Financial performance, environmental compliance, and social outcomes: The three challenges of reverse logistics

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Case study of IBM Montpellier

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Abstract

For economic, legal, or strategic reasons, manufacturers of electrical and electronic equipment (EEE) are increasingly managing end-of-life product cycles by choosing a recovery option: refurbishing, remanufacturing, and recycling. Reverse logistics is a process in which manufacturers collect their used products for possible revalorization, recycling, or disposal.

Some authors consider that this activity is an opportunity to achieve a triple bottom line - economics, environment, and social - benefit. However, beyond hypothetical assumptions, little empirical research provides practical knowledge about the way such a challenge can be met. The aim of this article is thus to provide some grounding for this proposal.

Based on an IBM Montpellier case study, this article examines how an integrated reverse logistics model can enable companies to meet three main objectives:(1) Provide economic opportunities through the resale or reuse of machines and parts, (2) successfully deal with environmental challenges such as waste management and legislation compliance, and (3) achieve an important social challenge in terms of local job preservation.

Key words: reverse logistics, sustainable development, closed-loop supply chain, IBM

Since the 1980s, the electrical and electronics equipment (EEE) industry has been expanding and new equipment is constantly flooding the market with ever-shorter life spans or duty services. Thus, according to a report of the United Nations Environment Programme, the volume of EEE waste has been increasing about 3% to 5% each year (PNUE, 2005). Until the 2000s manufacturers were not legally responsible for products' end-of-life management and most EEE was abandoned, landfilled, or exported to countries such as China, India or other African countries. Management of EEE waste has thus become an environmental issue, and for a decade, laws, rules, and ethical charts thrived around the world with the intent of having producers become in charge of their products' return management (Ponce-Cueto et al., 2011).

Reverse logistics is a process in which manufacturers manage products' returns for possible reuse, revalorization, or recycling. Although forward logistics is mainly defined as a unidirectional flow from the producer to the customer, reverse logistics is about going through the supply chain in the other direction. Return management requires a new organization and the implementation of new processes. Hence, it has long been regarded by manufacturers as not a valuable activity (Blackburn et al., 2004; Jayaraman & Luo, 2007). However, since the 1990s, some authors have been assuming that if manufacturers paid as much attention to reverse logistics as traditional logistics, this activity could present not only environmental but also economic and competitive opportunities (Dowlatshahi, 2005; Pourmohammadi et al., 2008; Ravi & Shankar, 2005; Rogers & Tibben-Lembke, 2001; Stock, 1998). Recently, some authors went further by considering reverse logistics as an opportunity to satisfy the threefold objectives of environmental, social, and economic benefits (Ijomah et al., 2004; Richey et al., 2005; Seitz & Wells, 2005). However, these findings lack empirical evidence and the aim of this article is thus to contribute to the grounding of studies that state that reverse logistics could be an opportunity for sustainable development. Based on a case study of IBM Montpellier, we will focus on the model of implemented reverse logistics and examine the driving forces of such a model through considering these questions: (1) What are the economic benefits embraced by this activity? (2) What are the environmental issues? (3) What kind of social purposes can be expected?

The first section of the article presents a literature review on barriers and drivers for reverse logistics implementation. The second part discloses the IBM case study analysis and shows how the integrated reverse logistic model implemented at Montpellier's IBM site (1) presents economic interests through the sale and reuse of parts and machines, (2) integrates environmental issues such as management and recycling of waste and used products, and (3) presents decisive socials stakes for the Montpellier site as part of a local strategy of diversification and job preservation.

Finally, we conclude with a discussion about the results of the study and then more generally about the concept of sustainable development.

1. LITERATURE REVIEW

Until the 1990s, supply chains were developed to support processes covering raw material supplies to finished products delivery. The customer thus represented the end of the process. However, since about 2000, for economic, legal, and strategic reasons, manufacturers increasingly have been managing products return at their end of life and then have designed new business processes (Thierry et al., 1995).

1.1. Reverse logistics: Definition and process

Reverse logistics is a process that transfers responsibility and ownership of end-of-life products from customers to manufacturers or suppliers. As defined by Rogers and Tibben-Lembke (1998, p. 2) 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." In other words, a reverse supply chain can be considered to be a classic supply chain redesigned in order to manage the flow of secondhand products aimed to be recycled (Dowlatshahi, 2000). The literature reviewed enabled us to highlight five main disposal options: remanufacturing, repair, reuse, recycling, and disposal.

Remanufacturing process aims to repackage a used product to a certain level of functioning and quality (Ijomah et al., 2005; Jayaraman et al., 1999; Lambert & Riopel, 2003; Thierry et al., 1995). *Repair* is the process developed to correct specific defects on products or components (Ijomah et al., 2007; Thierry et al., 1995). The objective of *reuse* is to maximize the reuse of parts, components, and materials and create new products (Dhanda & Peters, 2005; Thierry et al., 1995). *Recycling* aims to maximize the dismantling of each product and component in order to optimize the recovery and recycling of metals and raw materials (Dhanda & Peters, 2005; Thierry et al., 1995). Finally, *disposal* concerns components or materials that are not reprocessed or recycled for technical or economic reasons. It can use incineration or landfills (Dhanda & Peters, 2005; Fleischmann et al., 2000).

