Proposition of a methodology to model and analysis with the introduction of secondary market in the global supply chain

Faycal Mimouni and Pr. Abdellah ABOUABDELLAH
Laboratory systems engineering, MOSIL, ENSA, University Campus, 241 B.P, IbnTofail University, Kenitra, Morocco
mimounifaycal@gmail.com, a.abouabdellah2013@gmail.com

Abstract

In recent years, reverse logistics has become a field of importance for all organizations due to growing environmental concerns, legislation, corporate social responsibility And sustainable competitiveness. RL refers to the sequence of activities required to collect the used product from the customers for the purpose of either reuse or repair or re-manufacture or recycle or dispose of it. The direct supply chain has become increasingly implemented in all industries to ensure the customers' satisfactions at the lowest delivery time and at the minimal cost. The goal of this work is to propose a modeling methodology of the integrated the reverse logistics chain in the direct supply chain with the inclusion of the possibility of selling in a secondary markets. The first part of the article presents the problems caused by the integration of the return logistics chain in the direct chain. The second part presents a literature review of the reverse logistics and its importance. The third puts light on our methodological approach to modeling and analysis of the supply chain. The fourth part is subject to the application of the proposed methodology in a case study. The final part will represent the conclusion and prospects of this paper.

Keywords
Reverses logistics, recycling, Random behavior, secondary market, supply chain.

1. INTRODUCTION

The direct supply chain has become increasingly implemented in various industries to ensure the customers' satisfactions at the lowest delivery time and at the minimal cost. Furthermore, the new spirit of the reverse logistics is to maximize the potential benefice from returned products. However, most industries tend to concentrate on these categories of returned products:

- Product to raw material: They can be converted into raw material to be reused in the industry;
- Product convertible to finished product: they can be transformed into the final product after-sales processing or return;
- Throw Product: product Recovered without any benefit to the industry: they must be rejected.

Moreover, the convertible products in raw materials may create subcategories depending on the number of possible extracted raw materials and the rejected products. In our paper, we propose to categorize returned products by their quality and there beneficial benefits.

On a previous study (Faycal MIMOUNI ET all 2015a), we found that that the returned products for reparation represent the most beneficial type of returns in the global chain. That is why we chose to focus this paper on the impact of returns on the production process and specially the retuned products for reparation. Our study will focus on the relation between the production process and the "product for reparation on the production process"

The first part of the article presents a literature review and the importance of reverse logistics. The second puts the light on our methodological approach to model and analysis of the global supply chain. The last part is the subject of a conclusion and working prospects.

2. Literature review

2.1 Reverse logistics

The term reverse logistics is the most commonly encountered in the literature when it comes to returns management and processing of recovered products. This name is suggestive of the fact that it allows to refer to the related logistics activities of an organization, but in an opposite direction, as opposed to the regular activities of the supply chain. Given the emergence of the concepts of reverse logistics in the last ten years, it is not surprising that the use of a relatively varied and sketchy terminology. Reverse logistics is often treated in the literature in a given context: specifically address activities or disassembly of products in electronic commerce, or refers often to a definite case study focusing on a particular type return. (Serge Lambert ET all 2003)

Hajej et al. (2010) used the quadratic and linear stochastic model to develop an optimal production plan of a production system that takes into account the return of finished goods and minimizing inventory costs, lost production and demands. Dekker et al. (2010) have defined the structure of reverse logistics system in a closed loop in which the returned product will be reused or recycled within the same manufacturing company.

For their part, Beaulieu et al. (1999), Beaulieu (2000) have reverse logistics, this time under the term reverse logistics, as:

"A set of management activities to reintroduce non-core assets in sectors with added value."

