company to refuse credit to the retailers. Remarketing is also identified as a challenging activity based on the differing levels of quality on the returned products.

In overall, the company classifies its RSC performance as good and the effectiveness of the PMS of RSC as average. It has a clear procedure in handling returns, organizes internal meetings to review its RSC performance and is fully aware of what data to collect to achieve an effective RSC PMS.

- It recognizes that it is more difficult to set a target and to select performance metrics for RSC as there is more variability when compared with FSC. Nevertheless, the same strategic objectives and performance metrics are used for FSC and RSC. The lists of strategic objectives selected are shown in Table 7.8 and the list of performance metrics used is presented in Table 7.9.

Table 7.8 Selection of strategic objectives

Strategic Objectives	Not important at all	Somewhat important	Important	Very important	Extremely important
Minimise cost					✓
Maximise value recovery/profit					✓
Minimise the number of of (unwanted) returns			✓		
Maximise the number of (wanted) returns			✓		
Maximise speed of handling returns/ minimise leadtime				✓	
Minimise inventory of returned products				✓	
Maximise reuse			✓		
Minimise landfill		✓			
Comply with environmental regulation			✓		
Improve green image			✓		
Expand business (e.g. selling refurbished products in secondary markets)			✓		
Protect brand image/ avoid cannibalisation of new product sales/avoid grey markets				✓	

Table 7.9 selection of performance metrics

Performance attributes	Performance metrics
Cost-efficiency	•Reverse distribution/ transportation cost •Repair/refurbishment cost •Inventory cost •Value erosion cost (loss of value due to delays) •Penalty cost (e.g.: repair is over due date, error occurs after repair)
Value recovery	•Revenue from reselling repaired products •% of returns entering different recovery options (reuse, repair, refurbish, recycle, scrap & landfill, etc.) •Cost avoidance by reusing refurbished parts/products in the forward supply chain •Cost avoidance by recycling materials •Cannibalisation of new product sales from selling refurbished products
Returns flow& time related	•Return rates by product line/ product category •Return rates by return reason •Return rates by channel partners/ region/ location •Return rate variability •Inventory levels of returned products at each stage
Quality	•Quality of incoming returns •Traceability of product return (history of use/service/repair, location, documentation) •Accuracy of credit issuance •Accuracy of returns acquisition process •Accuracy of reverse distribution/ transportation •Accuracy of testing/ sorting/ dispositions
Flexibility	•Reusability of parts/ products (product modularity/ durability) •Reusability of materials •Number of outlets (market segments) for selling returned or refurbished products
Environmental & Sustainability	•Level of compliance with environmental regulations/ targets

Among the selected performance metrics, the five most important ones in the company environment are:

- Return rate by product return
- Return rate by retailer
- Recovery value by product
- Quality of returns
- Accuracy of return quantities

Respondent 7:

This company is involved in designing, developing and manufacturing home heating appliances with turnover of £2.1 million in 2007. It is a small company with 12 employees. The company primarily operates an open loop system where 80% of returns are refurbished and sold in the primary market, 10% are disassembled into parts and good parts are resold for the primary market, and another 10% of the returns go to landfill. The company recognizes that the disposition decisions provide maximum value recovery of the product returns. The company agrees that CLSC is the best solution to achieve maximum value recovery and the risks of the open-loop system is fully understood. To change its operation from open to CLSC, the company agrees that proactive acquisitioning and more coordination are needed, also close monitoring on quality and time; and better incentive alignment when dealing with the channel partners. The company already maintains good coordination with its channel partners where they fully understand all issues related to product returns, and they work towards the same objectives. The company rate its RSC performance as good and its effectiveness of RSC PMS as good too, though the company experiences severe bottlenecks in its RSC. It has clear procedures in handling returns and recognizes what data to collect towards achieving an effective PMS for its RSC.

The company uses the same strategic objectives and performance metrics for its RSC and FSC though it is more challenging to select performance metrics for RSC because of its variability. The strategic objectives used are listed in Table 7.10 and the list of performance metrics is presented in Table 7.11.

