POLITECNICO
DI TORINO

Master degree Thesis-Ingegneria Gestionale

2 April 2019

Performance measures in reverse supply chain- Implementation of a perfomance measurement system to measure and handle the operations involved in the reverse supply chain activities

Nicola Tesio

Academic year :2018/2019

Student: Nicola Tesio
Supervisor : Elisa Ughetto

Synthesis

The Supply Chain is a system of organizations, people, activities, information, and resources involved in moving a product or service from one point to another in a company. Most of the times when we talk of supply chain we consider the moving from a supplier to a customer. Nevertheless, since the last years the reverse supply chain(RSC), in charge of the moving from customer to supplier, are attracting more and more the attention and considerations in the business world.

Why?

Because the reverse supply chain is not just a series of activities required to retrieve a used product from a customer for disposal or reuse. It represents, in fact, a sustainable profit center in social and environmental terms. During the last years, more and more companies are starting to implement and include it in their strategies, seeing it as a key service for the future.

If we look from a business standpoint, the major reasons to implement the reverse supply chain inside a company are:

- Second return on investment: with the reuse or resold of the used instruments the company generates sources of revenues at high profit, since cost of manufacturing is absent or very low.

- Increase in public perception: the society has grown to accept and embrace protecting the environment as a key value and need of modernity. Nowadays all the environmentally-friendly products or services, like the activities involved in the reverse supply chain, permit to increase the public perception and the brand image.

- Increase in customer satisfaction and loyalty: in terms of customer care, implementing a reverse supply chain offers a service that permits to be more reactive and better satisfy its needs acquiring client loyalty . In addition, looking in terms of profits, some reverse supply chain activities could be easily sold as additional services for product offers.

Having regarded all the reasons above, we can easily understand the great opportunity that I have had to integrate the Reverse Supply Chain Team in bioMérieux and to learn the best practices from them.

During my internship, I have focused my efforts in the definition and proposition of the performance measures because the implementation study of them was at the initial state. I have chosen this subject because they are a tool essential to manage properly the operations and to reach the strategical targets chosen. This in agreement with the famous statement of Peter Drucker, a management consultant, that he said: “It is not possible to manage what you cannot control and you cannot control what you cannot measure!” ((1992) - Managing for the future).

Furthermore during my stage I had the possibility to talk with the supply chain performance dept. in bioMérieux, they gave me an explanation about the steps that they normally use to define

and create a performance measurement system. Therefore, I have been able also start integrating the reverse performance measures in the range of performance measures of the Global Supply Chain.

Therefore, in this thesis will be mixed two aspects: the performance measures and the reverse supply chain. The first one is one of the most known tool to control and manage the operations while the last one is a key service for the future. Finally, we can say that at reader will be given a managerial approach at a key future service.

Acknowledgement

Politecnico di Torino

I want to thank Politecnico di Torino to have allowed me to attend its school and for following me during this year. Furthermore, I want to thank them for the possibility that they give at the student to attend a double degree program.

I want to thank Elisa Ughetto for accepting to be my academic supervisor and for supporting me during the thesis preparation.

bioMérieux

About the thanks for the people in bioMérieux, I want to start with Anne Aguilar, my industrial tutor, for her advices, her patience (mostly for my italian accent) and her knowledges that she transmitted to me. The trust that she gave me from the day 1 has allowed me to grow professionally and personally and it permitted me an easily integration in the team.

Furthemore, I want to thank all the E&S team, that from the first day they made me feel like a part of the group. During the day-by-day operations, It was always a pleasure work with each one of them. Each day was always an occasion to learn something new, it is thanks to them that I will remember this internship as a great experience.

My Family

I want also to thank my family for the economical and moral support that they give me during these years.

Abstract & Resumes

This thesis shows the performance measures with a strong focus on the reverse supply chain. This one is divided in two parts: the first one constituted by the literature review and the last one that shows my case study in bioMérieux.

Questa tesi ha per obiettivo quello di mostrare gli indicatori di performance focalizzandosi su quelli per la reverse supply chain. Sarà divisa in due parti: la prima concentrata sullo studio della bibliografia annessa mentre la seconda sull'analisi del caso pratico fatto a bioMérieux

Ce rapport a pour objectif de montrer les indicateurs de performance avec un focus sur ceux pour la reverse supply chain. Il sera divisé en deux parties : la première sur la revue de la littérature et la deuxième concentrée sur l'analyse du cas pratique fait à bioMérieux.

Table of Contents

1. Introduction

This thesis, as briefly introduced in the preface part, illustrates the performance measures for the reverse supply chain including my practical case in bioMérieux in the final part. Its aim is to introduce, in the first part, the reader at the performance measures world, for then provide a focus on the performance measures for the reverse supply chain.

More in particular, in the chapter 2, there is a brief explanation about bioMérieux Company in order to give at the reader the right context for the case study that will be explained in the chapter 5. Then, in the first part of the chapter 3, the report is providing a general overview about the performance measures in order to introduce the reader at the subject, and in the final part the focus is shifted on the performance measures for the supply chain. This chapter is key as it is giving the right definitions and a good focus on the supply chain. Furthermore, it is essential to properly understand the chapter 4, where a large description on reverse supply chain world is given, from a characteristics and performance measures perspectives. Finally the chapter 5, is dedicated to my case study in bioMérieux .

2. Overview about BioMérieux

The aim of this chapter is to provide a general overview about bioMérieux company and to give an idea of where I have been working during these 6 months internship. The chapter starts presenting the Institut Mérieux and bioMérieux, focusing the attention on the Global Supply Chain GSC) dept. located in Craponne. At last, an explanation about the major project inside this GSC is presented. This final part will be useful to understand the next strategies of GSC and the role of its performance measures.

a. Institut Mérieux

bioMérieux is part of holding named Institut Mérieux (founded in 1897 in Lyon by Marcel Mérieux) whose initial focus was industrial biology to improve medicine and public health across the world. As show the figure 1.a the Institut Mérieux is integrating several companies: ABL Inc. which is infectious disease and oncology research; Mérieux Development, which works with innovation and entrepreneurs whose service really worship patient and cosumer health;Transgene, which is in charge of developing theraputic vaccines and oncolytic viruses to treat diseases like cancer and some other infectious diseases; Mérieux NutriSciences, whose main activity is to prevent health risks that have to do with food consumption and the use of everyday consumer products; and bioMérieux that has its major business in producing diagnostic in vitro reagents, instruments and services.

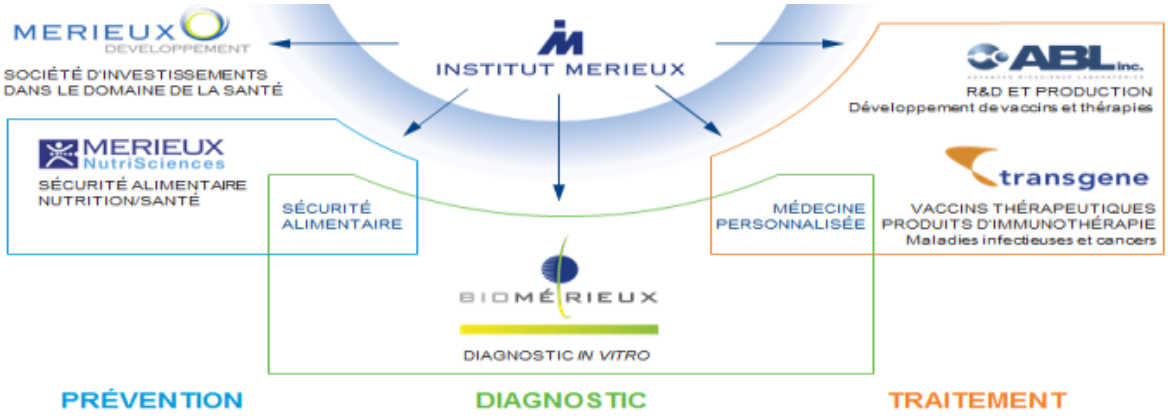


Figure 1.a: illustration of Institut Mérieux holding

b. *BioMérieux Company*

BioMérieux was founded in 1963 by Alain Mérieux, it's a international company presents in more than 160 states with 42 subsidiary and a large network of distributors worlwide, as show by the figure 1.b. The company make the 90 % of turnover abroad (with the 44% in Americas region, 39% in EMEA region and 17% in ASPAC region). Its markets are mostly concentrated in developed countries such Nord America, Europe and Japon. The biggest one is the USA, but since recently bioMérieux is facing increasing demands in emerging countries like Brasil, China, India, Indonesia, Mexico, Russie, and Turkey.

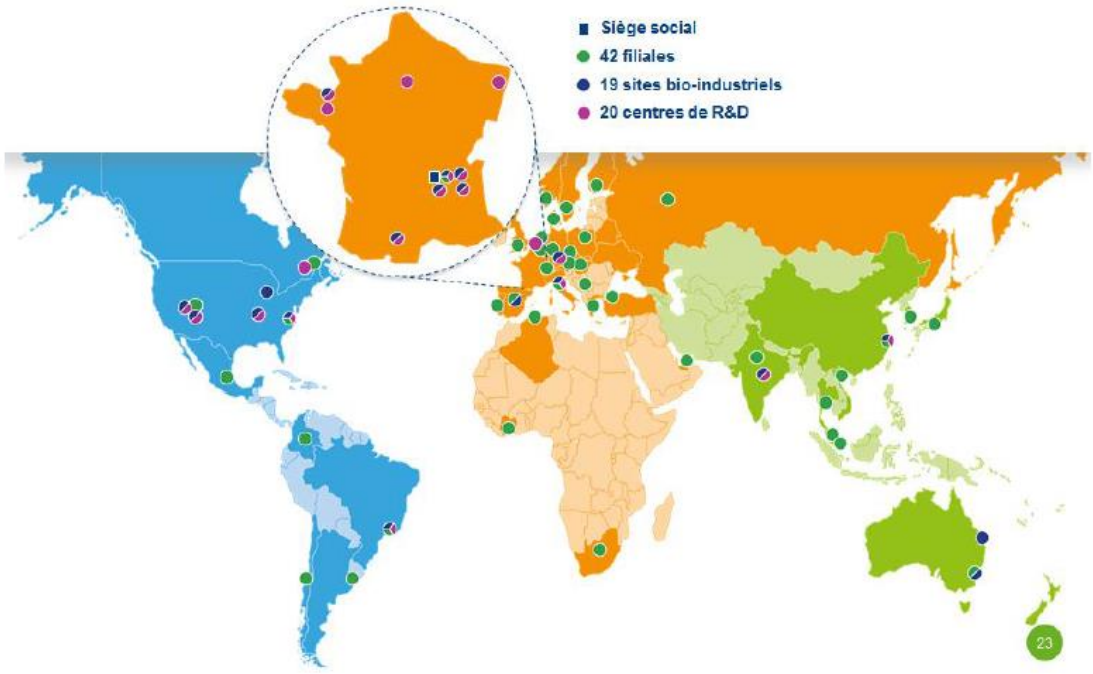


Figure 1.b.:illustration of the bioMérieux over the world

The company is specialized in diagnostic in vitro offering solutions for industrial and medical applications to determinate the origin of a disease or contamination. With a turnover of 2288 billion of euro in 2017, bioMérieux is an international leader in microbiology (42% of the market)

and in industrial application (mostly in agro-alimentary, cosmetic, pharmacy and veterinary). It designs, develops, produces and commercializes system for the 80% in the clinical domain (infectious diseases) and for 20% in the industrial domain (microbiological control). Reagents, instruments and softwares compose the systems and bioMérieux offers, as well, the service client for the installation, the maintenance and the client formation for the use. It has more than 90 000 systems installed worldwide and the sales are increasing more than 10% per year. It has three principal domains where it develops the diagnostic products: microbiology, immunoassays and molecular biology. For each of these domains it sells the instruments with the right reactive and spare parts offering all the services after-sale.

As said, the range of bioMérieux products could be divided in 3 categories: reagent, instrument and spare parts and services. The reagents are addressing several large fields of inVitro Diagnostic markets: microbiology & bacteriology, immunology and molecular biology . The most known reagent is the Petri dish(figure 1.B.2). It's a transparent cylindrical box shallow and covered. It is partially filled with a media to permits the microorganisms culture and growth.

Fig 1.b.2:"Boite de Petri" picture

Depending on the application, the instruments are managing the diagnostic protocols. One of the newest is the VIDAS®3 (figure 1;b.3), it could manage more 100 different parameters (called the menu) and up 36 samples tested per hour. While the spare parts are the parts used to service the instrument for curative or preventive maintenance.

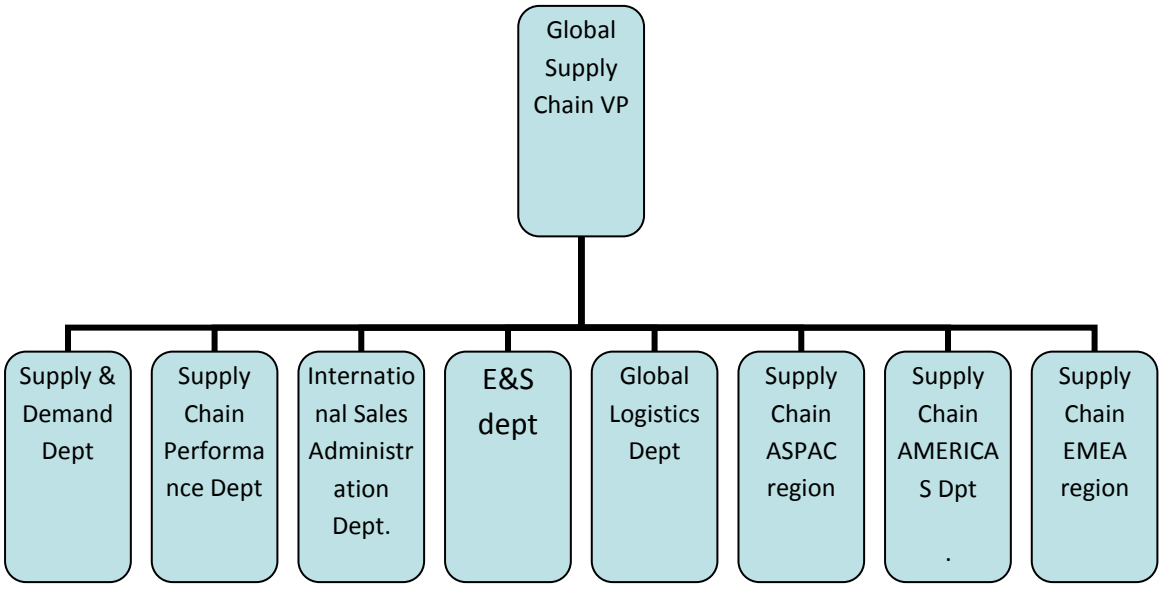
Figure 1.b.3: VIDAS®3 picture

c. *Global Supply Chain organization*

The Global Supply Chain inside bioMérieux is divided in two parts as illustrated in the schema 1.c.1. One part is managed by region and each one is in charge of the demand and distribution management for itself.