2.2 Modeling in reverse logistics

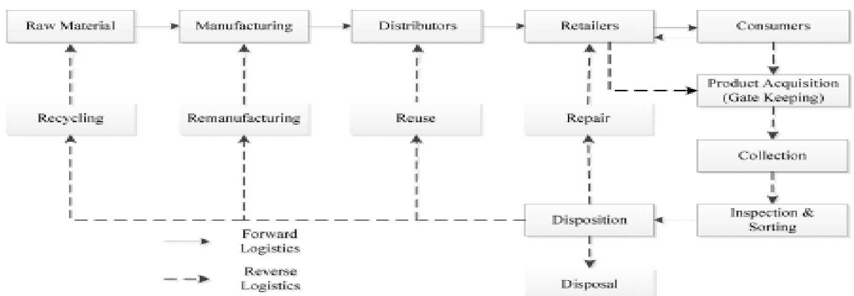

Figure 1 Basic global supply chain (Agrawal, S., Singh et all 2015)

As we can see on the basic global supply chain, there is no secondary market option. The general studies focus on the direct reintroduction of products in the primary chain and the primary market. However, several studies have introduced the secondary market in some specific companies.

In a previous study, we found out that reverse logistics has a big impact not only on the cost but also on delay and on the stocks management. (Faycal MIMOUNI ET all 2014)

The following chart represents several studies of the secondary market.

Even without the inclusion of the secondary market, previous study has shown that reverse logistics can be very beneficial at low rates of returns for companies producing automotive wiring. (Faycal MIMOUNI ET all 2015b)

Table 1: Review of secondary market models

Authors	Industry	Remarks
Louwers et al (1999)	Carpet	A model for recycling and reusing old carpets with an option of considering secondary market for resale of carpets
Realff et al. (2004)	Sand	A stochastic programming model for recycling sand while considering selling the sand into the secondary market
Liekens and Vandaele (2007)	General	A mixed integer linear programming model for with queering model and genetic algorithm
Francas and Minner (2009)	General	Considering two cases, first where the newly manufactured and remanufactured products are sold on the same market and second, the case where recovered products are in a secondary market
Abraham (2011)	Apparel Aftermarket	An empirical study
Ahlumur et al (2012)	Washing Machine	A reverse logistics model for washing machines considering an option of selling them in the secondary market
Demirel et al (2014)	General	Mixed integer programming model,
Huang et al (2014)	Retail	Retailers' inventory decision considering secondary market to salvage the returns and the left lovers from the initial sales
Liu et al (2014) [	E-Waste	Developed the network model by using theory of constrains

Our study will focus, on the impact of the introduction of the secondary market in the reverse chain both costs and gains.

3. Proposed methodology

Our approach will be based on the construction of a model that will allow us to study the inclusion of the secondary market in the global chain.

For this, we will follow the following steps

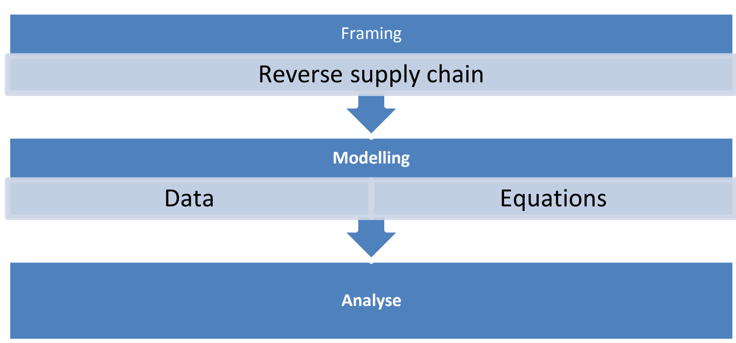

Figure 2 Methodology steps

The first step will consist of defining the limits of our model.

We propose to study each supply chain separately, the direct chain and the reverse chain, before combining them in the global chain.

3.1 Framing and modeling the reverse supply chain

In our study, we chose to categories returns depending on their quality instead of the usual classification. We obtain the following categories:

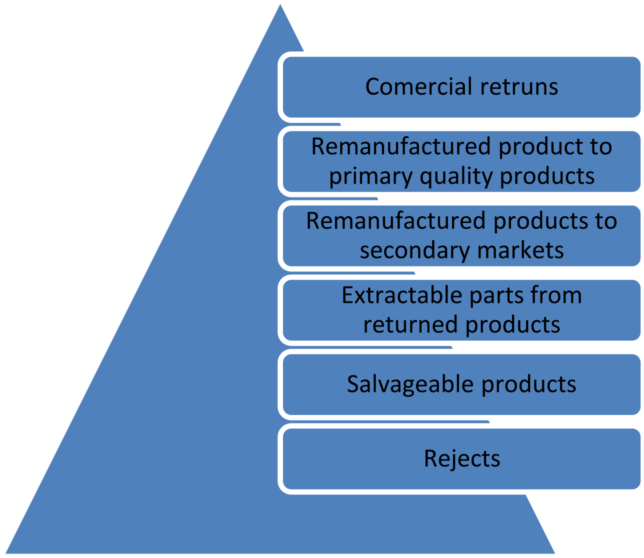

Figure 3 Returns' categorisation

As such, the reverse chain will be more complex and will be composed of diverse process for each perspective category of returned products:

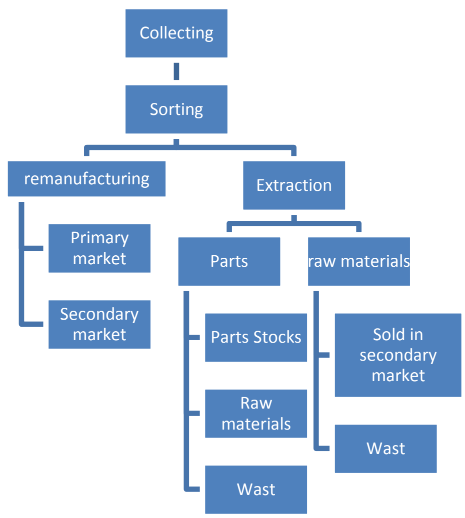

Figure 4. Reverse chain process

The liaison between the direct chain and the reverse chain resides between the process "Reintroduction" and the process "Supply" or "Manufacturing" from treated returned products to the direct chain either as extracted raw materials or finished products. Moreover, another liaison resides between the process "Deliver" and the process "Collecting" from collected returned products originated from a portion of the delivered products. The problem in the process "Collecting" resides in the random ratio returned each month.

3.2 Modeling

To evaluate our model efficiency, we propose to evaluate the cost of the global supply chain and compare it to the actual global supply chain.

We propose the following mathematical model:

NB:

- We identify "raw material" as a basic component such as silver, gold, iron …;
- We identify parts as a component of the final product needed for the production.

Monthly demand DP_i;

Finished product sell price SP;

Production cost CP;

Unit cost for product recovery and sorting costs CR;

Unit cost for product reparation CFP;

Unit cost for product reparation for secondary market SFP;

Unit cost for parts extraction CEP_j with j identifying the product part;

Unit cost for raw material extraction CER_j with j identifying the raw material;

Unit cost for part acquisition CPP_j with j identifying the product part;

Products stock S_i with i representing the month;

Products parts needed for a finished product QP_j with j identifying the Products part.

Unit remanufacturing cost product destined to secondary market SRS

Unit price for sold product in secondary market SPS

Price for raw material sold in secondary market SRS_k with k identifying the raw material.

Price for disposing of the waste from returned products CD

R_i represents the global rate of returns;

RF_i for products returns to remanufacture and to sell in primary market (Standard quality).

RS_i for products returns to remanufacture and to sell in secondary market (Lower quality).

RP_{ij} for products parts returns. It is equal zero for non-recyclable products;

RM_{ij} for raw materials extracted from returns to sell in secondary market.

RR_i for waste from returned products.

"i" represents the month.

We note that for each month i, we have:

$$\sum RP \quad \sum RM$$

These values represent the ratios for each different type of returns and as such there summation must be equal to "1".