Table 7.10 Strategic objectives

Strategic Objectives	Not important at all	Somewhat Important	Important	Very Important	Extremely Important
Minimise cost					✓
Maximise value recovery/profit					✓
Minimise the number of of (unwanted) returns					✓
Maximise the number of (wanted) returns					✓
Maximise speed of handling returns/ minimise leadtime				✓	
Minimise inventory of returned products					✓
Maximise reuse					✓
Minimise landfill					✓
Comply with environmental regulation					✓
Improve green image					✓
Expand business (e.g. selling refurbished products in secondary markets)				✓	
Protect brand image/ avoid cannibalisation of new product sales/avoid grey markets					✓

Table 7.11 Performance metrics

Performance attributes	Performance metrics
Cost-efficiency	•Reverse distribution/ transportation cost •Cost for testing/sorting •Repair/refurbishment cost •Remarketing/ redistribution cost
Value recovery	•Revenue from reselling repaired products •% of returns entering different recovery options (reuse, repair, refurbish, recycle, scrap & landfill, etc.) •Cost avoidance by reusing refurbished parts/products in the forward supply chain
Returns flow& time related	•Return rates by product line/ product category •Return rates by return reason •Return rates by channel partners/ region/ location •Return rates by quality •Inventory at risk (to become obsolete/ write-off)
Quality	•Traceability of product return (history of use/service/repair, location, documentation) •Accuracy of credit issuance •Accuracy of returns acquisition process •Accuracy of reverse distribution/ transportation •Accuracy of repair/ refurbishment operations •Customer satisfaction •Customer complaints resolved
Flexibility	•Reusability of parts/ products (product modularity/ durability) •Reusability of materials •Feasibility in recycling/ repair options
Environmental & Sustainability	•Level of compliance with environmental regulations/ targets •Level of environmental emission •Waste reduction

Respondent 8:

This company is a manufacturer of shoes and is involved in wholesale and retail. It has 1500 employees and its turnover amounted to £500 million in 2007. it operates an open-loop supply chain where 45% of its returns are resold *as is* in the secondary market, 35% are scrapped and sold to a broker, 10% are resold *as is* in the primary market and another 10% are recycled for materials. The company believes the disposition decisions do not achieve the maximum value recovery of its return products. Closed-loop is not seen as the best solution to the problem though the risks of open-loop system are fully understood. To change its operation from open to a closed-loop supply chain, the company requires proactive acquisitioning. When dealing with its channel partners, it identifies the need for better coordination, close monitoring on quality and time; and better incentive alignment. Currently, the company does not achieve a good coordination where channel partners still do not fully understand the issues related to product returns. It still experiences severe system bottlenecks in its RSC. Therefore, the company rates its RSC performance as average and its effectiveness of PMS for its RSC also as average. It does not have clear procedures in handling product returns, has no internal discussion to discuss its RSC performance and does not have a systematic data collection in measuring its RSC performance.

The company segment its product streams according to quality/ condition of returns, time sensitivity of products (highly sensitive vs. low sensitivity) and re-marketability (speed to re-enter markets). It applies different strategic objectives and performance metrics for different product streams.

Different sets of strategic objectives and performance metrics are used for FSC and RSC. There is more variability in its return streams when compared with forward flows. For its RSC, performance targets are more difficult to set and more points of control are required. Once the targets are set, however, there is no difficulty in setting the performance metrics for its RSC. Table 7.12 lists the strategic objectives used and Table 7.13 presents the performance metrics used.