The second one is handled at corporate level, located in Craponne, and it composed by four dpt:

- Supply and demand: in charge of the demand and replenishment management of the reagents at worldwide level
- International sales administration: in charge of managing the order coming from the subsidiaries and the distributors.
- Global Logistics; in charge t managing the entire distribution network and the distribution centers.
- Supply Chain Performance: in charge of developing and implementing projects dedicated to Supply chain offer optimization, transformation and enhancement
- Equipment & Spare: in charge of managing all the demand and replenishment of the instruments and spare parts at worldwide level

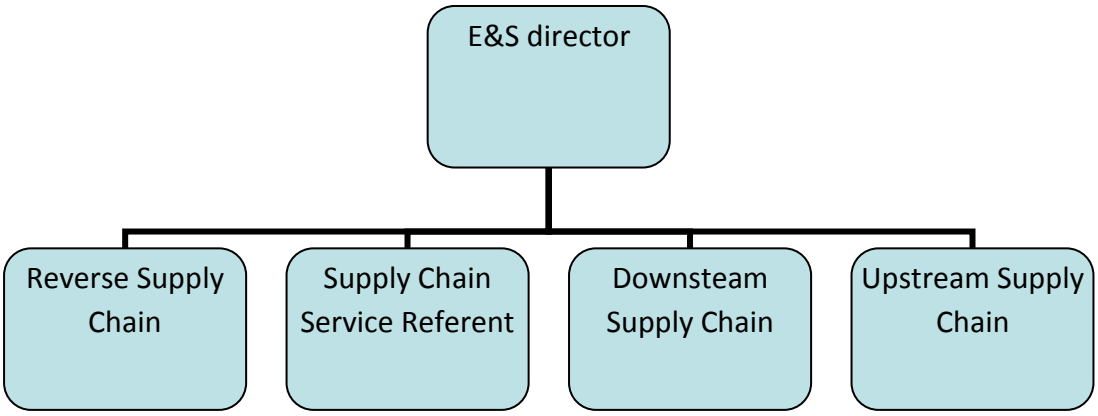


Schema 1.c.1: BioMérieux Global supply chain organizational chart

d. E&S department organization

Since I worked in the reverse supply chain inside the E&S dept, it's important to know its organization(schema 1.c.2), this one is divided in 4 teams:

- The reverse supply chain one, that is in charge of managing all the reverse flows and operations of the instruments and spare parts
- The supply chain service referent one, that is in charge of improving the field action of the supply chain and supporting the lifecycle management of the Equipment and spares from a GSC perspective.
- The downstream supply chain team that is in charge of managing the Field service engineering and subsidiaries inventories
- The upstream supply chain team that is in charge of managing the regional distribution center inventories and the replenishment with the suppliers (internal and external)



Schema 1.c.2: E&S team organizational chart

e. Logistics organization of supply chain

In order to understand properly the following chapters, it is important to have in mind the organization of the supply chain in terms of infrastructures and logistic flows. BioMérieux manufactures its products through its 19 manufacturing sites located in all regions, the inventories of finished goods are centralized in 3 international distribution centers. One of them is based in France (Saint-Vulbas) storing Reagents, equipment and spares while the 2 others are in the USA, one for the reagents (in Louisville) the other one for the equipment and spares.. From the distribution center the goods are sent to subsidiaries and distributors who are distributing the goods to the customers and third party distributors. Only France and Suisse customers are directly served by the French International distribution center. The figure 1.e.1 is indicating the forward flow. About the reverse flow, it's important to know that all of them

need to pass through the International distribution centers for flow consolidation purposes, this is considered as a best practice.

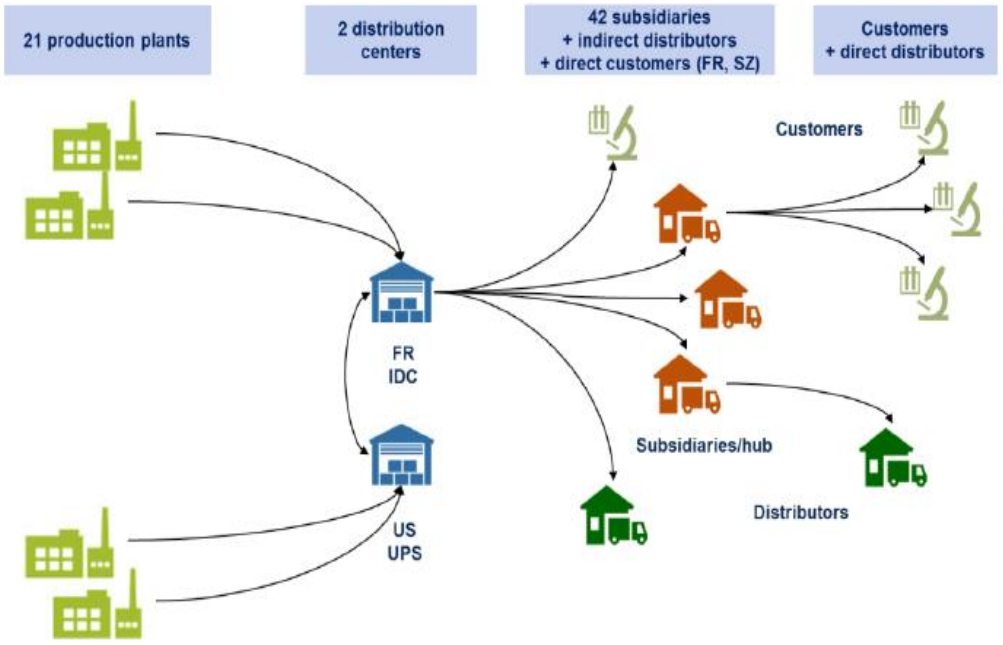


Figure 1.e.1: illustration of logistic flow inside BioMérieux Supply Chain

f. BioMerieux supply chain project- SCORE

The most important program in bioMérieux Global Supply Chain currently is called SCORE (Supply Chain Oriented to Result & Excellence), it's constituted by 20 projects. It has been launched at the end of the SCREEN program (SC Re Engineering), beginning of 2018 as a transformation roadmap for the next 5 years. Its goal is to make, the supply chain inside bioMérieux a competitive advantage and a service to be sold to our end customers. The figure 1.f.1 below explains the three main axes, now the attention is focused on the robustness & traceability, which represents the base for the supply chain offer and the connectivity.

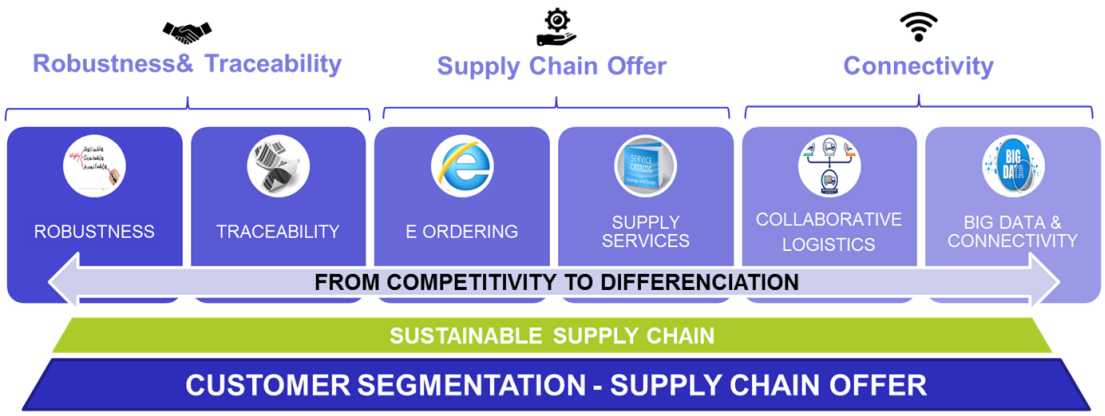


Figure 1.f.1: explanation of project SCORE.

It's important to keep in account this large project mostly in term of performance indicators, considering these ones in the bioMérieux supply chain have to be aligned with the transformation and able to:

- Measure the performance for a continuous growth
- Permit at the supply chain stakeholders to create their own analysis rapports;
- Provide a tool to monitor the operations

3. The performance measures and its aspects

a. Introduction

In this chapter, we will be focusing on one of the two main arguments of my report: the performance measures.

The first part presents in a general overview of the performance measures and the new trends; in the second part, we will review the performance measures for the supply chain based on all the literature and giving some considerations. Finally, in the third part, the attention is focused on the managerial implications for the application of performance measures. This path from the general to particular will permits at the reader to understand the PMs from a global perspective to a supply chain specific point of view.

b. General overview on performance measures

Inside this subchapter, in the first part the reader will have a brief description about the basic concepts that will be used in the following chapters, and after that, a list of the major purposes of a performance measurement system and the new trends.

The performance measures (PMs), also called performance indicators or metrics, permit to measure the performance of an action. To explain the concept of performance, I will use the definition provided by the supply chain performance dept. in bioMérieux. The performance is a concept between the efficacy and efficient ones. The efficacy is the realization percentage of the objective fixed at the beginning of the project or chosen ongoing. Generally an activity is considered efficacy when the output is the same of target one(For instance, in the forward logistic could be the number of clients served in time and with the right quantity). While the efficiency is the ratio between the resources utilized and the results achieved and this one permits to control that the company is using optimally the available resources and that it isn't wasting time and money.

A performance measurement system (PMS) is a set of PMs used for a company or for a specific department of a firm with the aim to provide the the management sufficient information to control the activities of the company, address specific action wherever and whenever needed and take the business decisions. It permits, as well, to keep track of the improvement and the achievement of the targets chosen. Furthermore, it is important to know that the performance measures and metrics are not just measuring the performance but they are also embedded with

emotions, politics and other behavioral issues, and these ones could influence the reading of the metrics results and the overall view on the PMS[1].

When we look at the manager purposes of a PMS, we have (following the list of Gunasekaran and Kobu (2007) [2]):

- Identifying the success
- Identifying if customer needs are met
- Understanding the processes
- Tracking processes
- Enabling processes
- Facilitating a transparent communication and co-operation.

The list above permits to understand how the performance measures inside a company are vital for the strategy formulation and in forming diagnostic control mechanism by measuring actual results. When we look at the history of PM we can see that in the past the traditional business performance measures were mostly financial, while the intangible indicators were often not considered. Since, the attention was more focused in term of costs and revenues. Nevertheless, from the past years the companies started to introduce more performance measures based on the value-added by the activities. This means create a PMS with a vision and orientation longer than before and more focused on the final client than about the financial aspects. Furthermore, with the introduction of innovative PMS, the team metrics prevail over the individual ones and we assist at a reinforcement of the coordination between the different function. While in term of vision, this one is more focused on the continuous improvement than a comparison with the standard performer [2].

The table below reassumes the main differences between the traditional PMS and the innovative one listed above (McCormack et al. (2008) [2]):

Traditional PMS	**Innovative PMS**
Based on cost/efficiency	Based on value
Trade-off between performances	Compatibility of performances
Profit oriented	Client oriented
Short term orientation	Long term orientation
Individual metrics prevail	Team metrics prevail
Functional metrics prevail	Transversal metrics prevail
Comparison with the standard	Monitoring of improvement
Aimed at evaluation	Aimed at evaluation and involvement

Finally, in a performance measurement system the KPIs(key performance indicators) play an important role, these ones represent a set of measures of a PMS focusing on those aspects of organizational performance that are the most critical for the current and future success of the organization. They are chosen from the PMs in relation of the activities or process more critical and essential in term of result. If we want give a definition we can say that while the performance measures tell you what to do, the KPIs tell you what to do to increase performance drastically[3].

c. *Introduction to the types of perfomance indicators for Supply Chain*

After seeing the perfomance measures in a general view, it's time to focus the attention on the ones for the supply chain, but before that, it is important to know the main changes of the latter during the past years and the new role that it's playing inside the companies.

A supply chain is the entire process of making and selling commercial goods, including every stage from the supply of materials and the manufacture of the goods through to their distribution and sale.
Supply chain management (SCM) is the oversight of materials, information, and finances as they move in a process from supplier to manufacturer to wholesaler to retailer to consumer. The three main flows of the supply chain are the product flow, the information flow and the finances flow. SCM involves coordinating and integrating these flows both within and among companies

For an enterprise the supply chain and its coordination have become strategically important and a key factor to be a business best performer, this is proved also by the fact that the focus has shifted from a factory level of management supply chain to an enterprise level. This means that the supply chain has won visibility and has extended its application domain, but in the same time means that it needs to change is previous way to work.

In terms of changes, with the market globalization and the global outsourcing, the businesses are becoming boundaryless and the companies need supply chains more and more integrated. The need of integration is brought also by the changes in the structure itself of the organization and the introduction of new products. Furthermore, with the usage of strategical alliances and shorter product life cycles, the supply chain needs to be more flexible, proactive and able to manage the internal and external integration. In fact the operations need to be in time and properly done if you want the supply chain to be a real service. In terms of support brought by the technology, some tools are already been implemented like the ERPs (enterprise resources planning) to facilitate the operations. With this new type of environment, the collaboration and the use of IT represent the basis and the starting points to bring up a sustainable supply chain. Another important point over the integration and flexibility is the fact that the supply chain is more and more managed from a global standpoint than a local one, so the coordination plays an key role. [1;2].

d. Current literature on the Supply Chain PM

In this subchapter, it represents the literature review about the PMs for the supply chain. It's done viewing all the different types of PMs in relation with the criteria studied. As it will be possible to see, some of considerations about the new trends of the supply chain, done in the chapter 3.c, will be involved.

Here, the list of the different types of criterion [1]:

Key references	**Criteria**
Kaplan and Norton (1997)	Balanced score card perspective
Beamon (1999)	Components of performance measures
Porter(1987)	Location of measures in supply chain links
Gunasekaran et al. (2001)	Decision-making levels
Financial base (Maskell 1989)	Nature of measures
Gunasekaran et al. (2001)	Measurement base
Bagchi (1996)	Traditional vs. modern measures

Balanced score card perspective

The Balanced score card criteria is one of most popular tool, in fact it permits to create a performance measurement system linked with strategy formulation and vision of the company. With this method the performance measures are divided in four perspectives: financial, customers, internal processes, innovation and improvement. For each one of these five perspectives some targets are chosen and they have to fit with the strategy and vision of the enterprise. It's a tool very used because it allows to implement the indicators following four important perspectives of a company remaining in correlation with the mission and the target a corporate level. I have used it for my case study, so a more detailed explanation will be provided in the next chapters.[4]

Components of performance measures

With the criteria of components of performance measures, in 1999 Beamon has given the 4 major group of metrics to keep in account to construct a PMS. He identified: the time, the resource utilization, the output and the flexibility. These four keep in account the characteristic of the new type of environment where the supply chain works (chapter 3.c). In fact, he recognized the need for the supply chain to be reactive in term of time and output, trying to use the minor quantity of resources and remaining in the same time flexible. If we look that from a computationally standpoint, one of the most difficult task is how to measure the flexibility with quantitative metrics and not only with quality ones.

Location of measures in supply chain links

Before the studies of Beamon, Porter and others has developed the criteria of Location of measures in supply chain links to create a PMS. The starting point of this criteria is the fact that we can consider the supply chain as formed by 4 steps ((i) plan; (ii) source; (iii) make; and (iv) deliver) or divided by key-functional activities (inbound and outbound logistics, operations, marketing and sales and service) and support activities (infrastructure, HR, technology, and procurement). In both case it's important to determine the right PM for each activities/steps without forgetting the integration and the coordination between them. These last two are important to keep in account the transversal nature of the supply chain, and to avoid local point of optimal that could affect the general optimal one. In addition, one another reason is to give a PMS to support the development of an integrated and sustainable supply chain.

Decision-making levels

With the criteria of decision-making level is introduced an important subject in term of management and organization inside the company, because the PMs are divided following the strategic standpoint. In fact, in a PMS we need to consider three types of PMs: strategic, tactical and operational ones. It's essential for the achieving of the strategic targets that all the PMs in the different levels are all aligned, and that for each PMs is well defined the level type. This aspect is key in order to avoid communication and management problems. Following this criterion, a PMS should have a pyramid form, where more the level becomes strategic less PMs are used, like in the figure 1.d.1.

Fig 1.d.1: illustration decision-making levels criteria.

Nature of measures

In the Criteria of nature of measures the main aim is to obtain a balanced PMS in term of financial and non-financial measures. In fact, what Maskell found was the fact that many company failed to understand the importance of the integration inside a PMS. In this criterion, the integration inside PMS is seen in terms of financial and non-financial metrics. Because for Maskell, while the financial performances are important for the strategy decisions, the day-to-day control of the operation is better handled with non-financial PMs. When we look at this type of criteria the relation with the making decisions one becomes necessary. In fact if we put in relation these two criteria, we can say that at strategic level the PMs needs to be mostly financial, at tactical level can be both financial and nonfinancial PM while at operational level the performances need to be mostly based on nonfinancial indicators. This relation could be a good

starting point when we want to start to design a PMS, of course the specific features remain an important aspect to keep in account.

Measurement base

With the measurement base, the focus is about two major groups of PMs: quantitative and qualitative. In fact, for a manager, one of the most challenging task is how to determine the qualitative PMs and its relation with the quantitative ones. Because, for example, if a company works in a high variety market the flexibility PM could be necessary, but since it's a qualitative PM should be quantifiable and one of the easiest way is to put in relation to a quantitative PM. This criteria, makes clearer the fact that in a PMS the relation between these two type of PM needs to be well defined and understood by all the stakeholders.

Traditional vs modern measures

Since the fact that the supply chain is different from the one of 15-20 years ago, new types of measures have been introduced to follow the new trends. As already said previously, the traditional measures were often related to financial measures. One of the most used was the Activity-based costing (ABC) method that identifies and assigns costs to overhead activities and then assigns those costs to products. A method with the main aim to control the costs and reduce them. But in the supply chain, since the high level of outsourcing, is a method difficult to use and properly adaptable. So some companies have started to introduce the value based management tool, this one measures the value offered by the company at its shareholder including the outsourcing and the alliances as part of the value offered. Furthermore, another type of measures was the ones related to the process-based approach. Nevertheless, nowadays the application alone it is not appealing, as it will attempt to focus on improving functional areas without taking into account the organization's overall mission and objectives.