Equations:

To measure the benefice of the addition of the secondary market option, we measure the cost and the potential benefice of different reverse chain process:

Table 2: Costs and gains of reverse processes for a month I

Process	Cost for month i	Gains for month i
Sorting and recovery	$R_i \times CR \times DP_{i-1}$	0
Remanufacturing for primary market	$R_i \times DP_{i-1} \times RF_i \times CRP$	$R_i \times DP_{i-1} \times RF_i \times SP$
Remanufacturing for secondary market	$R_i \times DP_{i-1} \times RS_i \times SRP$	$R_i \times DP_{i-1} \times RS_i \times SPS$
Products' parts extracting for products j	$R_i \times DP_{i-1} \times RP_{ij} \times CEP_j$	$R_i \times DP_{i-1} \times RP_{ij} \times CPP_j$
Raw materials extracting for raw material k	$R_i \times DP_{i-1} \times RM_{ik} \times CRP_k$	$R_i \times DP_{i-1} \times RM_{ik} \times SRS_k$
Waste disposing	$R_i \times DP_{i-1} \times RR_i \times CD$	0

We will evaluate both the costs and the gains from the secondary market.

4. Case study

Our case study was conducted in a manufacturing automotive cable. Indeed, the manufacturer already has the basic reverse logistics installed in there supply chain and plan on adding the secondary market option.

We chose to study the behavior of the company for one year with a preliminary study to evaluate different rate of returns of each type.

Furthermore, we managed to extract the basic data necessary for the study:

- Extractable products parts: in our case study, they are the types of cables and accessories needed for production;
- Extractable raw material: we chose to take only into consideration the two most beneficial raw materials
- Reverse chain costs;
- Behaviours of returned products;
- We consider that products take once month to return and to be reintroduced in the supply chain.

4.1 Results and analyses

The following graph represents the cumulative cost of the reverse chain:

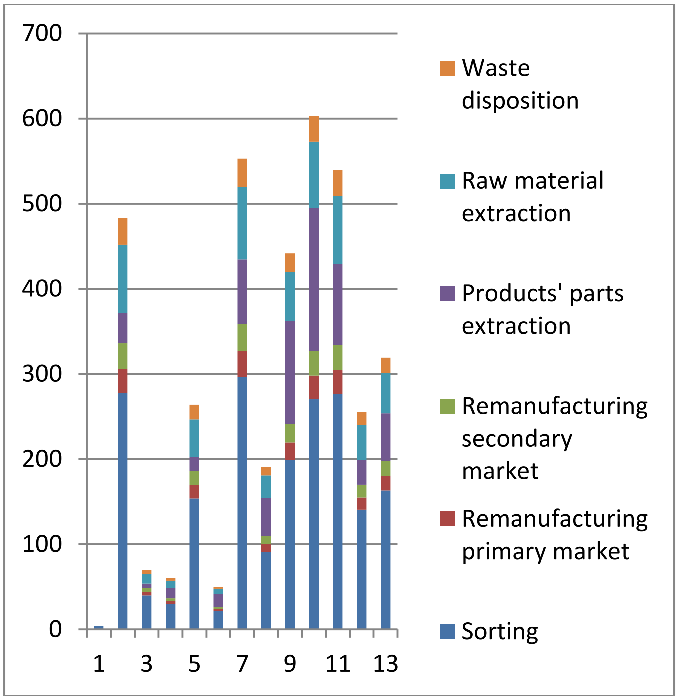

Figure 5. Reverse logistics costs

We notice that the process “sorting” represents the biggest part in the reverse chain costs. It is due to the quantity of products sorting since it treats all the returned products even with a lesser expanse than the other process.

The graph bellow represents the potential benefice from the reverse chain:

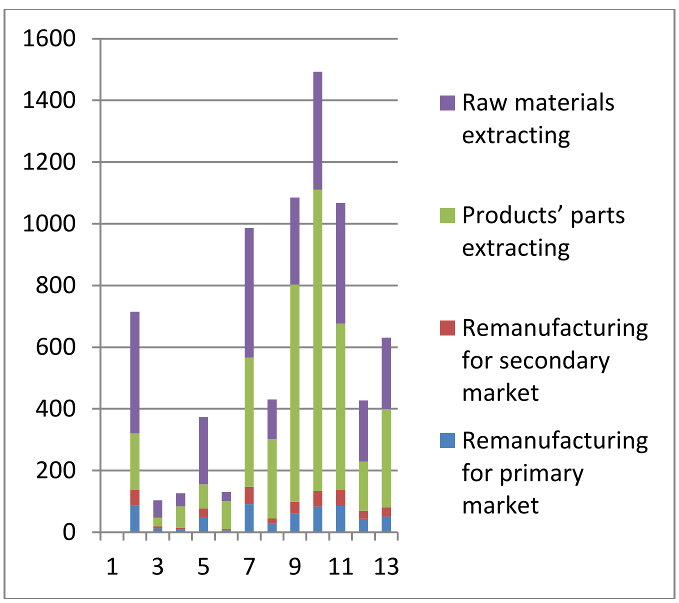

Figure 6. Reverse logistics’ benefices

We notice that overall the benefice gained from the reverse chains is more important than its expenses.