Table 7.12 Strategic objectives

Strategic Objectives	Not important at all	Somewhat important	Important	Very important	Extremely Important
Minimise cost				✓	
Maximise value recovery/profit			✓		
Minimise the number of of (unwanted) returns			✓		
Maximise the number of (wanted) returns					
Maximise speed of handling returns/ minimise leadtime				✓	
Minimise inventory of returned products					✓
Maximise reuse				✓	
Minimise landfill					✓
Comply with environmental regulation					✓
Improve green image					✓
Expand business (e.g. selling refurbished products in secondary markets)			✓		
Protect brand image/ avoid cannibalisation of new product sales/avoid grey markets					✓

Table 7.13 Performance metrics

Performance attributes	Performance metrics
Cost-efficiency	•Reverse distribution/ transportation cost •Cost for testing/ sorting •Repair/refurbishment cost •Remarketing/ redistribution cost •Inventory cost •Land filling/ scrapping cost
Value recovery	•Revenue from reselling repaired products •Percentage of returns entering different recovery options (reuse, repair, refurbish, recycle, scrap & landfill, etc.)
Returns flow& time related	•Return rates by product line/ product category •Return rates by return reason •Return rates by channel partners/ region/ location
Quality	•Accuracy of credit issuance •Customer complaints resolved
Flexibility	-
Environmental & Sustainability	•Level of compliance with environmental regulations/ targets

Respondent 9:

This company is a manufacturer of electrical equipment and electronics which earned £200 billion turnover in 2007 worldwide. It operates with 160 000 employees all over the world. The company segments its product returns according to the returns value (high value vs. low value; obsolete vs. active) and the remarketability (speed to re-enter markets). It applies different strategic objectives for different product return streams. Although the company operates an open-loop supply chain, the company recognizes that its disposition channels do not give maximum value recovery from the return products. It identifies that a closed-loop would be the best solution as open loop supply chains present a greater risk because of possible channel conflicts, grey markets and damage to brand name. To change operation from open to closed-loop supply chain, the company requires more coordination with the channel partners and close monitoring on all activities involved. Better incentive alignment is also an important criterion. Though the company communicates with the channel partners regarding any issues with product returns, they do not fully understand the issues and do not work towards the same objectives.

In general, the company rates its RSC performance as average, and the effectiveness of PMS towards further improvement of RSC performance as good. It has clear procedures on how to handle returns and knows what data to collect for an effective PMS. It still experiences severe bottlenecks in its RSC but conducts internal meetings to review and discuss its RSC performance.

The company uses the same strategic objectives and performance metrics for forward and reverse supply chain processes. Its RSC experiences more variability than FSC therefore it is more difficult to set performance targets. Nevertheless, selecting performance metrics for RSC are not difficult once the performance targets are identified and its RSC do not require more control than FSC. The strategic objectives selected are listed in Table 7.14 and the performance metrics selected are presented in Table 7.15.

Table 7.14 Strategic objectives

Strategic Objectives	Not important at all	Somewhat important	Important	Very important	Extremely important
Minimise cost				✓	
Maximise value recovery/profit					✓
Minimise the number of of (unwanted) returns			✓		
Maximise the number of (wanted) returns	✓				
Maximise speed of handling returns/ minimise leadtime				✓	
Minimise inventory of returned products				✓	
Maximise reuse					✓
Minimise landfill				✓	
Comply with environmental regulation					✓
Improve green image					✓
Expand business (e.g. selling refurbished products in secondary markets)		✓			
Protect brand image/ avoid cannibalisation of new product sales/avoid grey markets		✓			

Table 7.15 Performance metrics

Performance attributes	Performance metrics
Cost-efficiency	•Product acquisition cost •Reverse distribution/ transportation cost •Cost for testing/sorting •Repair/refurbishment cost •Remarketing/ redistribution cost •Inventory cost •Value erosion cost (loss of value due to delays)
Value recovery	•Revenue from reselling repaired products •% of returns entering different recovery options (reuse, repair, refurbish, recycle, scrap & landfill, etc.) •Cost avoidance by reusing refurbished parts/products in the forward supply chain
Returns flow& time related	•Return rates by product line/ product category Return rates by channel partners/ region/ location •Return rates by return policy (impact of change on return policies) •Return rates by quality •Inventory levels of returned products at each stage
Quality	•Quality of incoming returns •Accuracy of reverse distribution/ transportation •Accuracy of repair/ refurbishment operations •Customer satisfaction •Customer complaints
Flexibility	•Reusability of parts/ products (product modularity/ durability) •Feasibility in recycling/ repair options
Environmental & Sustainability	•Level of compliance with environmental regulations/ targets •Number of environmental programme/initiatives involved •Volume entering landfill •Waste reduction

Appendix 3 : Interview Script for case study

1.Introduction: Company's Background

Can you briefly describe your job descriptions, particularly the ones that involve with reverse logistics?