Final remarks

As if possible to see, the literature studies the PM following different criteria and categorizes them in base at their different attribute. Each one shows a different way to see the PMs. What it's important to keep in mind is the fact that a PMS should be balanced in terms of types of PMs used and always reengineered to be in line with the characteristics of the company and its strategies.

e. Final overview on the current literature

In this subchapter is shown an interesting final overview about the current literature performed by A. Gunasekaran and B. Kobu.

The literature description above permits to have a global vision about the different type of PM used in the supply chain and to understand the main differences between them. At this point it's interesting the study conducted by A. Gunasekaran and B. Kobu. In fact they have studied the articles about the PMS in supply chain management between the 1995-2004, and they have collected around 80 PMs. After an alphabetical listing of all these measures, it is observed that

while some measures were the same, some others were easily replaceable. At the end of their study they were able to give a list of the most 26 PMs used in the supply chain.

Here, the list of metrics [1]:

1	Accuracy of scheduling
2	Bid Management Cycle time
3	Capacity utilization
4	Compliance of regulations
5	Conform to specifications
6	Delivery reliability
7	Forecasting accuracy
8	Inventory Cost
9	Labor efficiency
10	Lead Time for procurement
11	Lead time manufacturing
12	Obsolescence cost
13	Overhead cost
14	Perceived quality
15	Perceived value of product
16	Process cycle time
17	Product development time
18	Product/service variety
19	Production flexibility
20	Return on investment
21	Selling price
22	Stock out cost
23	Supply Chain response time
24	Transportation cost
25	Valued added
26	Warranty cost

General definition of the PMs in the list:

1. Accuracy of scheduling: ratio between the resources scheduled with the resources utilized.
2. Bid management cycle time: total time to respond to a Request for Quotes with bids reflect customer requirements.
3. Capacity utilization: ratio between the capacity utilized with the capacity available.
4. Compliance of regulations: number of compliance to regulations
5. Conform to specification: ration between the number of products conform over the total products produced
6. Delivery reliability: Ratio of the number of deliveries made without any error (regarding time, place, price, quantity, and/or quality) to the total number of deliveries in a period.

7. Forecasting accuracy: accuracy of forecasts made regarding customer demand for a product(it's computed with different methods
8. Inventory cost: cost per time of products stocked in inventor
9. Labor efficiency: ratio between the actual output of a work and the output expected
10. Lead time for procurement: Total time between the initiation of procurement action and receipt into the supply system of production model(excludes prototype) purchased as the result of such actions. it is composed ot two elements production lead time and administrative lead time
11. Lead time manufacturing: total time required to manufacture an item, including order preparation time, queue time, setup time, run time, move time, inspection time, and put-away time. For make-to-order products, it is the time taken from release of an order to production and shipment. For make-to-stock products, it is the time taken from the release of an order to production and receipt into finished goods inventory.
12. Obsolescence cost: cost of products in inventory that become obsolete before they are sold or used
13. Overhead cost: total expenses associated with running a business that can't be linked to creating or producing a product or service.
14. Perceived quality: customer's perception of the overall quality or superiority of a product or service with respect to its intended purpose, relative to alternatives.
15. Perceived value of product: difference between a prospective customer's evaluation of the benefits and costs of one product when compared with others
16. Process cycle time: total time from the beginning to the end of process.
17. Product development time: total time to develop a product
18. Product/service variety: number of different product/service offered by the company
19. Production flexibility: ability to alter the production when demand varies from forecast.
20. ROI: Return on Investment: ratio of a profit or loss made in a fiscal year expressed in terms of an investment
21. Selling price: price at which the products are sold.
22. Stock out cost: cost associated with the lost opportunity caused by the exhaustion of the inventory.
23. Supply chain response time: time taken by supply chain to rebalance after a change in market demand is noticed.
24. Transportation cost: all the costs related to products transport.
25. Value added: the difference between the price that the product or service is sold at - cost of producing the product.
26. Warranty cost: charge to expense when a product is replaced under a warranty program.

Final remarks

The PMs listed above are the ones most used in the supply chain and for each one, the table in the annex 1 shows their categorization in relation with the criteria shown at the chapter 3.d..

Using that table, we can make further considerations about the PMs for the Supply Chain:

- The PM for internal process(50% of PM) and for customer(50 % of PM) plays an important role in supply chain mostly for the operational performance,
- The most used PMs are financial, this means that in the supply chain we cannot consider the role of cost and revenue aspects, but the non-financial measures are useful for measure the operational performance
- Innovation and process improvement don't still plays a significant role(28%), this means that the companies have still to introduce this type of performance,
- The time and productivity have a significant role, while the resource utilization and flexibility are still not too much consider for the their intangible factors and difficulty in computing.

f. Managerial implication and application of key performance measures

The implementation of PMs does not mean only choose of the right ones for our PMS. Because other aspects are involuntary involved. Inside this last part of the chapter 3, at the reader will be presented the classical issues that can occur when we decide to design a PMS and some important final remarks.

First, when we choose the PMs for a PMS, we need to consider the characteristics of the business itself. It is important to define well the level of each PMs used (if strategic, tactical or operational) in order to avoid organizational problems. It's also important point to verify the way to gather the data for the measures. This one in fact represents one of the major tasks and sometimes there is the need for computerized information systems and the ERP tools as SAP could be helpful [1].

Then another big challenge is to identify the key performance indicators in the PMS. Since they are key to add value at the organization and to understand the factors that affect the core of the business processes.

Maskell(1989)[5] has suggested some pillars when we want design a performance measurement system:

- the PMS should be directly related to firm's strategy;
- nonfinancial measures should be adopted;

- measures should vary between locations (departments or companies);
- measures should change as circumstances do;
- measures should be simple and easy to use;
- measures should provide fast feedback;
- measures should stimulate continuous improvement.

In these pillars we can find some points of the balances scorecard criterion, as the direct relation between the strategy firm and the need to change the metrics in relation with the circumstances.

Finally, another important remarks are that a PMS should: be comparable to other organizations' PMS, have low operating costs, avoid unnecessary double counting and performance measures too much similar between them[1;2].

4. Reverse Supply Chain aspects

a. Introduction

During my internship, I have worked in the reverse supply chain team within the global supply Chain in Craponne and besides I have initiated the design of the Performance measures system for the Reverse activity; I have also managed the coordination step by step between the different depts. involved in a return. I never handled the return with the end customer because the return from the end customer is managed by subs/distributor locally. In any case, this task was helpful because it has permitted me to understand and manage each phases of a return.

About this chapter, I will give an overview about the reverse supply chain activities and aspects and also make a comparison with the traditional supply chain. Finally, I will provide a detailed list of PMs useful for the reverse supply chain that will be used in my case studied in the chapter 5.

b. Weight of the reverse supply chain in the businesses

In this subchapter are given an idea about the weight of the reverse supply chain in the economy and in some businesses, in order to highlight the importance of the reverse supply chain before to enter more inside the technical aspects.

An estimate[6], made by Delaney, says that reverse logistics costs account for a significant portion of U.S. logistics costs, in fact they account for the 10,7 % in 1997. Even if, it's difficult to say the exact amount of reverse logistics activities because most companies do not know how large these are. Looking at the research made by Rogers and Tibben-Lembke[7], for the firms the reverse logistics costs represents approximately four percent of their total logistics costs. Applying this number at the gross domestic product (GDP), Rogers and Tibben-Lembke estimate that the cost of reverse supply chain accounts for a half percent of the total US GDP. And Delaney estimates that logistics costs were $862 billion in 1997. Of course, the importance and impact of reverse logistics in the costs varies by industry and channel position and furthermore it varies depending on the firm's channel choice. In any case, it was already clear with the research

of Rogers and Tibben-Lembke that the overall amount of reverse logistics activities in the economy was large and still growing. More recently, following the data of Tuscorlloyds, in the 2005 the volume of annual return in USA was of 150-200 billion dollars (0,7% of the GDP)[8].

If we look again the research of Rogers and Tibben-Lembke[7], the reverse logistics activities can be critical for some industries. In fact, in the type of industry where the value of the product is important or where the return rate is important, it's spent more efforts in improving the return processes and the activities related because the margins can be higher.

For example, in the auto parts industry, the remanufactured auto parts market is estimated (by the Auto Parts Remanufacturers Association) to be $36 billion. This also because the 90 to 95 percent of all starters and alternators sold for replacement are remanufactured. Furthermore, a conservative estimate says that there are currently 12,000 automobile dismantlers and remanufacturers operating in the United States. The operations involve during the rebuild and the remanufacture have a considerable amount of resources According to the ARPA, about 50 percent of the original starter is recovered in the rebuilding process. This could result in saving several million gallons of crude oil, steel, and other metals. ARPA estimates that raw materials saved by remanufacturing worldwide would fill 155,000 railroad cars annually; or in other term a train of 1,100 miles[7]. With this number we can also understand how the reverse supply chain has an important role in term of social and environmental impact.

c. *Reverse supply chain definition*

Here, in this subchapter are provided some definitions about the reverse supply chain useful to understand the next chapters.

The definition that is done by The Council of Logistics Management for the logistics is :

"The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements".

The Reverse logistics in terms of definition includes all of the activities that are mentioned in the definition above. But the point is that reverse logistics encompasses all of these activities as they operate in reverse. Therefore, reverse logistics is:

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

More in particular, the reverse logistics is the process of moving goods from their typical final destination for the purpose of capturing value, or proper disposal. Here, in this thesis, reverse logistics and reverse supply chain are assumed and used as synonymous.

The operations related to the remanufacture and refurbish processes can be included in the definition of reverse logistics. In fact, the reverse logistics doesn't represent only the reusing containers and recycling packaging materials. While the redesigns of the packaging to use less

material, or the energy and pollution reduction from transportation are one the most important activities but they could be better included in the field of “green” logistics. In fact, we can consider that any movement of goods or materials backwards is involved, the activity probably is not a reverse logistics activity.

In the reverse supply chain are also included the processes of merchandise return due to damage, seasonal inventory, restock, salvage, recalls, and excess inventory. Furthermore, there are also included recycling programs and asset recovery. As it’s possible to see in this subchapter the reverse supply chain involves many activities, later in the text will be given a description more detailed for some of them.

d. Reverse supply chain history

In this subchapter is given a short overview about the reverse supply chain history. Reading this one, the reader will understand the reasons for this presence nowadays.

Looking at the history of the reverse logistics we can see that it has been around us for a long time. In fact, we can consider as the start point of the reverse supply chain the American civil war. There are some literature that consider the history of the reverse supply chain earlier of the American Civil war but the activities concerned weren’t yet well defined or recognized.

Below a little resume of the main steps about the history of the reverse supply chain[9].

1861-1865: As for the logistics one the history of Reverse Logistics begins in the Military field. In fact, at the final stage of the American Civil War, General William T. Sherman realized that the supply chain and the mobility played an important role for the nature of his armies’ campaign and that his operations through hostile territory would be difficult without them. It was in the moment when he had to supply his soldiers on the march that the first reverse logistics activities had been put in place.

1872: from this year the retail industry enters in the reverse supply chain. In fact, the retail returns of today find their births in the customer service policy of Montgomery Ward. The last one, it’s an American furniture shop established in 1872; and they were the first to adopt the philosophy and policy that if the customer is not 100% satisfied, they could bring it back for a full refund.

1942: with the 2WW we assist at the creation of new solutions for the reverse supply chain. In fact it was also in this period that Automotive Aftermarket History born. The shorting of the materials during World War II have created a need to rebuild automobile parts. It’s interesting the fact that this trend is still present nowadays.

Figure 4.d.3: Collecting point of used cars[9].

1984: in this year we assist at the first recall of Successful Product, that increases the massive use and adoption of the reverse supply chain. In fact in 1984, Johnson & Johnson along with McNeil Laboratories quickly responded as America watched on the evening news about the "tainted lot" of Tylenol. McNeil had to respond quickly switching all the failed products with new ones, it was able to do that and this fact brought the need to set new standard for reverse logistics and also the American public understood the need to implement by the companies of good reverse supply chains.

1991-1996: during this period the attention starts to be more focused on the Environmental Impact from Reverse Logistics and we can see also the introduction of laws in this direction. In 1991, The Federal Republic of Germany issued a recycling ordinances in the environmental reverse flow and included mandatory recycling programs. In addition, in these ordinances were inserted prosecution for violators of the ordinances, and some rigid guidelines for the handling and transporting of hazardous materials and also responsibilities for the waste recovering.

With the German ordinances, in the 1996 the United Kingdom legislation indicated the shippers and manufacturers to be responsible for the return and recycling of packing materials. While in the 2002 the European Union establish a goal of 50-65% recovery or recycling of packaging waste. This bring the rest of the world to be compliant if they want to do business with the EU.

1998 to 2000s: in this period the reverse supply chain grows in terms of sophistication and it becomes a strategic business.

If we look at the more recent history, the reverse supply chain started to get attention from the last decade, before its role was seen more as value added. In the 90s the Council of Logistics Management (now the Council of Supply Chain Management Professionals) made two studies about the reverse logistics giving it the right importance. The first one is written by J. R. Stock, that explains how to set up and make the operations for the reverse supply chain. While Rogers & Tibben-Lembke[7] presents an extensive collection of various reverse logistics business statistics data categorized by industry types. Over the two studies listed above there are others

articles focus more on the optimization and management of reverse logistics and about the characteristics of reverse supply chain for the remanufacturing system around the year 2000[8].

e. Two reverse supply chain application

Here a brief description, useful as introduction, of two recent applications of the reverse supply chain. The first one is about the eCommerce while the second one of the aftermarket industry. Both follow the consideration made by Adam Robinson in its article[8]

eCommerce

The use of the reverse supply chain is increased with the rising of eCommerce and the aftermarket. During the last years the eCommerce and the reverse supply chain are grown together. In fact, for the eCommerce the reverse supply chain is a fundamental asset and it represents a requirement. If we look at Amazon, Ebay and also all the other companies that sell online, without the reverse supply chain they couldn't offer a competitive service. In addition, it's important consider the client-orientation of these companies and how the reverse supply chain can be considered a service essential in this direction.

If we think at eCommerce, often the attention is focused on the cycle that ends up with the delivering of goods to a customer. But not all know, that there are many others activities to put in action once the goods are delivered, and it's in this moment that we enter completely in the reverse world. And this world is fundamental and essential to can handle this type of business, in the list below some of the reasons for which a business enters in the reverse world.

Here ones of the most common reasons:

- Returns
- Mis-delivered or Undelivered Goods
- Damaged Goods
- Malfunctioning Goods
- Exchange Programs

Aftermarket Industry

The estimate grow of the U.S. auto aftermarket industry is of 3.4 percent annually through 2016 to $263.8 billion, adding $32.6 billion to the economy. This estimate is made in according to a report produced jointly by the Automotive Aftermarket Industry Association and the Automotive Aftermarket Suppliers Association.

The ordinary logistics flow involves all the steps that happen before the sale and between the sale and the point at which the customer has the product in hand.

The product has to be manufactured and then warehoused in preparation for final shipment, or must be distributed throughout a variety of retail channels or other businesses for position in front of the consumer.

While the reverse logistics for automotive aftermarket product is focused on the return processes, and the reasons are the same of the ones indicated for the eCommerce in the subchapter above. For the automotive aftermarket logistics activities, the reverse supply chain plays an important role. In fact, if there are a problem for a part because a damaged or not useful, it has to be returned. So, the reverse supply chain in the aftermarket industry is involved each time when has to be returned a part to the auto parts store, for example when you have to repair your own car.

So, what is the reason for which we assist a boom of the reverse logistics inside the automotive industry? Mainly for the fact the industry is growing, but also following this quote from AAIA CEO, President, Kathleen Schmatz because: "The forecast model demonstrates that despite strong new vehicle sales, historic high gas prices and a flattening of miles driven, our industry is poised for steady growth. Why? The average age of vehicles is 11.3 years, the oldest ever, and the age mix of vehicles continues to favor older vehicles, creating a robust sweet spot for service and repair."

f. Reverse supply chain per industry

In this subchapter, the reader has an overview of the reverse supply chain for two of the most important industry the computer/electronics and automotive one. This overview follows the consideration made Nandan Kumar in its article[10].

Computer/Electronics Industry

In this industry the items have a shorter product lifecycle than other, and this fact brings some differences in comparison with other industry. As all know, the market of the used PCs has had a boom in whole world, both in developing and developed countries. In terms of numbers Gartner (source: Gartner Inc., "Gartner Says Emerging Markets Could Become Dumping Grounds for Secondary PCs, ") says that: 37 million secondary PCs were refurbished and exported to emerging markets in 2008, and the market research firm predicts that this number will rise to 69 million by 2012. In 2007, nearly 68 million secondary PCs had to be discarded worldwide. In emerging countries, approximately 15 million secondary PCs had to be discarded in 2007. Gartner estimates that by 2012, emerging countries will need to dispose of a total of 30 million secondary PCs annually. These data that refer to 2012 explain how in this type of industry the reverse supply chain plays a fundamental role and it will be more and more important set it.