And the primary beneficial process is not from the process “remanufacturing for primary products” as one would expect but it comes from both process “products parts’ extraction” and “Raw materials extracting”. It is due to having bigger ratios from the returned products than both “remanufacturing” processes.

Overall, the global chain is beneficial as the gains are more important than the cost of the reverse chain with the secondary market. The graph bellow proves the benefice of the reverse chain:

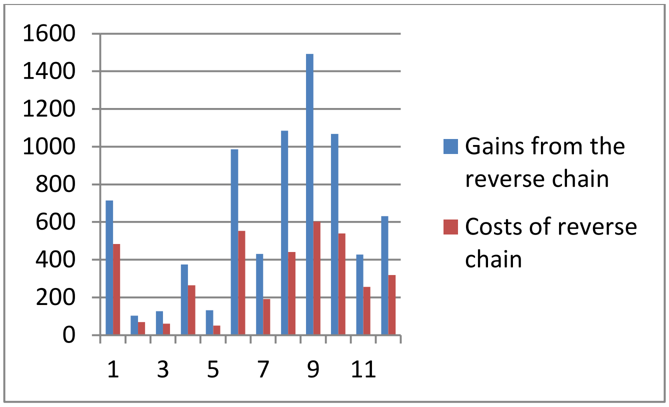

Figure 7. Overall reverse logistics costs and gains

On another note, we found out that the introduction of the secondary market has caused the increase of cost in the reverse chain by “20.28 %” from the basic reverse chain but also increased gains by “44.28 %” with on overall gain benefice in the reverse chain of “81.05 %” based on a previous study of the basic reverse chain process.

5. Conclusion and perspectives

We found out that reverse logistics can become even more profitable with the inclusion of the secondary market even though the increase in of the costs and complexity in the reverse chain. This option remains highly profitable for the company with returns. However, we must be wary of that in certain cases where returned products are low quality; we can have an inverse impact with additional costs instead of increase in gains.

Reverse logistics is a double-edged sword. It could be a source of savings or a source of additional expense reducing the effectiveness of the company instead of supporting it.

Please note that our model is limited to non-perishable products or food products since they can’t be “repaired” for health reasons. However, there are possible profitable returns for these types of products such as packages since they can be cleaned and reused and the transformation of perished products to fertilizer is certain cases. For example, The Coca-Cola Brand recovers glass bottles to be reused in their factories after being cleaned.

As perspective of working for this article, it would be interesting to extend our analysis not only on the impact on the global process but also take into consideration the potential of vehicles routing in the reverse supply chain and stock management.

Finally, it would be to better if we could use prevision methods to study the evolution of the reverse chain and to better manage its randomness.

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Biography

Include author bio(s) of 200 words or less.

Fayçal MIMOUNI received the degree in industrial engineering from The Mohammadia School of engineering, in 2013(EMI) in Rabat. He is a Ph.D. candidate of National School for Applied Sciences in Kenitra (ENSA). His research is the modeling of reverse logistics, predictions systems and logistics.

Pr. Abdellah ABOUABDELLAH Doctor of Science-Applied is the head of the Modeling, Systems Optimization Industrial and Logistics attached to laboratory Systems Engineering at the University Ibn Tofail, Kenitra, Morocco.
Currently, he is professor research at the National School of Applied Sciences, Kenitra. And it is also the director of the engineering sector in industrial and logistics engineering and the director of master in industrial engineering and logistics in ENSA Kenitra. He is the author, co-author of several articles in journals, national and international conferences. His research is the modeling of business processes, predictions systems and logistics.