2. Importance of product returns

2.1 What is your company perception of reverse logistics?
a) Ignore the significance of reverse logistics to its supply chain
b) Gradually recognised its importance
c) As a strategic variable

2.2What are the drivers which lead the company's interest and effort in handling the returned products?

2.3 Can you list your strategic objectives for your company's reverse supply chain, from the most important ones to the least important ones.

2.3.1 Are the goals/objectives different for (whether they are influenced by these factors):
a) Different decision of recovery options
b) Different product families/type [(responsive/functional) / life-cycle stage (new/ mature/ EOL)]
(If yes for above questions, please describe why)

3. Importance of product returnms and reverse supply chain structure

3.1 In your division, can you describe the type of products involved? *[e.g. end-of-life, warranty, service, reimbursement guarantees- B2C commercial returns, stock adjustments at retailer, unsold products or wrong/ damaged deliveries- B2B commercial returns*]

3.2 Which is the largest return stream? (customer, EoL, EoU)

3.3 Can you share the figures of the product volumes (and value-£) per annum?

3.4 How each returned product is valued? (For re-marketing/ component re-use)

3.5 What are the ways to recover the value of returned products used by your company? (briefly, because the detail process will be asked later)

3.6 What are the criteria that affect the decision made (above)?

For value recovery maximisation

For green image

3.7 Can you explain briefly the possible uncertainties of returned products faced by the company? Can you rank them?

3.8 What is the biggest key challenge involving returned products apart from the uncertainties above?

3.9 Is your company affected by any regulations? What are they?

3.10 What is the future for return products in the company? Will this grow in importance or not?

3.11 Why? (*for the above explanation*)

<u>4. Production Planning and Control of Reverse Logistics</u>

4.1 Can you explain, the whole process of each product, from:

* Product acquisition stage to the stage it is ready for remarketing?

Product acquisition

Reverse distribution

Test/ sort/ disposition – what are the quality to be met?

Refurbishment/ repair/ recycle?

Remarketing?

4.2 Among the above activities that you listed, which is most difficult to control? Any bottlenecks?

4.3 What is/are the key factors that have the big impact on cost/profitability of the entire process?

4.4 Do they relate to the type of returned product or recovery options?

4.5 Where are all the reverse logistics activities in your company carried out? In-house or out-sourced?

4.6 (if both) Which one is out-sourced? How many partners do you have? Which one is carried in-house?

4.7 Are all the RL activities done centralised or decentralised?

4.8 Are the links between forward supply chain and reverse supply chain? Explain

- *The same production lines for new and refurbished products*
- *The same storage/ sorting area*
- *Other resources*

4.9 What hardware and software technologies do you have installed, or plan to install, to assist your reverse supply chain:

- *Automated material handling equipment*
- *Bar codes*
- *Computerised return tracking*
- *Computerised returns entry at most downstream point in supply chain*
- *Electronic data interchange (EDI)*
- *Radio frequency (RF)*
- *Other, please specify*

5. Performance Measurement/ Management

5.1 Do you have a performance measurement systems (PMS) for your reverse supply chain?

5.2 Is your PMS model/ process design originally developed by your personnel/staff or adapted from other resources?

5.3 Do you have different PMS for different:

5.3.1 Decision of recovery options?

5.3.2 Product families/ type/ life-cycle stage?

5.4 What are the process phases involved in your PMS design? Can you explain?

5.5 What key measures are used pin your PMS? *I want to write them out, easy to refer later.*

5.6 Can you put them in a hierarchy of importance?

5.7 Among them, which are related to:

5.7.1 Strategic objectives? Global, report to top management

5.7.2 Tactical objectives?

5.7.3 Operational objectives?

5.8 What influenced the selection criteria?

5.9 What do you measure each of them?

5.9.1 What are the scales used for each measurements? [type of data collected: subjective- based on opinion or estimates/ objective – independently – observable facts]