In the other hand, the reuses of obsolete products is a need that shouldn't be emphasized. Because the building to order can minimize the return chain, in fact it permits at the manufactures to postpone the final transformation of the items and make it able to give at the customer the product that it wants. In addition, with this approach the inventory holding period could really decrease, this point is strongly in contrast with the rest of the industry, in fact they will have typically 30 to 60 days of inventory pre-sold into the channel. Who sell directly at the

client, as the manufacturers and the retailers, with the building to order will have significantly lower return rates than the other in the industry. In terms of numbers, the return rates is around 5%, about half of the rest of the industry. One of the executive interviewed in the research of Rogers & Tibben-Lembke[8] says: “We send out a million computers. Pretty soon, most of them come back.” As said also before this problem is strongly reduced when the building to order model is combined with the direct sales. There are many manufacturers that are developing solutions to this problem with remanufacturing specialists, these work together in order to evaluate the rootcause of returns and so develop solutions to control cost and return rates.

Automotive Industry

One of the largest industries in the world is the automobile industry and it deals with one the most expensive of consumer goods. In this industry the reverse supply chain is an important subject. The reverse supply chain is mainly involved in:

• Salvage of parts and materials from end-of-life vehicles.

• Remanufacturing of used parts.

• Stock-balancing returns of new parts from dealers

In this context, Vehicle Recycling Development Center (VRCD) has been implemented by the big three automakers in the U.S together, in order to can increase the parts recyclable inside the cars. In this program the focus is to build vehicles that can be easily disassembled. In addition, this program is investigating in one of the newest trends in engineering the DFD (design for disassembly). With DFD, product disassembly is made easier by reducing the number of parts, rationalizing the materials trying to reduce the using of chemical bonds or screws. This initiatives are different from others in the manufacturing context because offer to remanufacturing.

In the automotive industry we have the longest history of the reuse of old products. In accord to the Auto Parts Remanufacturers Association (APRA), the remanufactured auto products market is of $34 billion of dollar annually. And the ARPA estimates also that there are in total 12000 firms that make remanufacturing involved in the auto parts industry. One particular company remanufactures more than four million alternators, starters and water pumps every year. Between 90% to 95% of all starters and alternators sold for replacement are remanufactured.

If we look from the automakers point of view, they would like to maintain a closed-loop system of their spare parts. For example, if a vehicle needs a new part, they hope that the client will take the part from a dealer to exchange the old one with new one. So, in this case, the dealer sends the old part to the automaker for remanufacturing, and the last one will have a stable supply of that specific part of the vehicle. For example in the Indian auto and auto spare parts industry the estimated cost of the reverse logistics is around 0.5% to 1% of total sales. And it’s interesting how the reverse logistics segment has been growing at the same rate for both the auto and auto components industries during the same period.

g. *Reverse supply chain per product*

In this subchapter it's illustrated the reverse supply chain from a product standpoint. Two products are considered: the products as items and the packaging.

The reverse supply can include many types of activities, these activities can be divided in this way: whether the goods in the reverse flow are coming from the customer or from any other actor of the distribution channel as a retailer or distribution center, and whether the material in the reverse flow is a product or a packaging material. These two factors help to understand and to provide a basic framework to characterize the reverse logistics activities, also if other important factors could be involved for the classification of the activities. For what concerns the final destination, all products inside the reverse flow must be collected and sorted before being sent at the next step of the chain. Where the products are going to be inserted is a fundamental determinant for the result of the reverse logistics system.

In the table 4.c below[7], there are illustrated the reasons for which a product should enter in the reverse process. Furthermore, the table distinguishes if it enters from a customer or from a supply chain partner. In the case that it enters form a customer, the product could be defective or an unwanted product. There is also another case where the customer thinks that is a defective product where it isn't, in this case the product is called "non-defective defectives". Furthermore, the end users could return the product, when the product has not yet reached its end file, for any type of service(as maintenance) or for a manufacturer call. In the case, where the product has reached its end life, the end user could return the product until the manufacturer for a proper dispose or recycle.

Where in the case that is a supply chain partner that has to return a product, the reasons could be for balancing the stock(for example for excess stock). The reasons for an excess stock could be different, as for a marketing promotion, seasonal sales or because some products are failed. Furthermore, the partner could return a product because it's at end of this life or because it has been damaged in transit.

	Source of Reverse Flow	
	Supply Chain Partners	**End Users**
Products	Stock Balancing Returns Marketing Returns End of Life/Season Transit Damage	Defective/Unwanted Products Warranty Returns Recalls Environmental Disposal Issues
Packaging	Reusable Totes Multi-Trip Packaging Disposal Requirements	Reuse Recycling Disposal Restrictions

Table 4.h: source of reverse flow per product and packaging[7].

If we look at the reusable packaging, in the US its usage is very limited, it is reasonable to say that the majority of reverse activities are related to products and not to packaging. There are exceptions to this perception. A number of domestic firms are beginning to use reusable containers—such as plastic totes and knockdown cages. However this fact depends from the policy of each country, for example European manufacturers are required to take back the packaging for that item. In such an environment, packaging and related materials account for a very significant amount of reverse logistics activities. As more U.S. firms establish a presence in Europe, reusable packaging will become more commonplace.

h. Reverse supply chain as strategic asset

In this subchapter there is a presentation of how the reverse supply chain could be seen as strategic asset for a company. It permits to understand the importance for a firm and how in some cases could be essential. The considerations are made following the researchs and the book of Rogers & Tibben-Lembke[7]

Introduction

When a company has to think about their strategic variables, it has to take in account variables and element that have a long-term impact for their business and for themselves. And these variables will have to response at problems that are more than tactical and operational tasks and actions to takes. Furthermore, these variables have to been taken looking at the sustainability of the business, trying to taking in consideration the viability of the firm.

When we look at the past years, the variables that were strategic for a firm were the marketing and finance ones, and they were considerate as business functions. Only in the 80s, some companies started to consider and view the logistics and its capabilities as a strategic asset, important for the whole firm and for its future. Furthermore, more and more companies have

started to take back material using the supply chain and this operation started to gain more and more weight and consideration. But in these years, we cannot say that the reverse logistics was considered as a strategic variable. Only in the recent years, the consideration for the reverse supply chain grown and now it's considered as important asset and the challenges brought by it are considered as essential.

As said in the chapter related to the history of the reverse supply chain, the 1984 is an important year for the reverse supply chain considering the McNeil Laboratories' case. This is one is emblematic because a division of Johnson & Johnson (McNeil Laboratories) experienced a very serious threat when someone poisoned several people by placing cyanide inside unopened bottles of Tylenol, a Johnson & Johnson flagship product. The interesting fact is that this product was poisoned two times in few years, but while for the first the company wasn't ready for the second time it was. In fact, it deployed a specific reverse logistics process and it was able to cleaned the channel of any possible poisoned product and so saved many lives. This ability to can clean the channel fast and have a structured reverse supply chain permitted at the McNeil Laboratories to have in the following three days record of sales. It's easy to understand the situation without a reverse system to can face quickly the issue, probably the laboratories would have lost a good portion of sales and of brand image. This example of more than 30 years ago permits to understand of the reverse supply chain could have a strategic weight for the firm and the reverse capabilities are an important asset.

Another example useful at the reader to understand how much the reverse logistics is a strategic variable is in the case where the retailers want maintain the product fresh and interesting for a longer time. According with Dan Eisenhuth's quote, the executive vice president for asset recovery at GENC Distribution System, "Retailers used to liquidate to compensate for 'screw-ups.' Today they do it to stay fresh." If we look from a retail store point of view, the most important asset for them is its retail space and it's one of the spaces where they can make the best profits. So, in order to maximize this area per meters square of selling space, the store has to keep visible the fresh food. With this vision the grocery stores, with their modest profits have understood that is important for them to keep only the products that will be sold faster on the shelf. So in this term they should have high inventory turns to avoid spoilage and waste loss and to maximize the return in term of space. It's for these reasons that for the grocery stores, one of the first reclamation center is been implemented and developed in the 70s. they chose to place it where the oldest and the non-selling products would be sent or in other case the reclamation centers were attached to the store. With the time the supermarket chains started to ship the non-used products in one and unique reclamation center for processing, these ones were the embryony of the centralized return centers that will be explained later in the text. So, we can say that the grocery industry gave the idea for one of the most important facility for the reverse supply chain.

Interaction with the forward supply chain

If we continue to look the reverse supply chain in strategic term, this one is also useful for the actors that are in the forward supply chain channel, as the retailers and the wholesalers. In fact, the reverse process can reduce or avoid the risk to buy the items called "hot selling product".

The case of the record company could be helpful to understand this point. In fact, for instance a record company that has deployed a program to control and adjust the return rates for the product considering the variable as the name recognition and the individual recording artist. This type of program permits to create environment that are winning for the producer and the retailers. Furthermore, it's important to consider that from a customer service point of view, the final user will have more a broader selection. In fact, there will be more new artist present. In the case where the record company wouldn't use this program, the retailers will carry and buy only the products that is sure to sell.

In this sense another example about the strategic use of returns is in the electronic distributors business. In fact, during a period where the prices of the memory chip is volatile, they create a program that helps resellers to better control their inventory and balance the stocks in case, for example, of excess stock. In this type of program the resellers can return anything in a reasonable time frame, while customers are encouraged to keep inventory low and purchase in just-in-time and this make able to reduce the cost and improve profits.

Increasing of switching cost

Another point is the fact that reverse logistics could increase the switching costs of changing suppliers and this is an important point in order to have constant selling. Furthermore, almost every company has the target to lock customers that will not switch supplier. To do that there are many ways that permit to create linkages that make difficult and unprofitable for customers switching to competitor. For example, an important service that can be offered at the customers is the fact to take back unsold or defective products quickly and refund them. With this type of service, the company could gain in term of client loyalty and also construct a longer relationship with it.

The retailers must have a strategic vision of reverse capabilities because, If not, they will probably have problems in future. The ones in high-return categories (as toys and electronics) can go out if they haven't a good reverse supply chain. In fact, given the competitive on North America retailers, the contributions provided by good reverse logistics programs play an important role for the firms' overall profitability. For more than one mass merchandiser included in the research made by Rogers and Tibben-Lembke[7], the bottom line impact of good reverse logistics was large. Another large retailer found that 25 percent of the profit of the entire firm was derived from its reverse logistics improvements during its initial phase.

Competitive reason

Some companies in the research made by Rogers and Tibben-Lembke[7] consider the reverse supply chain as a strategic variable in term also of competitive reason. In addition, when the research was made, most of retailers and manufacturers had liberated their return policies in the last years due the competition. With this increase of liberalization of return policies the companies still believed that a customer satisfied was an important asset. Of course, between the returns for damaged unit there were also the returns where the customers return the products if them don't meet their needs also if the products are functioning. Nowadays this type

of pressure about the return policies is spread worldwide also because with the rise of the ecommerce the edge of the business are larger and in whole world.

About the return policy, some firms have begun to take a more aggressive behavior with customers, and have attempted to reduce the number of returns. Because with customer service pressures, it is difficult to make a preemptive step, if other firms operating in the same industry have liberal return policies. In fact if one of the company inside the same industry reduces the power of return policies, it's quite impossible for the others companies to do not flow this trend, they will lose in fact many clients. Some of the retailers are trying to balance their value as marketing tool against the cost of liberate the policies.

In addition, it's important to know that the fact to give policies more and more generous is brought also by the fact that the company want share the risk between the customer and the sellers. There are some cases, where it's the manufacturer that takes all the risks for the products and so the end users can return anything at the retailers and the retailers will do the same with the manufacturer. In any case, also with the liberalization of the policies it's difficult that the manufacturers will take all the risks.

The reverse logistics can have also competitive reason in terms of social impact, in fact there are some companies that use it to help the society and for altruists reason. We can say that sometimes the reserve logistics has a philanthropy goal. Emblematic is the case of Hanna Andersson, a retailer of clothes for infants and toddlers, that developed the program called Hannnadowns. In this program, the customers that sent the clothes back at Hanna Andersson, they had the 20% percent off when they bought new clothes. And the returned products were given and distributed at schools, homeless shelters and other charities. The program in 1996 was very successful, in fact they were collected more than 133,00 garments and accessories.

Another example in this sense, it's the one of Kenneth Cole Productions, a shoe manufacturer, that forced the customers to return their old shoes and they had a 20% of discount for the new shoes. As for the Hanna Andersson case, the shoes returned were given at homeless or anyone needed them.

Also Nike encouraged the consumers to give back the shoes used. In fact, Nike with them constructed basketball courts and running tracks. It didn't give customers discount, like the two cases above, but it reused the material and donates the funds to maintain the constructions made.

In any case, it's important to know that the three projects above have an altruistic side but also there are a marketing incentive for the product selling. Furthermore, in these examples are using the reverse supply chain as a strategic asset. For what concerns the social impact, they help the people in poverty to improve their situation, improving in general the welfare of the community. This fact gives them a good brand image and brought also an increasing in term of sale. While, with the return policies more generous, they incentive the customers to buy, so it acts as a marketing tool.

Cleaning of the channel

Another strategic aspect of the reverse logistics is the cleaning of the channel. In fact, it permits to clean the customer inventories and permits at them to buy and purchase new goods. For the example in the automotive industry, the auto companies to clean the channel of the dealers they have liberalized the return policies. With this liberation they can get back components from the dealers. And in the case where the dealers give back a new component the auto companies give an important return allowance. In addition, it's important to know that for most of them the capital spent in inventory represents an important effort, so with this program the auto companies can reduce the credit-line constraint and also indirectly improve the customer satisfaction. Furthermore, at the dealers permit to have always a fresh inventory and can ask better price and so better protect the margins. Of course to do that, it's important to develop and build a good reverse network to can handle properly the operations.

Dispose issue

The reverse supply chain is also strategic in terms of disposal issues. In fact, the disposing of non-salvageable materials is becoming more difficult since the increasing of the landfill fees and the option for disposal the dangerous material decreases. A firm has to act very carefully with certain type of products if it doesn't want have problem with the authority. In order to reduce possible problems is better set a good reverse process for this type of products, without it the operations could be done in a chaotic way and the product not dispose properly.

Recapture Value and Recover Assets

In terms of recapture of value and recover the assets, the reverse supply chain can be strategic and fundamental to make a second profit over the used products. The asset recovery program could represent a good way to improve the profitability of the entire firm. In fact, the products that the company discarded now can resell or reuse gaining profit for a second time.

Challenges in reverse

When we look the challenges in the reverse supply chan, we can see that one is brought by the difference in the objectives of manufacturers and retailers. For Caly Valstad, Seras, Rorbuck and Co. the distance of objective between them on many issues seem like a chasm, as shown in the figure 4.h below[7].

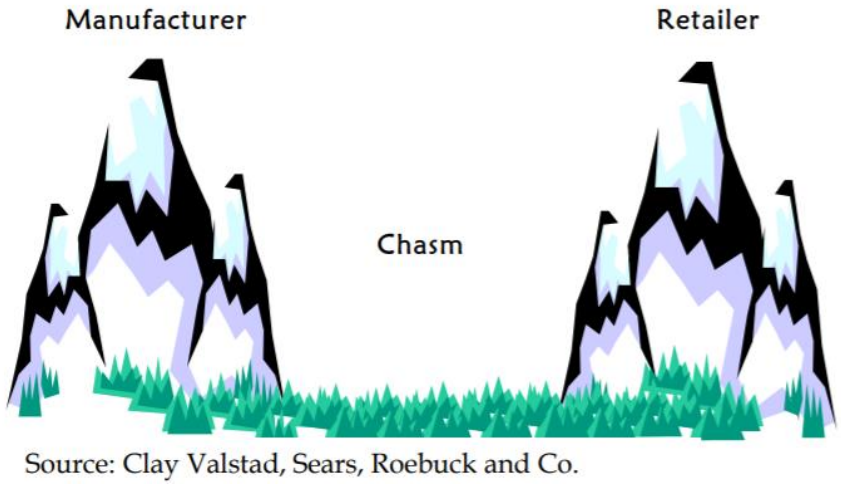


Figure 4.h: Chasm between manufacturer and retailer. Source: Clay Valstad, Sears, Roebuck and Co.

When a retailer wants or need to return an item, the first one and the manufacturer could be disagreed on one or more of the following reasons:

- Actual condition of the item
- Residual Value of the item
- Timeliness of response

Often, if we look from the retailer's perspective, the damages over a product occur because there is a manufacturing problem or during the transit. While from the manufacturer side, the returns made by retailers are because they make not good planning or because are themselves to damage the products. And also, during the dealing of the value could occur some problems. The retailers will ask for a value higher than the manufacturer one. This type of problem is quite difficult to resolve, one of the better to face this problem is to determine before the price. In any case, this solution is not exhaustive.