5.9.2 What are the data sources for each measure defined? [Internal data source company's history data]

5.9.2.1 How difficult is it to get data for your PMS? (from internal/ 3PLs)

5.9.2.2 How do you check on the accuracy of the data gained/used?

5.9.2.3 Is having multiple 3PL/partners ever resulted any difficulties?

a) For you 3rd party logistics provider, do you set the goals/ targets/ rules for them to meet?

b) What are they?

c) How do the 3PLs use /implement them?
d) Do they set targets, define projects or improvement?

5.9.3 What is the reference base used to set targets/ limits for your control measures? (benchmark/ self-referenced)

5.9.3.1 How do you monitor any out-of-control measures?

5.9.3.2 What would you do to rectify the situation?

5.9.4 Where is the location at which the measurement is taken? (process orientation: input/outcome, RL activities)

5.10 Is the PMS for RSC made integrated with forward PMS?

5.10.1 Are the same metrics used in both PMS?

5.10.2 Are the metrics in RSC PMS made widely known in the closed-loop chain? (so that PMS in FSC can identify return reasons easily and can be developed to work in reducing returns)

5.10.3 Are there any aspects which both of the supply chains (RSC and FSC) share (e.g. same resources) in measuring their performances? (facilities/ labour)

5.11 For you PMS, if you have to name one critical success factor, what would it be? And why?

5.12 Does the current PMS successfully translate company's strategic goals into performance data?

5.13 Do you see your current PMS give contribution to your RSC performance?

5.14 Is there anything needed to be changed for future operations?

5.15 What are major difficulties you faced during practising your PMS for your RSC/CLSC?

5.16 If in future your company has managed to eliminate the problems that you mentioned, what the PMS will be like for your RSC?

APPENDIX 4: Case examples on open and closed-loop system

Case & References	RL activities	Type of product	Facilitating factors	Implications	Comment/drivers
1) Xerox-Europe Guide and van Wassenhove (2003)	Repair, remanufacturing and recycling of products	Copiers, printers, and office products	•Design for disassembly, durability, reuse and recycling has enabled Xerox to maximize the end-of-life potential of products and components •Depending on leasing enables more accurate forecasting of the timing and quantities of product returns •Identifying four grades of returned products facilitates the sorting process	•Misperception among customers about products with recycled-parts having inferior quality to those built fro all-new parts	•Drivers include financial benefits providing competitive edge, complying with legislative regulation, and meeting customer requirements
2)CopyMagic Thierry *et al.* (1995)	Remanufacturing, recycling, cannibalization, and repair operations of photocopiers	Copiers	•Changing product design requirements to take into consideration design for disassembly, standardization of materials, and replacing non-recyclable materials with recyclable ones. •Modular design of the products •Material election criteria based on lifecycle costs and performance instead of purchasing and manufacturing costs •Using coded materials facilitates and reduces the costs of the sorting process, especially for different types of plastics •Outsourcing all recycling activities in which the company does not have the required experience such as fabrication •"green-marketing" products while at the same time assuring customers that the quality level is not affected by the use of recycled materials. •Decreasing the number of suppliers due to the standardization of materials used. And fortifying supplier relationships by involving them in the design process to provide advice regarding product recyclability. •Obliging suppliers to code all materials to facilitate the sorting process. •Obtaining new skills and equipment to perform necessary remanufacturing activities such as testing, repair, quality control, etc. •Centralization facilitates control of all product recovery management process	•Durable components can be reused more often than other ones, causing business losses for suppliers that make long-lasting components.	•Business-economic drivers