As said also before, the return to manufacturer could be seen by the retailer as a method to avoid excess stock and better balance the inventories. The manufacturer can from its side slowly accord a return, for delay the return in another accounting period or in other case because it doesn't refund it of the full price.

Other challenge for the manufacturer is the fact that the retailers could ask for a refund from an invoice that is not the same of the goods that have been returned.

In conclusion, the best solution for both parts is the cooperation. They can develop a solid partnership and try to derive a mutual benefit. Each one is essential for the other one, to live they have to live together. And it's also important to take in account that for both parts the inefficiencies will create problem for both parts.

i. Centralized return center

A single subchapter is dedicated at the centralized return centers that are the most common facilities in charge of handle the returns quickly and efficiently. This type of facility has been utilized for many years, but only in the last years it has become more popular and the most part of companies (retailers and manufacturers) have decided to build one in order to can manage and process returns in a more efficient way. The consideration done in this subchapter are made following the book and the research of Rogers and Tibben-Lembke[7]

In this type of centralized system, all products involved in the reverse supply chain pipeline are brought to this central facility, where they are sorted, processed, and then shipped to their next destinations. With this system we can have the benefits of creating more volume for each reverse flow customers, that often leads to higher revenues for the returned items. In addition, the firm can maximize its return on the items, thank to sortation specialists that are able to develop expertise in some areas and can efficiently help to find the best destination of each product.

Normally, the centralized return centers work in this following way. The retailers or the end users(less probable) send products back to one or more centralized return centers. More the retailers are large in terms of market and probable they will have more than one CRC, for instance, following the data of Rogers and Tibben-Lembke research, Kmart Corporation has four CRCs in its system, and Sears, Roebuck and Company has three. Anyway, then the CRC accumulates the returned products for processing and for each of them the CRC will make a decision about the appropriate disposition for the product, based on guidelines set by the retailer and manufacturers

The sortation step inside the CRC is considered one the most important activities. During this step of the process, the people in charge make decisions about whether the product can be resold or if it has to be scrapped, it could be considered as a gate-keeping operation. Of course, the determination of the best channel for dispositioning of the product is of critical importance if we look at the maximation of revenue from the products in the reverse logistics pipeline.

Based on the research interviews handled by Rogers and Tibben-Lembke , the centralized return centers are an important part of a reverse logistics management strategy. In fact, these centers put and impose order on the reverse flow and permits to better introduce and implement processes. Normally, they are associated with information system improvement. In fact, in order to use in the right way a CRC, a firm must have some sort of reverse logistics system in place(like an WMS). In almost every instance, research respondents said that centralized return centers had a positive impact on the operations hold. In one case, a large company said that the combination of implementing centralized return centers, moving to an asset recovery program, and improving its reverse logistics information systems improved the corporate bottom line by 25 percent. So we can see how a CRC can play an important role also in terms of profit.

If we look at the amount of product that a network of CRCs processes for the large retailers, we can see that this amount is really important. For example, one retailer included in the research

handle over $800 million of product through its network of CRCs in the 1997. With this data we can understand another time the importance to implement a CRC.

These return centers permit also to simplify in-store processes. In fact, they permit to have disposition decision more uniform along the chain of stores for many reasons. Also because the employees working the customer service desk may be not properly trained because new or because they don't know that specific type of return.

If we look in term of consistency, a CRC permits to handle the process in a better way because they are more standardized. With the standardization the errors are found easier and avoided, furthermore the knowledge is better spread with a CRC.

If we look at the space utilization, of course a CRC can be strategic because normally the retailer stores don't have sufficient space. And a retailer can use the space saved as a space for the selling. In fact, in terms of space it will lose profit per space, it represents a trade-off to take in account.

While in terms of labor saving, in a CRC an employ properly trained can do more in less time, because it repeats during a day many times the same operations and a retailer reduces the time to process a return. We can say that with a CRC some learning and specialization economies occur.

In terms of transportation cost, this one decline due to consolidation. With a CRC model, a retailer or manufacturer can utilize "milk runs" to pick up returned goods and in this way economies of scale are involved. A company can move more pallets and so consolidate the transports in a better way. A negative point for a CRC is the fact that the transportation cost increase because all the products have to be send at the CRC. And in the case where the products have to bee thrown away, this represents an important waste of money and lost in profit, because they cannot be resold and they have been moved towards the CRC. This negative fact could be reduced if the retailer store doesn't process the merchandise that would be surely thrown away.

Another positive point to implement a CRC, for a manufacturer, is the fact that it can improve the performance in terms of customer service. Because we can assist an improve in term of treat time of the return, for example the return authorization material (RMA) will be made faster. And with the consolidation a return, the manufacturer can see the different return trends and the fact to well done thee reverse process can be a good way to improve the loyalty of the final client, because the time to treat the returns and refund will be faster. In general, the disposition cycle time is reduced.

Of course, if a firm establish a CRC, this one is a commitment from the firm about the fact that it wants include in its strategic asset the reverse supply chain. In fact, it means that someone at the top level wants that thee return are good handled and made.

The centralized return centers permit to have a more performant service. Also, because if it's not presented the retailers accumulate the products in the store, and they will send the product back in a infrequent and chaotic way. In addition, In a classical distribution center the returns

wouldn't be handled as priority so the problem would augment. Furthermore, this type of inefficiency brings at an important loss of value, because the products stay for a longer time no processed. So, the retailers would receive less credit from the manufacturer and could be start to think to change it.

Working with a CRC has also the advantage to find faster and easier the problems of quality inside the product flow in the reverse supply chain. In fact, in the research made by Rogers and Tibben-Lembke, many firms say that with a CRC and an IT system process to match the returned merchandised they can increase the quality of their products and also reduce the number of returns. Emblematic is the experience of a major retailer that had large lots of dehumidifiers that arrive at CRC. So, the manufacturer calls an engineer to solve the problem, and the engineer easily fix the issue. How we can see, thanks to the CRC that easily manages the information, the problem was easily fixed avoiding much greater expense to all the members of the supply chain.

Furthermore, tracking the return authorizations a firm can follows the data and lists all the return reasons. With the consolidation is easier find a problem on a product and so it's possible to fix the problems faster. While In the electronic industry, a large number of returns are not defective. They can consider as non-defective defective products. With the CRC, the manufacturer and the retailer can work together to find a solution to reduce the non-defective defectives returns.

Interaction between the forward and the backward supply chains in the CRC

In the research conducted by Rogers and Tibben-Lembke, large part of the firm believes that a distribution center doesn't work well if inside it is present the backward and the forward flow. There are many DCs that are able to well process the forward flow but if they add also the reverse operations, they have difficulties to handle the operations. This problem is brought principally by the focus on the actual capability. In fact, normally the forward supply chain is seen a primary asset and it's also handled more efficiently, a distribution center manager will focus always its attention in the forward flow, the reverse supply will be done in a second time. With this type of vision, the reverse supply chain will never be an important asset. Either in terms of responsibility; the forward distribution management is the top priority of a distribution center.

In the research the respondents say that when one distribution center handles both forward and reverse shipments the cycle time processing is negatively affected. For example, if a distribution centers have limited number of dock doors and dock space, the arrives of products tend to be no good handled and we assist at the postposition of the processing of that materials. it's for this problem that several firms assume specialists to try to better handle these two-opposite flow. But in the same time, for the executives is difficult to justify the expense related at the construction and staffing of a building to handle failures. Because it's important to know that the returned products are often seen as a failure inside the company.

The fact to distinguish and doesn't mix the two flow is more efficient also for the employees. In fact, this separation permits to have learning economies, the employees that are concentrating

only the reverse processes will handle better them. Also, because they will not be distracted by the activities of the traditional supply chain.

The last point to keep in mind for the CRC is the accounting problem. In a CRC, the information system should perfectly interact with the accounting system and the others in order to avoid possible problems. Of course, in the CRC the operations have to be well done. So, when a CRC has to be implemented is also important to keep in mind to fit the different systems involved.

j. Reverse supply chain activities

In general, the reverse supply chain could involve many activities on a product, in the table below are indicated the major ones (Rogers et al. 1998[11]):

material	Reverse logistics activities
products	Resell
	Return to supplier
	Sell Via Outlet
	Salvage
	Recondition
	Refurbish
	Remanufacture
	Reclaim Materials
	Recycle
	Landfill

The most common reverse logistics activities are the processes a company uses to collect used, damaged, unwanted (stock balancing returns), or outdated products, as well as packaging and shipping materials from the end-user or the reseller.

When the product is come back at the company, the product can be returned to the supplier for a full refund, or if the product has not been used, it may be resold to a different customer, or it may be sold through an outlet store. Or in the last case, it could be sold to a salvage company to export it to a foreign market.

If the product cannot be sold “as is,” or the selling price could be increase by reconditioning, refurbishing or remanufacturing the product, the company could perform these activities before

selling the product. In the case that the company doesn't perform these activities in-house, a third party be reclaimed, and any other recyclable materials will be removed before send the remainder to a landfill.

About the materials packaging, in the most of the cases, is returned to a company and it will be reused. Of course, reusable totes and pallets will be used many times before disposal. In the case that the totes and pallets are damaged, they could be recovered for a second use. This type of actives could be done in-house or by a supplier. In Europe, by law the companies are to take back transport packaging used for their products. To reduce costs, firms attempt to reuse as much of these materials as possible, and reclaim the materials when they can no longer be reused

Furthermore, the reverse supply chain is in charge of services as [12]:

- Gate keeping: it consists the screening of defective and unwanted returned merchandise and it's done at the beginning of the reverse logistics process. With it we determine which products allow in the reverse logistics system. If the gate screening is managed properly, it will translate into a control and a decrease of the return rate and avoid unnecessary cost by screening unwanted returned merchandise

- Sorting and Storing:refers to deciding what to do with each product by segregating into categories that will be processed, sold, or disposed. It is a crucial step in the reverse logistics process because employees make decisions on what ultimately happens to the returned product.

- Asset recovery: it consists in the classification and disposition of returned goods as surplus, obsolete, scrap, waste and excess material products, it objective is to recover as much of the economic and ecological value is possible, reducing the quantity of waste. The action that a company could take in asset recovery is: repair, remanufacture, refurbish, recycle, retrieve and dispose.

- Transportation: it consists in the movement of goods from one node to another within the reverse logistics network. It represents the largest reverse cost, often 25 per cent or more of the total cost.

If we look at my internship, I managed the return to supplier, the refurbishment, and the reclaim materials coordinating all the process and the department involved from the return request by the subsidiaries until the end of the operations.

k. Difference between the forward supply chain and the reverse supply chain.

As it is possible to see in the figure 4.k.1 and 4.k.2, the reverse supply chain is the workflow invers at the forward one. In fact, it could involve the flow from the customer site until the initial center of manufacturing, if the products are not scrapped or sold before. Nevertheless, this logistic difference is not the only one, and this subchapter has the aim to look into the main

differences between these two supply chains with a final part reserved to the advantages brought by reverse activities.

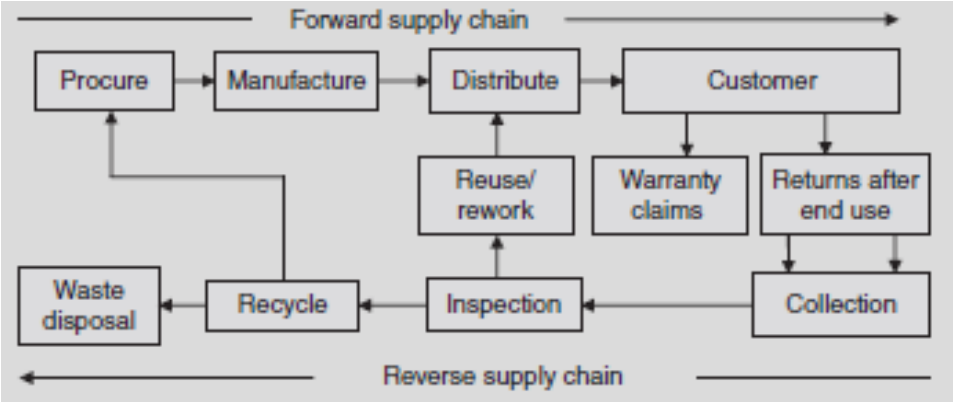


Fig 4.k.1: illustration of the different workflow between the forward and reverse supply chain[13]

Figure 1 Forward logistics information flow for retail

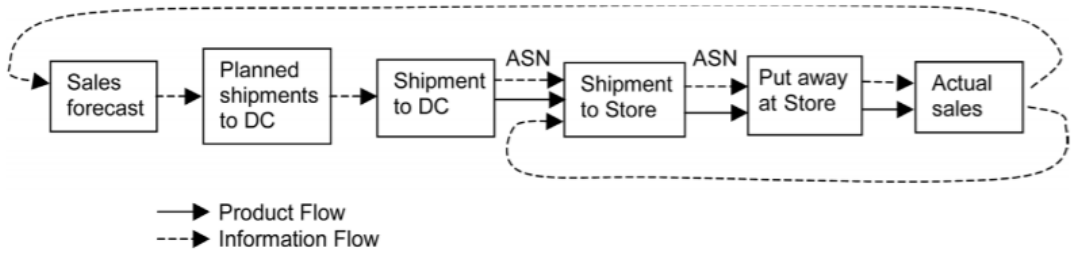
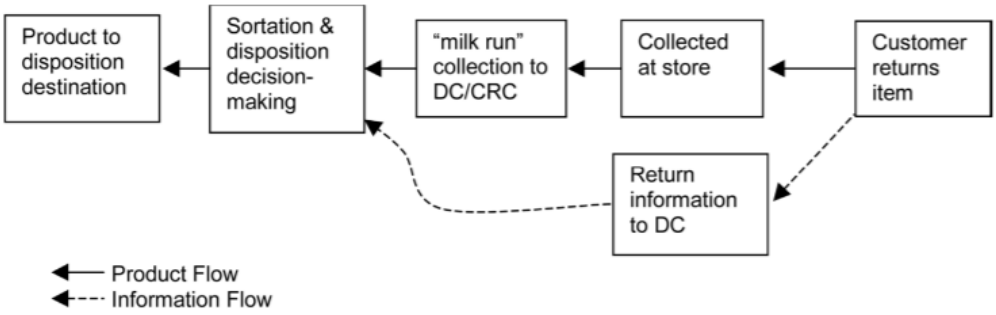


Figure 2 Reverse logistics information flow for retail



4.k.2: information flow for retail in terms of forward and reverse logistics[14]

Over the logistic standpoint, the other differences are principally brought by the products managed and by the fact that the reverse supply chain is less developed than the forward one. Below are indicated the major ones and the problems to face when we choose to implement the reverse activities, some of which I have had also the possibility to note in bioMérieux [14].

Supply chain position

The position within the supply chain is an important variable when we look at the reverse supply chain inside an enterprise. Because often this one drives the size and scope of the reverse logistics problems that the firm has to face. Generally, more the firm is closed to the end consumer and the size and scope of the reverse logistics issues will be greater. In fact, if we take the case of the retailers, they work with customers directly and they have typically a larger volume of deal with the end users than suppliers.

Collecting the returned material from the retail store, the retailer provides the vendor with larger shipment of returned merchandise. The vendor has different problems to face in comparison with the retailer. Normally the retailer receives smaller shipments with different items inside on a daily basis. While the vendor receives batch larger and more in a monthly basis. Another point is that the vendor can deal better price for their second-hand products, in fact the brokers prefer deal with larger batch, so the retailer cannot provide the products at the same price of the vendor one. A retailer would typically contract with a third party to remanufacture product, so it wants to externalize the task. While since the vendor deals in much larger volumes, it may be economically feasible for the vendor to remanufacture in-house and maintain the operation internally. In addition, the fact to maintain the task internally is enforced in the case where it's vendor that produces the item, in fact it will be even more likely to have the skills and equipment necessary to remanufacture the product itself. For what concerns the reselling of the products, the vendor can be in a better position than a retailer. Because in the case where a retailer doesn't sell a product the vendor could give it at another retailer that has a better experience and higher demand for that specific product. For the disposition of the product the vendor could have some advantages over the retailer, because it can give at the retailer only a part of the refund and it may or may not require to send the product back to itself. But in any case, the amount recovered for both is typically not large. It's for this reason that some vendors have evaluate the policy of zero-returns. Where the retailers are credited for the customers returns but the products are never returned physically at the vendor. The retailers will dispose the products inside their facilities, following the vendor's instruction.