Case & References	RL activities	Type of product	Facilitating factors	Implications	Comment/drivers
3) NEC Computers International (NEC-CI) Geyer *et al.* (2005)	Handling commercial product returns, product failures during production, and obsolete components in stock	Electronics (desktops, notebooks, and servers)	•Collecting information on failures and quality issues to be handled by their "respective process owners" •Conducting questionnaires (connecting with customers to know the reason of the return) •Obtaining info about frequency and nature of faults and defects in returns	•"Assemble to order" policy is inappropriate in managing product returns (time pressure, no time to analyse reasons of product failure, scrap immediately) •Challenge in computer industry: obsolete components, e g microprocessors have long lead times and very short life cycles →high chance of becoming obsolete before used in production. •Unpredictable demand	•Short life-cycles of computers, high rate of obsolescence → need (1)coordination with suppliers (2) rotate component inventory faster (3)minimise inventory of product return due to faults
4) HP Davey *et al.* (2005)	Managing commercial returns (obsolete products, products received in open boxes, products received in closed boxes)	Electronics (printers, scanners, cameras, etc.) (high seasonality)	•"late point differentiation" concept in inkjet product lines → easier to reuse •Outsourcing Testing and Refurbishment and Returns depot to 3rd party service providers	•Consumer return products as a matter of convenience in North America → high return rates •Volume of returns strongly influenced by seasonality (e g. Christmas) •Shorter printer lifecycles; products are returned towards the end of their lifecycle, leaving less opportunities to recover the full value of the product •Lack of retailers' understanding of the returns, process, and their lack of motivation to control returns •Problem in remanufacturing environment: no control of returns flow (if demand does not match return flow rate →stock piles up) •Scepticism regarding marketing of remanufactured goods (fear of cannibalisation of new product sales)	•Drivers: (1) Reseller overstock (2) customer expectations not fulfilled/improper knowledge of product/ consumer behaviour (3)Defects (small percent) (4)Misleading product info •HP's strategy : (1) Reduce total business cost (reduce return volume, reduce handling costs)(2)generate max revenue of remanufactured goods (generate demand for remanufactured goods)

Case & References	RL activities	Type of product	Facilitating factors	Implications	Comment/drivers
5)Recellular Inc. Guide *et al.* (2005) & Guide and van Wassenhove (2003)	Acquisition, remanufacturing, and reselling used cellular phones	Cellular phones	•Good relationships with suppliers to ensure steady supply of used cell phones •Bulk procurement of cell phones from airtime providers and third party collectors instead of recollecting them from end users •Operating on a global level facilitates reselling used products from one market in another •Establishing a fixed quality scale linked to the procurement prices. This scale yields less uncertainty in quality of incoming flow, less sorting effort, and less scrap •Using bulk air transportation to cut down costs	•Restriction on potential markets for remanufactured cell phones due to the lack of worldwide standard technology (certain phones cannot be operated in all countries) •Short product life-cycle makes fast processing and reselling important factors before product becomes obsolete	-
6)Mercedes Benz Dreisch *et al.* (2005)	Remanufacturing car and van engines	Car and van engines	•In order to cope with the uncertainty, factors based on past experience are used. (e g. using probability factors in forecasting the time phased requirements of different reconditioning activities/ due to the uncertainty in the results of the reconditioning activities) •Use of chips that contain all kinds of data about parts, which facilitates planning and control of processes, and the pricing of engines to be replaced with remanufactured ones •There is increasing demand for basic elements of engines (e g. long and short blocks)	•Declining prices of new engines •Technical restrictions, e g the gear-chain problem (if chain needs replacement, then gear would also need to be changed so that they would fit), which creates a restriction on combining new and used components •Demand and supply of remanufactured engines are not controlled by MB •Uncertainty in time, quantity, state, and configuration of engines supplied by dealers •Increasing number of engine variants, with short delivery times and high obsolescence costs	•Offers replacement of current engine/other parts with remanufactured ones with same quality of new ones but 20-30% lower prices •In order to be able to provide service parts for 20 years: need facilities to produce components of older engine types, or build enough stock of new parts to fulfil incoming years' demand, or (the cheaper option) remanufacturing (used engines) •Having a network for engines recovery is mainly for business – economic drivers •It is not clear whether remanufactured engines affect the sales of new ones, and whether having the remanufacturing option increases sales of new cars