Another important point is the fact that vendors have spent money to build the right image of their products in the mind of the costumers. And maybe these ones don't want that their products appear in any sales locations when damaged. So, for some of them the solution is that the vendor sells to the broker and this one has to guarantee that the products will be treated following a certain deal. While, when we want to look a situation between a manufacturer and a supplier: the most likely situation where a manufacturer would return a product to its supplier is when it discovers during manufacturing that a component or material supplied by the firm is defective. In this case, the supplier wants replace the product or refund the manufacturer. And depending form the different return policies, the manufacturer has to face a set of decisions: send back the material to the vendor; rework the material; sell or recycle it. In conclusion, the best solution, as for the forward logistics is try to find agreement and to coordinate all the actors of the supply chain.

Difficult to Forecast

One of the major differences between these two types of supply chain is the forecasting. In fact forecasting demand for reverse activity is often more difficult than for the forward supply chain as most of the time the end customer initiates the process. But when Reverse team has access to robust data in terms of installed base, it's then possible to manage better this problem. However, in any case forecasting is still more difficult than for the forward flow, and it's also for this reason that the reverse supply chain is more reactive than proactive.

Many to one transportation point

Another difference is related to the logistic flow, because while the forward is generally the movement of product between from one origin to many destinations, the reverse movement of the product is the opposite, from many to one. This fact could create problems since normally the pick-up is done by the same firms that manage the forward logistics so the coordination and the planning of these two different flows is an issue to take in account. It is for this reason also that some companies decide to manage separately the two flows.

Product and packaging quality

The first quality products leave the distribution center with the complete packaging, which protects them during the operations. This permits also to be easily handled, the new products could be palletized, stacked and storage easily. By contrast, most of the products in the reverse flow may not have complete packaging, and even if the products is properly in his packaging, the shipping returned product is more difficult because the shipping of the new units is sent in large quantities. A large number of boxes going to a particular destination allow pallets to be stacked more efficiently occupying less space. The result is that the majority of the pallets arriving at the return centers consist of unorganized pallets and in small quantities.

Pricing not uniform and cannibalization

Because new product is of uniform quality, the price that a consumer would be willing to pay for it might be expected to be uniform. While for the second market product, the price is not uniform and it's difficult to understand when a product with that price will be attractive or no. Furthermore, another aspect related to the price, it's that the second market products, since their lower price could cannibalize the sales of the new products when the same company sell both.

Destination/routing not clear

When a product reaches a CRC from a store, the next destinations can be unclear. And we can say the same about the forward distribution, when the product reaches a DC, it will stay there until a decision is chose to which customer the item should be sent. But an important difference remain about how the next stop for the item is determined. In fact when a new product is at a forward DC, it's known that this product will be eventually sent to another DC's customers. And it will be the customer needs that will determine which customer and when. Anyway, in the for make-to-order environments, cross-dock operations, and urgent shipments (in a make-to-stock

environment), the name and location of the destination of the inbound shipment are known at the time the product arrives at the facility. While in a reverse logistics facility could have the need to spend significant amount of time determining where a particular item will be shipped

Disposition options not clear

The disposition decision have a crucial role for the success of the reverse logistics. In any case, the CRC have to identify, before that a disposition decision can be made, the possible destinations for the product. And in addition, any restriction by the manufactures has to be included in the decision made by the CRC. Some of the vendors will require certain products to be ‘‘demarked’’, that is, all traces of the vendor’s identity must be removed from the product before it can be re-sold. Some vendors could permit this demarking to be performed by approved brokers. In addition, the vendor may allow sales to some brokers only if the retailer performs the demarking, and may forbid outright sales to other brokers. By contrast, in forward logistics, the potential customers is udes to made any type of screening.

Different importance of speed

In the forward supply chain, the fulfill of the customer orders quickly is important in order to can keep high the customer satisfaction. In fact, if the customer is not served in time, additional costs could occur also if in a indirect way. In the classical logistics, the cost of penalty could be see later in the time, for example with a reduction in the future orders. While sometimes, for example for the ecommerce retailers the penalty cost is paid immediately. For the reverse supply chain, it’s the broker the last step for the product looking from a retailer’s standpoint. Also if, there are any placed orders by the brokers for these products. The value of product is likely to decline more the product stays at the CRC and in addition the probability to damage increases. For the seasonal products, if the season passes the product could worth less and it will lose its value. Also, for the technological products the losing in term of value is more considerable, because they have a shorter lifecycle and so a quick reselling is important to can recover much value possible.

Inventory management

Another difference is related to the inventory management because the assumption of tradition methods aren’t applicable for the reverse. In fact, for instance, the traditional economic order quantity and reorder point require some supply chain information (mean and standard deviation demand), that unfortunately in the reverse is very difficult to have, in fact the arrival of the product in reverse tends to be random and it doesn’t follow any type of trends.

Product lifecycle issues more complex

The product lifecycle in the reverse logistic represents a more difficult aspect to manage than in forward one in fact the product as it passes through the stages of its lifecycle the value of the secondary market changes drastically in term of price and demand so it's important to take preventive actions to avoid rupture in term of stock.

Visibility of entire process

The forward supply chain is more tracked than the reverse one, because the latter normally has a lower priority for the firms and the IS resources necessary to improve it generally are not available. This brings to a lack of visibility that makes the short term operational planning more difficult.

Difficulties in terms of marketing operations

The marketing operations involved for the new products can be more difficult to implement for the new products. For example, some restrictions for the reverse logistics are also brought by the vendors who believes in the market cannibalization. In fact, some of them think that the increase in the sales of their products reconditioned or remanufactured can only increase at the expense of sales of new products. This also for the reason that the new products are more profitable. One way to increase customer interests in this items is to reduce drastically the price. For some products, remanufacturing may have additional appeal for environmental reasons, for example for the starters and alternators, a very percentage of aftermarket sales are remanufactured items. Another point that make the marketing more difficult for the reverse supply chain is the uncertainty of the supply. The client will rely on the retailer that supply it with that second-hand product. The sporadic nature itself of the arrival of reverse flow makes this difficult.

Differences in nature and visibility of costs

As it's shown in the figure 4.k.3, the costs in the reverse supply chain and in the traditional one can be different and some of the best practices for the traditional supply chain doesn't work for the reverse one. The accounting system used normally takes care of the different steps of a product when it moves in the forward channel. But most of the companies are not specialized to manage the amount of detailed derived when a product moves backwards. Below are explained the main differences in term of costs between the two supply chain.

Cost	Comparison with forward logistics
Transportation	Greater
Inventory holding cost	Lower
Shrinkage (theft)	Much lower
Obsolescence	May be higher
Collection	Much higher – less standardized
Sorting, quality diagnosis	Much greater
Handling	Much higher
Refurbishment/repackaging	Significant for RL, non-existent for forward
Change from book value	Significant for RL, non-existent for forward

Figure 4.k.3: comparison in terms of cost between the forward and the reverse logistics[14].

Of course, a new product is not subject to refurbishment or repackaging, while for returned products could be necessary a simple reworking as a pressing or a repackaging. The operations for an used products could be higher than for a new products, but in any case the incremental cost of the reused products could still be lower than make a new one. When we look at the forward supply chain, one of the most important factor to take in account is the cost to placing an order if we want to determine the dimension of the batch and how much frequently we have to place an order. While in the reverse logistics this one is not a real problem because are the transportation costs, in fact it has the major cost associated with collecting returned product from a location. The forward supply chain has costs smaller because the reverse trips for the shipment are generally smaller. For example, a store may receive full truckloads of new product inbound each week, but return only one or two pallets of reverse material in that same amount of time. In addition, if a truck has to make more stops, it's not possible to maximize the cube utilization in the same way that is done with the forward supply chain. Furthermore, the creation of standardized pallets is difficult to have because the variability of the product is higher, the result is that some retailers send individual pallets at the distribution center. Also, for what concerns barcodes and other types of labels for identify the items, many retailers don't use them and this fact could bring differences in packaging and missing packages. Either during the shipments is important to keep physically separated the goods of the retailers because if not it would be a problem to credit them. It easily to understand that with all these constraints the maximation of the space inside a truck becomes really hard and difficult to solve. Furthermore, the fact to handle smaller volume of shipments mean also that there is more important handling cost and also significant difference of cost in the additional labor necessary to identify the disposition of each product. For what concerns the inventory costs is really difficult to say if they are lower or higher. Because the holding cost traditionally are calculated considering the value of the product, and in the reverse supply chain normally the products have a residual value. In any case, this method to compute the holding cost fails because a product inside the reverse channel could have been damaged during the handling or maybe not repackaged properly and all these aspects have to be considered. In addition, when we have to evaluate the second-hand product value is important to take in account the obsolescence and seasonality and also the fact that from the product is purchased until it arrives at the return center can be passed a lot of time. This last point is really important for example if we look at the technological products that

has a shorter life and that lose the value fast in the time. Also, in the case of seasonal product the value decreases and the end of the season, and for example if the reverse process is not fast enough maybe the season can pass. It's for these reasons that is not easy to say if the holding cost are higher or lower for the returned product.

Advantages reverse supply chain

As indicated above, the implementation of the reverse supply chain requires the reflection about some issues that could occur and about the combination with the forward supply chain. Nevertheless, it's not for these reasons that the reverse shouldn't be implemented because its presence could bring a lot of advantages at the company. In fact, the main advantages to implement a reverse supply chain are:

- Providing of a second return on investment from the instrument and the spare parts
- Increase public perception due to its environmentally-friendly properties
- Increase the product lifecycles
- Leads to productivity and growths
- Allows for added value from used or returned goods instead of wasting manpower, time and costs of raw materials originally involved
- Improves customer satisfaction and loyalty by focusing on faulty goods and repairs

l. Performance indicators for Reverse supply chain

If we enter more in details in the PMs for the reverse supply chain, the framework (fig 3.m.1) below could be a useful way to define the six major aspects: customer satisfaction, financial performance, warehousing, manufacturing and transport. In fact, with this framework, it is possible to take into account the financial and the customer service aspects, important in strategic term and to put in value the advantages of the reverse supply chain (chapter 4.c). While the transport, warehousing and manufacturing to take under control the issues (chapter 4.c) as the forecasting and the product lifecycles more complex. Of course, each aspect has points in common with the others, for example, the transportation cost will have a relation with the financial aspect in term of profit per unit. Nevertheless, this way to see the framework could be useful to understand the relation between the aspects and the PMs of the reverse supply chain.

Pursue in the explanation, for each aspect, we can define a set of metrics easily utilizable in a real case.

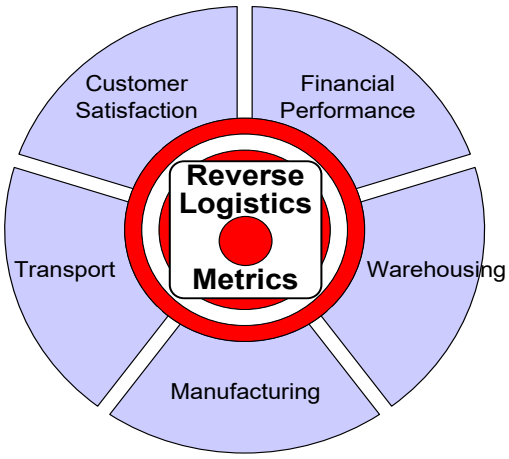


Fig 3.l.1: A Reverse Logistics Performance Management Framework[15-10]

In the financial performance we can use metrics that measure the cost associated to the reverse activities as the physical return and the repair but also the amount of credit issued for returns and the warranty rate. This aspect permits to keep under control the operation costs but also the cost of warranties given at the customer. Furthermore, we can include all the metrics related to the profits made with the reverse activities as the profit of the return units and its annual sales.

The customer satisfaction is one of the more important aspects, since the reverse has to represent a service offered at the client. The metrics that could be utilized are the return rate (distinguishing the defect and non-defect units founded), the order fill rate on RMAs(the rate of return order that are satisfactory) and the time to treat the return and the reverse activities (the time to manage and finalize a return including the reverse activities). We can include as well the backorder on RMA(the rate of return that are still to be performed), the customer order promised cycle time(the promised time between the request of the client to the performing of the service). In addition, the time to process a credit and a warranty claims (time to refund the client) and more in general a customer satisfaction index of the reverse activities and the number of eco-friendly products that are offered in the market.

For the transportation we can use metrics associated to the freight cost for the outbound and the inbound per unit shipped, but also we can use metrics related to the on time pickups and deliveries and the idle time.

About the warehousing aspect, we can measure the inventory turns of the refurbish goods or spare parts, but also the pool of replacement units or spare parts available for months in order to be reactive during the operation.

And for the last one, the Manufacturing, we can measure the manufacturing cycle time so the time from the receipt of the unit in the site until its refurbishing/recovering/repairing, the defect and scrap rate of the until and also the value recovered per returned item [16].

Furthermore, it's important to keep in mind that the Reverse logistics can be used to help companies with environmental standard especially when it comes to product returns and waste disposal. Since the return market is still underdeveloped compared to the forward supply chain, there is real strategic logistics management in terms of reducing waste[17]. So it could be interesting introduce some metrics related to the environmental sustainability as: energy consumption during the operations, number of spare parts reused during the refurbish process, instruments recovered per months, etc.

If we want to make a comparison between the 26 general PMs (chapter 3.e) and the ones for the reverse supply chain, we can see that almost 26 are utilizable for a reverse supply chain PMS. The ones that are not interesting to implement are the bid management cycle time and the product development time principally because do not involve directly activities related to the reverse supply chain.

5. Case study in bioMérieux

The aim of this chapter is to show my practical case of performance measures implementation inside bioMérieux's reverse supply chain. To do that I started from the construction of a balanced scorecard supported by the literature (chapter 2), for then create a set of more operational PMs in order to control properly the day-by-day operations (using the ones in chapter 4.l). The reader will follow the same mental path that I used me to implement the PMS.

a. Balanced scorecard

At the beginning of my study, I've decided to build the performance measurement system starting from the balanced scorecard criterion (Kaplan and Norton 1997). Since it's represent one of the most powerful method to set strategical and tactical performance measurement remaining to the strategy and the vision of the company. For a recap about the four perspectives of the scorecard: the customer perspective asks what customers must believe about the company's reverse operations in order for it to be successful; the internal business perspective asks what the reverse operations must achieve internally to meet and exceed the customer's needs. While the innovation and learning perspective asks how the reverse operations can continuously perform and improve to create more value for the customers and finally the financial perspective asks how the reverse supply chain could succeed financially.

To build a successfully balanced scorecard is important to keep in mind the relation with the strategy of the company or dept., furthermore that the measures used have to be change accordingly with the vision and the strategic changes. In mine, the targets aren't determined with a quantitative way because I didn't have sufficient data to determine challenging targets. About the relation with the literature review, I've integrated the concepts of the Gunasekaran and Kobu (2007)'s list in the chapter 3.b . Because the aim of my balance scorecards is principally to identify the success, increase the customer care and tracking the processes.

For the selecting of the PMs in each perspective, I have used the PMs indicated in the chapter 4.l, since they integrate already the aspects of the reverse supply chain.

Below my balanced scorecard:

General Strategy	Plan, Implement and control the efficient and effective flow and storage of Instrument and spare parts with the aim to offering an added-value to the customer and recover value or proper disposal.

perspective	Objectives	Measures	targets
customer perspective (internal customer)	To improve customer view of RSC operations and services and to increase customer satisfaction	1. Customer satisfaction Index 2. No of eco friendly products 3. Time to treat the return and the reverse activities	Increasing of customer satisfaction and No of eco friendly products, reducing the time to treat the return and the reverse activities
Internal business perspective	To reduce the product recovery time and to augment the volume of product that enter in the RSC	1. Idle time of returned products 2. Capacity utilization 3. Recycling fraction	Reducing of the time to treat a return and the reverse activities related, reducing of the capacity utilization and augmenting the recycling fraction.
innovation and learning perspective	To develop new RL operations and be competitive in the market	1.Implementation of leading technologies,2. Information flow through the department involved	Starting to implement leading technologies and spreading of the information through the department involved
finance perspective	Achieving financial success-To reduce the overall cost of the RL operations and capture maximum value	1. Annual sales of returned products 2. Cost related to reverse activities(refurbish/repair/ exchange)3. Cost of transportation of returned products	Increasing of annual sales of returned products, reducing the cost related to the whole processes.

With the balanced scorecard, I can collect the performance measures useful for my study. But the PMs collected are mostly strategical and tactical, so for my daily work I have created a monthly dashboard with more operational PMs. This has permitted also to have a root cause to take corrective and proactive actions in a faster way (Maskell list, chapter 3.f). The monthly dashboard has generated a number of operational PMs higher than for the strategical and tactical ones, this in accord with the decision making criterion (Gunasekaran et al. (2001)). Furthermore the use of the balanced scorecard has permitted to me to define operational PMs that could be easily reconducted at the strategy of the firm. This is an important link, because often in the daily work we lose the strategic vision. Therefore, my PMS is constituted by a balance scorecard and a monthly dashboard.

b. Monthly dashboard

The monthly dashboard is a tool to have under control different activities and establish a root cause in order to can action when necessary. The mine permits to have under control the different types of return and the reverse supply chain activities.

In my monthly dashboard, making the relation with the balanced scorecard, I've put performance indicators mostly related to the customer perspectives (Time to treat the return and the reverse activities),to the internal business perspective(capacity utilization) and to the finance perspective(cost of transportation of returned products and cost related to reverse activities). I've chosen these ones to focus the attention on the customer satisfaction, that represents one of the advantage (chapter 4.l) but without forgetting the financial aspects like the costs and having a look in terms of internal process. This also in accord with the nature of measures criterion, that advices to create a PMS as more as possible balanced in terms of financial and non-financial PMs(chapter 3.d).

Furthermore, with the monthly dashboard, I have been able to integrate some of the consideration done in the chapter 3.f about a PMS, in fact I've been able to have faster feedback, track better the process and avoid double counting.

Before to start the presentation of my monthly dashboard, it's important to explain a useful method that I have used to operationally compute the performance indicators and categorized them (advised by the supply chain performance dept). This one is QQOQCCP method (Qui Quoi Où Quand Comment Combien Pourquoi). Where:

- Pourquoi(why) is the objective,
- Qui(who) is the service responsible for it
- Quoi(what) Is the definition
- Quand(when) is the frequency to communicate the KPI(monthly, weekly, ecc.)
- Comment(how) is the way how it's calculated
- Où(where) is the link with the documentation(if it exists)
- Classification: importance degree.

It permits to define the most important points of a PM and avoid misunderstandings for an organizational standpoint; in fact, each one knows for which PM is responsible.

Coming back at the monthly dashboard I have distinguished three types of return categories: one for the return for replacing, one for the return for refurbish and another one for the returns inside the off-site repair project scope

c. *Return for replacing*

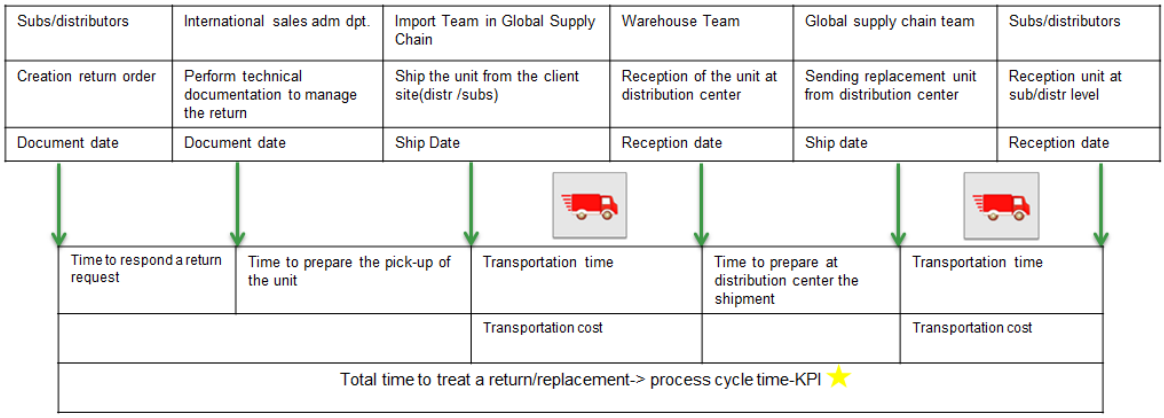
The return for replacing occurs when the subs/distributors ask for a replacing unit because their one is failed, and with the PMs we want control all the operational tasks involved during the return in term of time and cost.

About the workflow, there are many phases between the sending of the failed instrument from the sub/distributor until the reception of the replacement one. The objective is try to reduce the time and cost involved during the different phases in order to: be proactive, saving money and giving a performant service.

I've divided the process in different steps, in order to properly measure the metrics, but also have a root cause to understand the weaker step that can be improved or changed. As said before, I have used the QQOQCCP method, and if we look at the image 5.c.1: who is responsible for each phase is indicated in the first row, what is indicated in the second one. While when is monthly, how is indicated below the image, where is in SAP with the help of a spreadsheet, and for the importance degree I've distinguished them in two categories: the normal PM and the KPI. Finally, the why, as already said, is for all: try to reduce the time and cost involving during the different phases in order to be proactive and to give a performant service.

From a logistics standpoint and to make clearer the schema below, a standard return for replacing starts with the creation of the return order by the subs/distributors(the final client is not involved in this process, since the return from the final client to the subs/distributors is managed by the subs/distributors). Then the international sales administration dpt, belonged to Global supply Chain, perform all the documentation necessary in order to perform the return (for instance the MRA material return authorization). Then the import team in Global Supply Chain organizes the pick-up and manages the shipment from the sub/distributors towards the distribution center in Saint-Vulbas (IDC). After that, the warehouse team in IDC makes the reception of the unit. Finally, the Global Supply Chain team in charge of the replenishment of the product sends the replacement unit from the distribution center to the subs/distributors and finally the subs/distributors make the reception of the unit.

The schema below shows the process and the PM that is a KPI:



Schema 5.c.1: root cause return for replacing

The PMs related to the time are calculated like the differences between each date and the transportation costs are calculated considering an average cost per route.

The KPI chosen for this return is the process cycle time, because it is critical since englobe the time where the sub/distributor is without a functioning unit. Therefore, it's essential reduce it to gain in customer perspective in the balanced scorecard (time to treat a return).

Furthermore, if we want to make a link with my balanced scorecard:

PMs for transportation costs	3. Cost of transportation of returned products(financial persp.)
PMs for times	3. Time to treat the return and the reverse activities(customer persp.)

Finally, an important point related to schema 5.c.1, to keep in mind also for the two other types of return, is the fact that it has permitted to me to integrate the advices of the Location of measures in supply chain links criterion. Since, with it, I can measure the performance of each step but I can also have a vision of all the process (in this case, for example with the KPI-process cycle time).

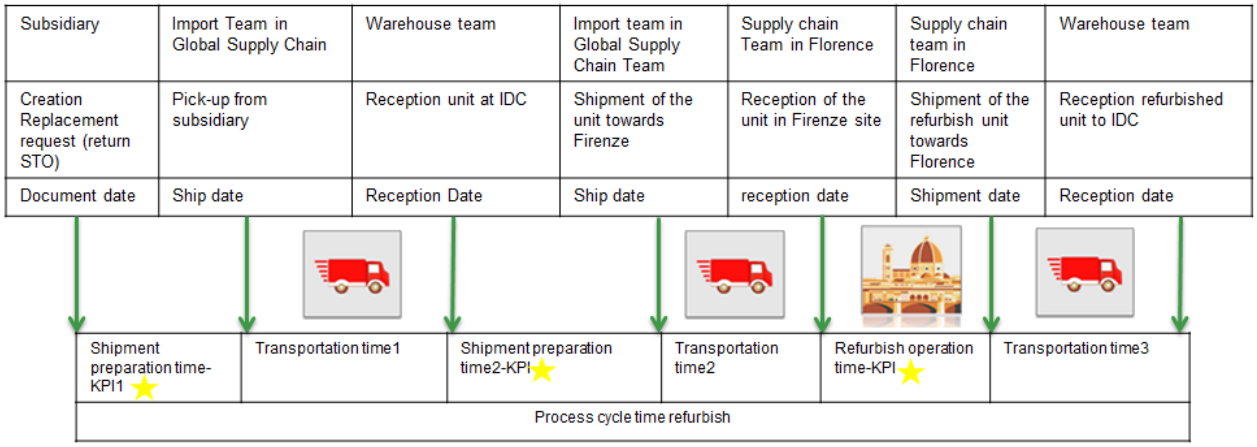
d. Return for Refurbish operation

The return for refurbishing occurs when an instrument is sent back from the subs/distributors for refurbish operation. Here, the logistic flow is different from the return for replacement. In fact, the unit to be refurbished is sent by the subsidiaries towards the IDC. Then the IDC ships the unit to the manufacturing site in Florence, and finally the latter send back the unit refurbished.

As made for the return for replacing I have defined each steps of the process(schema below 5.d.1), in order to can measure the metrics related to each ones and I have used the QQOQCCP

method where the why is to reduce the time for the operation and to have an higher volume of refurbished instruments.

In this case I have considered only the time, because the refurbish is an initial state and consider the metrics about the cost was difficult. But this case is emblematic to show how the PMs could help to increase the perfomance of a process and also to have a quantitative example.



Schema 5.d;1: root cause return for refurbish operation

Where the time PMs are calculated like the differences between each date, and all PMs are related in my balanced scorecards with the Time to treat the return and the reverse activities (customer persp.)

For the daily operations, we have constructed an excel sheet (Annex 2) that permits: to follow each step of this process, to collect the dates, to compute the metrics and to notify if there are problems in a specific link of the chain. Furthermore, with this excel sheet we have constructed the table (5.d) below with the computing of each PMs:

Perfomance measure	target	Real value(after 1 months)	improvement
Avg Shipment preparation time1	1-2 days	Below target	-50%
Avg Transportation time1	5 days	In target	-
Avg Shipment preparation time2	3 days	Below target	≈-45%
Avg Transportation time 2	4 days	In target	-
Refurbish time	24 days	Below target	-25%
Avg Transportation time 3	4 days	In target	-
Total refurbish cycle time	47-48 days	Below target	≈-25%

Table 5.d

As it was clearly visible after the month 1, it was necessary to take some actions during the shipment preparations and in the refurbishing operation; it is for these reasons that we chose the shipment preparation times and the refurbish time as the three KPIs.

The first actions that we took in order to decrease the two avg shipment preparation times were to mapping and establish a RACI chart for the whole process. Because after interviewing the parts involved, we noticed that the delay was brought by organizational confusion about who was in charge of each tasks(classical visibility issue chapter 4.c). For the refurbish time, as possible to see, the difference between the target and the real value was very large. The target is the minimum time to refurbish that was reached one time in Florence. After researching the cause of this large difference, we found that was brought by a stock rupture in Florence of a specific spare part (classical inventory management issue chapter 4.c). In both case the PMs worked like an alarm and they permitted us to take corrective solutions. For the large refurbishing time we proposed a corrective solution to Florence (taking that spare part from the instruments not recoverable). Then for a consistence solution, we started to insert in the S&OP with Florence a speech more accurate to avoid this problem and allocate the capacity expected. The actions taken, thank the control with PMs, permitted us to reduce drastically the time. As it possible to see in the table 5.d, we have gained almost 25% in term of total refurbish cycle time. This time reduction has permitted to us to increase the number of instruments available to the sale and therefore: increase the ROI, increase the average product lifecycles of the bioMérieux instruments and gain in public perception (advantages chapter 3.f).

The return for refurbish represents a good example of how the PMS should work. In fact, it should be a system that with the controlling finds the parts of the business weaker (where some corrective action are needed); then the team takes the actions necessary, and the PMS verifies again the results and says if there are some improvements still to do and signal again the points weaker. If we look in this way the performance measures, they could be easily included in the vision of Lean and continuous improvement and they are in line with the Maskell list.[18; Maskell(1989) chapter 3.f]

e. Off-site repair project

Beyond the two types of returns above, the reverse supply chain team is developing a big project about the reparation flow. In the scope of this project, there are specific ranges of bioMérieux products that are not reparable at the client site, so they need to be sent at the Florence reparation site. The project covers all EMEA region reparation flows.
The need to develop a specific project born because the range of products in the scope needs a repairing operation around each 6 months. With them, the expected reparation demand will be more and more important and the reverse supply chain needs to assist this increasing.

Inside the project, we can find two different types of return: the definite and the temporary one.

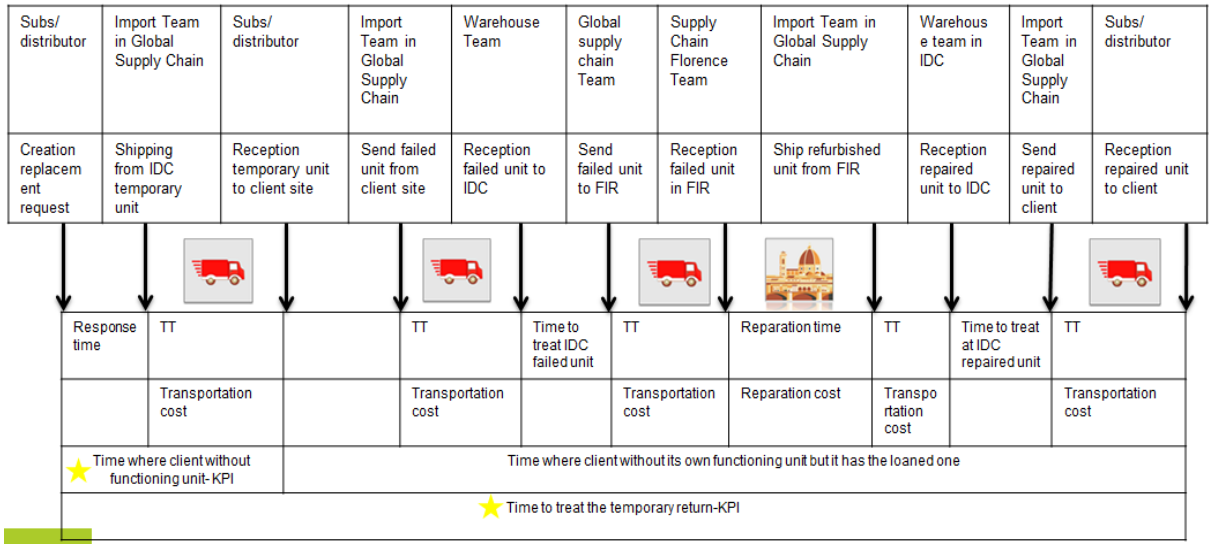
In the definite return, when a customer has a failing unit A, the latter is definitely returned from the customer to the distribution center, and replaced by another unit B at the customer site. This is a definite swapping of the 2 units (A replaced by B).

While in temporary return: the failing unit A is temporary returned from the customer to the distribution center, and replaced temporary by a loaned unit B. Once repaired, unit A will be

shipped back to the initial customer. This is temporary swapping of the 2 units (A replaced temporary by B until A returns from repair).

Here in this report, I show only the PMs and the schema related to the temporary return because is more particular than the definitive one. Since the latter could be associated at the return for refurbish in term of logistic flows.

Below as for the other cases, the schema 5.e.1 that represents each step and the root cause using the method QQOQCCP. From a logistic standpoint, the failed unit is replaced by a loaning unit and sent back to the distribution center. Then from the distribution center, the failed unit is sent to Florence manufacturing site. There it is repaired and sent back to the customer site through the distribution center.



Schema 5.e.1: root cause return for temporary replacing(TT=transportation time)

The PMs related to the time are calculated like the differences between each date, the transportation costs are calculated considering an average cost per route, while the reparation cost is computed through the reparation invoices.
The KPIs chosen for this return are the time where the client is without functioning unit and the time to treat the temporary unit. The first one is critical since englobe the time where the client is without an unit. While the second one because englobes all the activities and includes the time where the client is without its own unit. And in terms of relation with the balanced scorecard:

PMs for transportation cost	3. Cost of transportation of returned products(financial persp.)
PMs for times	3. Time to treat the return and the reverse activities(customer persp.)
PM for reparation	2. Cost related to reverse activities(refurbish/repair/ exchange)

f. Other transversal PMs

Furthermore in the monthly dashboard, as indicated in the table 5.f below, I want to take care also of the size of the replacement instruments pool in IDC in order to can know how many returns for replacement we're able to face. It's a KPI because represents the monthly ability to face the replacement returns. This KPI is strictly related with the problems of inventory management and forecasting (chapter 4.m) and its aim is to decrease them. Since these two problems, a way playable is to create a security stock (loaner pool) to face the volatile demand. With the Size of installed base at client sites, I want to keep track of the installed base in order to can try to set a forecast more accurate and anticipate the return needs.
I want to control also the YTD return to consider the returns order of magnitude. Furthermore, to see if an increasing capacity could be necessary and to face better the problem of visibility explained in the chapter 4.m.. In fact, if we are able to show that the YTD returns are increasing probably we can get the access at more resources. Finally, the last PM is the return type, in order to keep track of the types of return more frequent and could take proactive actions in the reverse activities more requested(first table in chapter 4.l).