Case & References	RL activities	Type of product	Facilitating factors	Implications	Comment/drivers
7) Xerox Copy/ Print Cartridge return Guide and van Wassenhove (2003)	Handling and reuse of printer cartridges	Printer cartridges	Incorporation of reuse requirements early in design phase	-	•Xerox is preparing for a bulk returns process to allow high-volume users to batch used cartridges (less transport costs)
8) Kodak Guide and van Wassenhove (2003)	Handling and reuse of single use cameras	Single-use cameras	•Product designs that ease the reuse of parts and components •Agreements with photofinishers to return the cameras to Kodak after consumers had turned them in for processing (known annual return rates) •Building strong relationships with photofinishers to maintain the flow of used cameras •Remanufactured and new products are identical, therefore they share the same market	-	-
9)Heineken Group Van Dalen *et al.* (2005)	Handling of returnable packaging materials (RPM) (returnable bottles, crates, and kegs)	Containers	•Implemented the "Chip in Crate" experiment to measure the "circulation time of crates through the RPM logistic chain" to accurately define circulation time	•Uncertainty in beer demand and circulation times, therefore increasing the size of RPM investment	•RPM is used to comply with Dutch packaging regulations

Case & References	RL activities	Type of product	Facilitating factors	Implications	Comment/drivers
10) Blue container Line S A (BCL) Pappis *et al.* (2005)	Recovery and reuse of maritime containers	Container s	•High capital cost invested in containers •"Standardization of containers" facilitates transportation, treatment, and storage, and enables multiuse of containers •Need to reach an agreement with customers (companies) regarding the condition and maintenance of containers + the timely return of containers •Having long term contracts facilitates estimation of future requirements for containers, which aids in implementing planning and control •Appropriate labelling of containers further assists in their management (info about owner, country of origin, dimensions, contents, etc) •IT important for tracking	-	•Primary reason for container reuse is profit (containers may come back loaded/ continuous cycle of forward and reverse chain)
11)RetreadCo Debo and van Wassenhove (2005)	Tyre recovery	Tyre recovery	•Good relationships with tyre dealers are required to maintain sufficient supply of good casings •Understanding reasons of failure (under-over inflation) by obtaining information about temperature and pressure during tyre operation, tyre age, number of retreads so far (using sensors) •Exchanging this information with tyre retreads	•Declining retreaded passenger car tyres market due to: -Bad perception of retreaded tyres quality. In order to improve image, testing standards to retreaded tyres should be imposed similar to the ones of new tyres. (already applied in Europe) -High logistics costs due to the unpredictability of the supply of retreadable tyres and the high sorting costs -Competition from Budget Tyres: tyres produced at cheap labour costs compete with retreaded tyres for market share. Moreover they	•Environmental drivers (the Landfill Directive 1999, the End of Life Vehicle Directive 2000) •The nominative system: "big fleets cooperate with a tyre dealer for tyre management •The customer system: "collection of used tyres from small fleets or individual vehicle owners •Truck tyre retreading is more profitable than passenger cars tyre retreading because: -Big fleets have tyre maintenance management programs and software. - Retreading is cost effective in this case (the nominative system can be used, yielding low logistics costs, and substantial material savings)

Case & References	RL activities	Type of product	Facilitating factors	Implications	Comment/drivers
				have lower retreadability levels. Therefore market demand for retreaded tyres is less, and fewer retreadable used tyres are available (higher collection and retreading costs) •In passenger car tyres. Difficulty of matching supply with demand; the batches of returned tyres are a mix of different makes, size, and quality, while the demand for certain models can be higher than other models (this problem is significant in the commercial tyre retreading in truck fleets)	
12)OMRON Kuik *et al.* (2005)	Managing electronic parts repair	Electronic parts	•Focus on generic components: due to rapid technological development, there are many versions and upgrades for same functionality. Generic components ensure compactability of repaired products with changing systems •Repair at the component level, which is better than the subassemblies level (less variety of components, maintain compactability since components are generic, provides better info about cause of failure) •To be responsive in dealing with returned products: fast transportation (no batching), outsource transport to a 3PL (DHL), centralization of high quality repair (no need to send defective products to Japan, cut down lead time and costs), and better communication and info exchange	-	•Products are used in vital systems (e g. medical healthcare), failure of product can interrupt critical processes →must resolve failure quickly

Case & References	RL activities	Type of product	Facilitating factors	Implications	Comment/drivers
13)Wehkamp De Koster and Zuidema (2005)	Managing commercial returns (mainly fashion and hardware)	Short life cycle products (fashion, hardware), and WSS (Wehkamp Supermarket Service) products (consumer goods-food/petfood/detergents, etc.)	•Mechanizing the sorting process by installing a conveyor system to sort returns to the correct workstations (a large volume of similar products are handled more efficiently than groups of different products, (De Koster *et al.*, 2002) •Returns as a source of supply: returned products are used to fill backorders (seasonal products are only delivered twice per season, while returns are received all season long)	-	•Part of Wehkamp's business concept: to make ordering and returning as easy as possible (customer relations and retention) •For any return: twice transport cost and 3 times initial handling cost •Returned goods usually have better quality tan new ones since they are individually inspected
14) Kmart Rogers and Tibben-Lembke (2003)	Managing commercial returns	Consumer goods, electronics, fashion apparel	•Outsourcing reverse logistics activities •Early identification of goods to dispose of •Centralized operations •Information system to evaluate and select disposition alternatives •Use of internet to resell returned merchandise and to better educate customers about products to reduce returns		
15) The Dutch Initiative De Koster *et al.* (2005)	The Dutch network for collecting and processing end-of-life white and brown goods	Large white goods (more than 50% of total weight WEEE flow in Netherlands)	•Combining efforts of producers/ importers of brown and white goods despite competition leads to cost reductions •Disposal fee charged on buyers of new white goods (not on discarded products to avoid owners illegally dumping products at the end of their life)	•Disposal fee is not shared fairly among parties involved in the recovery process (e g. partners in the collection phase do not get enough financial incentives), which leads to "network leaks". •No incentives for producers of white goods to design for ease of recycling	

Case & References	RL activities	Type of product	Facilitating factors	Implications	Comment/drivers
16) The Thessaloniki Initiative (Association of Local Authorities of the Greater Thessaloniki area ALGAT) Panagiotidou and Tagaras (2005)	Reducing land filling of car tyres through a program for collection of used tyres from retailers and retreaders to use them in a more environmentally conscious way	Passenger cars and truck tyres	•Finding an economical and environmentally friendly way to dispose of used tyres that cannot be reused in any other way E.g. to be used as fuel in the cement industry (no change in pollutants produced, and no residual ash from process)	•Collection schedule is done empirically leading to significant delays and accumulation of tyres taking up storage space. •Failure to agree with cement companies upon costs of construction of kilns and transportation costs	•Open loop recovery activity was selected, yet similar difficulties were encountered as those with end-of-life close-loop activities
17) The Industrial town of Kalundorg/ Denmark Ehrenfeld and Gertler (1997)	An industrial ecosystem consisting of four main industries a power station a large oil refinery, a maker of pharmaceuticals and enzymes, and a plasterboard manufacturer	-	•The technical compatibility requirements of different partners in the ecosystem •The identification of the net cost savings for all partners compared to using virgin materials •Having the symbiotic partners in close physical proximity to reduce transportation costs •Although contrary to concepts of pollution reduction, symbiosis functions best when a large amount of waste is produced by involved plants •Regulatory support to make symbiosis economically attractive (e g. through reduction of prices) •Having a cooperative relationship between governments and regulated industries while maintaining a certain degree of flexibility that allows creative arrangements for pollution reduction (as opposed to forcing technology standards which hinder technological innovation)	•The risk involved in the supplier-customer relationship between the symbiosis partners. Each customer is tied to one single supplier which adds costs due to backup supplies. At the same time any upset at the customer's side would force the supplier to dispose of large amounts of by-products /waste to satisfy regulatory requirements •The need for information exchange between partners (about their inputs and outputs), requiring to establish inter-firm trust, which is hard to achieve.	