PM title		
replacement pool size-KPI ★	**objective**	To see how many replacement we're able to face
	who	Warehouse Team in distribution center
	what	Size of replacement pool in IDC per instrument
	when	monthly
	how	Automatically generated and updated in SAP- number of replacement pool instruments at the end of the month
	where	SAP
	classification	KPI_ capacity utilization in BS
Size of installed base at client sites	**objective**	To have a general overview about the size of installed basis trying to forecast the future returns.
	who	Reverse supply chain Team
	what	Size of installed base at client sites per instrument
	when	monthly
	how	Automatically generated and updated in SAP- number of instruments at client sites at the end of the month
	where	SAP
	classification	Normal- capacity utilization in BS
Number of return YTD	**objective**	To know how many returns are already perfomed and returns volume
	who	Reverse supply chain Team
	what	Number of return already performed from the 1/1 of the same year
	when	monthly
	how	Automatically generated and updated in SAP- number of return perfomed from 1/1 Until the end of the month
	where	SAP
	classification	Normal- capacity utilization in BS
Return type	**objective**	To understand what are the more frequent type and prepare specific action
	who	Reverse supply chain Team
	what	Number of return performed for each return type from the 1/1 of the same year

	when	monthly
	how	Automatically generated and updated in SAP- type of return performed form 1/1 until the end of the month
	where	SAP
	classification	Normal-capacity utilization in BS

Table 5.f:explanation transversal KPI

g. Final remarks and comments

In this final chapter, I have tried to reassume the main points of my case study in bioMérieux. After showing the balanced scorecard, the attention is focused essentially on the 3 returns types. For me, the balanced scorecard represents one of the best ways to proceed if we want construct a coherent PMS. If we look at mine, one point that could be improved is the fact that not all the PMs inside are related with a more operational one. Therefore, a possible improvement is to put in relation the entire scorecard PMs with one in the monthly dashboard.
Other point that could be refined is the integration inside the PMS of a PM related to the impact sustainability, since this point represents one of the value reverse supply chain future (end of chapter 4.m).
During my case study, since the initial state of PMs implementation, was essential the literature review. With it, I've been able to understand the different aspects of the PMs and the reverse supply chain. The method that I used to design the PMS was to make a consistent literature review and discuss with the supply chain performance dept., trying to integrate the knowledges transmitted by both. At the end of my internship, I can say that : the supply chain performance dept. has explained to me the method to easily put in practice the PMS while the literature has given to me the theoretical knowledges and a global view (essential for further extension of my PMS). A final remark about the PMs is the fact that they are a lighthouse during the operations. In fact, if we look at the example given in the chapter 5.d., the PMs have permitted us to avoid wasting of time and they have given to us a clear process speech, without them we would have searched blindfold a solution.

6. Conclusion

As said in the introduction, integrate the reverse supply chain team in BioMérieux was a great opportunity. The reverse supply chain represents one of the greener ways to see the supply chain and the operations related. It will be a key value in the future, since the environmental issues that our society are living and will live. Furthermore, inside more and more companies the trend is to implement it and, if possible, sell some of its activities as an additional paid service. Therefore, the reverse supply chain is strategic both in sustainable term and in economical one. Said this, the design of the PMS was a great opportunity as well. Because when I arrived in bioMérieux, it was an initial state so I really could bring my contribute and not just improve it. Furthermore, I really understand the power of this tool. Emblematic is the case in the chapter 5.d. where we were able to reduce drastically the process cycle time for the refurbish and gain revenues. For me, the greatest point of the PMs is that they are able to give a picture of the weaker areas of the process and so say where some actions are needed, for then compare

the improvements brought by the solution chosen. It will be a great a tool to propose improvements and make a good impression when I will join a new company!
For all these points, I think that this internship and this report will be useful for my future career path, in terms of knowledges acquired and soft skills developed.

I hope that you have had a pleasant reading.

a. Bibliography and key words

Key words: KPI, reverse logistic, supply chain performance, performance measures, metrics, logistics, supply chain, perfomance measurement system, bioMérieux.

Bibliography:

[1]Performance measures and metrics in logistics and supply chain management: a review of recent literature (1995–2004) for research and applications, Gunasekaran Angappa; https://www.tandfonline.com/doi/abs/10.1080/00207540600806513

[2]Supply chain performance measurement: a literature review, Goknur Arzu Akyuz & Turan Erman Erkan; https://www.tandfonline.com/doi/full/10.1080/00207540903089536?src=recsys

[3]Key Performance Indicators: Developing, Implementing, and Using Winning KPIs, David Parmenter; https://books.google.fr/books?hl=fr&lr=&id=bKkxBwAAQBAJ&oi=fnd&pg=PA101&dq=key+performance+indicators&ots=cYWYm5m0eo&sig=AW7bKNbgLiRujEwCC78POx4__vM#v=onepage&q&f=false

[4]Kaplan, R.S. and Norton, D., The Balanced Scorecard, 1996 (Harvard Business School Press: Boston, MA)

[5]Maskell, B., Performance measures of world class manufacturing. Manag. Account., 1989, 67, 32–33

[6] Bob Delaney, Ninth Annual State of Logistics Report, (St. Louis, MO: Cass Logistics, 1998)

[7] Going Backwards: Reverse Logistics Trends and Practices; University of Nevada, Reno Center for Logistics Management, Dr. Dale S. Rogers Dr. Ronald S. Tibben-Lembke.

[8] https://www.tuscorlloyds.com/reverse-logistics-infographic/

[9] History of Reverse Logistics is at the Core of The Stories of War, Retail, eCommerce, and Automotive Aftermarket; Adam Robinson, Director of Marketing, Cerasis, Inc.; http://rlmagazine.com/edition61p24.php

[10]Reverse Supply Chain: Completing the Supply Chain Loop; Nandan Kumar; https://www.cognizant.com/whitepapers/reverse-supply-chain.pdf

[11]Reverse Logistics Planning: A Strategic Way to Address Environmental Sustainability While Creating a Competitive Advantage, Published online: 25 Aug 2009, ; http://trace.tennessee.edu/cgi/viewcontent.cgi?article=2701&context=utk_chanhonoproj

[12] Reverse Logistics: Performance Measures and their effect in product lifecycle; Alok Agrawal, Vijay Choudhary; http://ijcem.in/wp-content/uploads/2014/05/Reverse-Logistics.pdf

[13]Cradle to Cradle: The Reverse Supply Chain, Supply Chain Management, http://cmuscm.blogspot.com/2014/09/cradle-to-cradle-reverse-supply-chain.html

[14] Differences between Forward and Reverse Logistics in a retail environment, Dale Rogers, Ronald S. Lembke; https://www.researchgate.net/publication/235322400_Differences_between_Forward_and_Reverse_Logistics_in_a_retail_environment

[15] Reverse Logistics Performance Indicators: A conceptual Framework for evaluating reverse logistics services,Panousopoulou,Pagona,Manthou,Vicky,https://fr.scribd.com/document/328802168/Reverse-Logistics-Performance-Indicators-A-conceptual-Framework-for-evaluating-reverse-logistics-services

[16]Reverse logistic magazine n 43, http://www.rlmagazine.com/edition43p35.php

[17]Reverse Logistics Planning: A Strategic Way to Address Environmental Sustainability While Creating a Competitive Advantage, Published online: 25 Aug 2009, Goknur Arzu Akyuz : http://trace.tennessee.edu/cgi/viewcontent.cgi?article=2701&context=utk_chanhonoproj

[18]The role of performance measurement in continuous improvementAuthor(s):T.C. Bond;https://www.emeraldinsight.com/doi/abs/10.1108/01443579910294291

b. Annexes

Annex 1: table of the 26 PMs and its relation with the criteria[1].

	A				B				C					D			E		F		G			
Metrics	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	1	2	1	2	1	2	Total	Percentage
01 Accuracy of scheduling		X			X				X							X		X	X		X		7	32
05 Bid management cycle time		X			X				X					X				X	X		X		7	32
06 Capacity utilization		X	X			X					X				X	X		X	X		X		9	41
07 Compliance to regulations		X	X				X		X	X				X				X	X	X		X	10	45
08 Conformance to specifications		X		X			X			X	X					X		X	X			X	9	41
18 Delivery reliability		X		X	X		X						X			X		X	X			X	9	41
24 Forecasting accuracy				X	X		X		X						X	X		X	X			X	9	41
29 Inventory costs	X	X				X		X	X	X	X	X	X			X	X		X		X	X	14	63
33 Labor efficiency			X			X					X				X	X		X	X		X		8	36
35 Lead time for procurement				X	X					X					X			X	X		X		7	32
36 Lead time manufacturing		X		X	X						X				X	X		X	X		X		9	41
39 Obsolescence cost	X			X	X		X		X								X		X			X	8	32
44 Overhead cost	X	X			X	X			X		X					X	X		X			X	10	42
46 Perceived quality				X			X	X					X					X		X		X	7	32
47 Perceived value of product				X			X						X					X		X		X	6	27
50 Process cycle time		X			X			X	X		X	X			X	X		X	X		X		11	50
51 Product development time		X	X		X				X					X				X	X		X		8	36
54 Product/service variety	X		X	X			X	X	X					X				X		X		X	10	45
55 Production flexibility		X	X		X	X	X	X			X					X		X		X	X		11	50
62 Return on investment	X					X			X					X			X		X			X	7	32
63 Selling price	X			X		X	X						X	X			X		X			X	9	41
68 Stock out cost	X			X			X	X					X				X		X			X	8	32
71 Supply chain response time		X	X		X			X	X					X	X	X		X	X		X		11	50
76 Transportation cost	X					X						X			X	X	X		X			X	8	32
77 Value added	X			X		X					X		X		X	X	X		X			X	10	45
81 Warranty cost	X			X			X		X								X		X			X	7	32
Total	10	13	7	13	12	9	12	7	13	4	9	3	7	7	9	14	9	17	22	5	11	16		
Percentage	38	50	27	50	46	35	46	27	50	15	35	12	27	27	35	54	35	65	85	19	42	61		

Annex 2: spreadsheet for the returns for refurbishing:

	référence	S/N	STO U	ADVE/X PO reque	STO R	U arrived at F	R arrived at ID	n° STO U	n° STO R	RDD R	Comment	date de request STO fil-IDC	#STO fil-IDC	date STO fil-IDC	MRA creation	#MRA	date d'enlevement	reception physique IDC	reception SAP in IDC	pays filiale	Satus
2	200111 U/R EASYMAG	EASYMAG00614	X	X	X	X	X	6500477895	6500483134/00001	25-mai	R parti pour ZA										Clos
3	200111 U/R EASYMAG	EASYMAG00925	X	X	X	X	X	6500485257	6500486319/00001	14-juin	R en stock IDC										Clos
4	200111 U/R EASYMAG	EASYMAG00832	X	X	X	X	X	6500485257	6500486319/00002	28-juin	R en stock IDC-to verify if not already sold										Clos
5	200111 U/R EASYMAG	EASYMAG00716	X	X	X	X	X	N/A	6500486319/00003	12-juil.	R parti pour ZA le 20/07										Clos
6	200111 U/R EASYMAG	EASYMAG00704	X	X	X	X	X	6500486464	6500486781/00001	12-juil.	R in IDC										Clos
7	200111 U/R EASYMAG	EASYMAG01201	X	X	X	X	X	6500486464	6500486781/00002	2-août	R en stock IDC										Clos
8	200111 U/R EASYMAG	EASYMAG01120	X	X	X	X		6500518420	6500518433/00001	08-janv	arrived in Florence RDD R to receiv	31-août	6500512922	03-sept	04-sept	8006779661	17-sept	19-sept	21-sept	Espagne	
9	99735 U/R VIDAS	IVD3003929	X	X	X	X		6500498261	6500498267/00001	25-sept.											
10	80025 U/R TEMPO	IQIF01597	X	X	X	X		6500506277	6500506641	28-sept											
11	99735 U/R VIDAS	IVD3003972	X	X	X	X		6500498261	6500498269/00001	2-oct.											
12	200111 U/R EASYMAG	EASYMAG01063	X	X	X	X		6500497983	6500502309/00001	2-nov.		N/A	6500494384	19-juin	20-juin	8006465729	21-juin	27-juin	30-juin	Polonie	
13	200111 U/R EASYMAG	EASYMAG02366	X	X	X	X	X	6500502124	6500498010/00001	24-sept.	R in IDC	22-mai	6500491970	12-juin	12-juin	8006432811	15-juin	25-juin	16-juil	Allemagn	Clos
14	200111 U/R EASYMAG	EASYMAG00914	X	X	X	X	X	6500502329	6500502334/00001	19-sept.	R in IDC	08-juin	6500492558	12-juin	12-juin	8006432808	03-juil	09-juil	18-juil	Espagne	Clos
15	80025 U/R TEMPO	IQIF02471	X	X	X			6500517274	6500517292	09-nov	Mettre le R en RS01 à reception et en informer Laurent Rinaudo										
16	80025 U/R TEMPO	IQIF02304	X	X	X	X	X	6500517274	6500517293	16-nov	Mettre le R en RS01 à reception et en informer Laurent Rinaudo										
17	200111 U/R EASYMAG	EASYMAG00602	X	X	X	X		6500497983	6500498020/00001	22-nov.		N/A	6500494384	19-juin	20-juin	8006465729	21-juin	27-juin	01-juil	Polonie	
18	80025 U/R TEMPO	IQIF02043	X	X	X	X		6500517274	6500517294	23-nov											
19	200111 U/R EASYMAG	EASYMAG01053	X	X	X	X		6500518420	6500518433/00002	07-déc		31-août	6500512922	03-sept	04-sept	8006779661	17-sept	19-sept	21-sept	Espagne	
20	200111 U/R EASYMAG	EASYMAG02302	X	X	X	X		6500502124	6500502308/00001	10-déc.		22-mai	6500491970	12-juin	12-juin	8006432811	15-juin	25-juin	16-juil	Allemagne	
21	200111 U/R EASYMAG	EASYMAG02321	X	X	X	X		6500518420	6500518433/00003	14-déc		31-août	6500512922	03-sept	04-sept	8006779661	17-sept	19-sept	21-sept	Espagne	
22	200111 U/R EASYMAG	EASYMAG00856	X	X	X	X		6500497983	6500498019/00001	27-déc.		N/A	6500494384	19-juin	20-juin	8006465729	21-juin	27-juin	29-juin	Polonie	
23	200111 U/R EASYMAG	*EASYMAG00455*	*X*	*X*	*X*	*X*		6500502124	deleted		old instru - to be verified => NOT REFU	*22-mai*	*6500491970*	*12-juin*	*12-juin*	*8006432811*	*15-juin*	*25-juin*	*16-juil*	*Allemagne*	
24	200111 U/R EASYMAG	*EASYMAG00481*			*N/A*	*N/A*	*N/A*				**200110U / info Mario : scapper à l'IDC**	*15-juin*	*6500493710*	*15-juin*	*15-juin*	*8,01E+09*	*29-juin*	*04-juil*	*31-juil*	*Portugal*	
25	200111 U/R EASYMAG	*EASYMAG00096*			*N/A*	*N/A*	*N/A*				**200110U / info Mario : scapper à l'IDC**	*15-juin*	*6500493710*	*15-juin*	*15-juin*		*29-juin*	*LOST in Spai*	*LOST*	*Portugal*	
26	99735 U/R VIDAS	IVD3003934	X	X	X	X	X	6500498261	6500498268/00001	43368											Clos
27	200111 U/R EASYMAG	*EASYMAG00153*			*N/A*	*N/A*	*N/A*				**200110U / info Mario : scapper à l'IDC**	*15-juin*	*6500493709*	*15-juin*	*15-juin*	*8006449792*	*29-juin*	*04-juil*	*31-juil*	*Portugal*	
28	99735 U/R VIDAS	IVD3004194	X	X	X	X	X	6500498261	6500498270/00001	43375											Clos
29	200111 U/R EASYMAG	*EASYMAG00267*			N/A	N/A	N/A				**NOT REFURBISHABLE (S/N <500)**	31-août	6500512922	03-sept	04-sept	8006779661	17-sept	19-sept	21-sept	Espagne	
30	200111 U/R EASYMAG	*EASYMAG00432*			N/A	N/A	N/A				**NOT REFURBISHABLE (S/N <500)**	31-août	6500512922	03-sept	04-sept	8006779661	17-sept	19-sept	21-sept	Espagne	
31	200111 U/R EASYMAG	*EASYMAG00436*										NOT REFURBISHABLE								Chile	
32	200111 U/R EASYMAG	*EASYMAG00115*										NOT REFURBISHABLE								Chile	
33	80025 U/R TEMPO	IQIF01113	X					6500531143		15-janv											
34	418591 U/R / EMAG	IM03139									Stand by, car problème de process retour (08.11.18)										
35	418591 U/R / EMAG	IM03140									Stand by, car problème de process retour (08.11.18)										
36	80024 U/R TEMPO	IQIR01114	X					6500531143			TP en cours de demande (08.11.18)										
37																					