1.2. Barriers hindering reverse logistics

In the 1990s, Lambert and Stock (1993) described reverse logistics as an abnormal process and said that it was "going the wrong way on a one-way street" (p. 19). Although it becomes essential for producers who have to act in accordance with environmental laws, reverse logistics is often considered expensive and difficult to implement. Indeed, extending the traditional supply chain by including return operations, such as refurbishing or remanufacturing, complexifies operation management and can therefore generate additional costs and organizational concerns (Linton et al., 2007). A first major constraint, often associated with reverse logistics, is economic based: it essentially concerns costs related to new processes such as collection, transportation, and reprocessing of end-of-life products (Byrne & Deeb, 1993; Dhanda & Peters, 2005; Ravi & Shankar, 2005; Rogers & Tibben-Lembke, 2001). In his literature review, Dowlatshahi (2000) explains that one way to reduce these additional costs is to centralize and integrate return flows into transportation modes and networks that are already in place for forward logistics. More generally, he relies on authors such as Fuller (1978), Kopicki et al. (1993), and Thierry et al. (1995) to argue that "minimizing strategic costs depends on effective utilization of current resources, methods, and technologies, which is essential for a successful reverse-logistics system" (Dowlatshahi, 2000, p. 150). The second constraint discussed in the literature is the lack of information about the product to be recycled (e.g., quantity, delivering date, quality level, etc.). Such uncertainty can be enough to jeopardize planning and forecasting (De Brito & Van der Laan, 2009; de la Fuente et al., 2008; Ravi & Shankar, 2005). Many authors investigated the role of information systems on reverse logistic performance. Chouinard et al. (2005), for example, suggest that monitoring and controlling products and processes throughout their life cycle can reduce perverse effects of misinformation. They propose to integrate the flow of returns into existing information systems in order to provide a holistic perspective of the supply chain loop and facilitate control and monitoring of operations. Finally, several studies showed that a main barrier to reverse logistics implementation is the lack of interest and consideration from top management. Product returns are often considered as "junk" and reverse logistics is thus perceived to be a nonstrategic activity (Carbone & Moatti, 2008; Ravi & Shankar, 2005; Rogers & Tibben-Lembke, 2001).

1.3. Drivers to reverse logistics implementation

According to surveys done by Rogers and Tibben-Lembke (2001) and Carbone and Moatti (2008), the first motivation for establishing reverse logistics is the desire to improve customer service and satisfaction. Indeed, competitive advantage no longer lies only in manufacturing and sales of products but also in associated services (Chase & Erikson, 1989; Ellinger et al., 1997). Thus, by taking back products at their end of life and by focusing on activities such as recycling, reverse logistics is a means to improve respectability and customer loyalty (Carbone & Moatti, 2008; Olorunniwo & Li, 2011).

A second main motivation concerns the existing environmental regulations and the need for manufacturers to comply with the growing number of take-back policies (Carbone & Moatti, 2008; Dowlatshahi, 2005; Kumar & Putnam, 2008). Directives such as extended producer responsibility aim to make producers responsible for their products throughout their life cycle (Byrne & Deeb, 1993). Reverse logistics thus enables companies to adapt or even to anticipate environmental directives (Carter & Ellram, 1998; Donald, 1999; Ravi & Shankar, 2005; Thierry et al., 1995). According to some authors, legislation constraints might not be the only environmental driver of reverse logistics implementation. Carbone and Moatti (2008, p. 66) argued that some "companies have already adopted a 'green attitude' and thus see in reverse logistics a mean to reduce their environmental footprint." Finally the last main driver that emerged from the literature concerns economic perspectives. Some authors assert that reverse logistics can bring new sources of revenue to firms (De Brito & Dekker, 2002; Olorunniwo & Li, 2011): each year an increasing amount of products are trashed and still have an important residual value (Sahyouni et al., 2007). Although used products' management may be perceived as the end of the supply chain, it actually represents a new life cycle for many products that are recovered and reintroduced on the secondhand market (Dowlatshahi, 2000; Jayaraman et al., 1999; Melbin, 1995; Thierry et al., 1995).

Since the 2000s, research on reverse logistics has thus been trying to overcome difficulties and constraints of reverse logistics implementation. It has attempted to demonstrate that it is not just a cost center or a response to institutional pressure of existing environmental directives but also "a potential source for a sustainable competitive advantage" (Mazahir et al., 2011, p. 93).

Table 1 proposes a synthesis of main barriers, solutions, and motivations that emerged from the literature reviewed.

Table 1: Barriers, solutions, and motivations of establishing reverse logistics

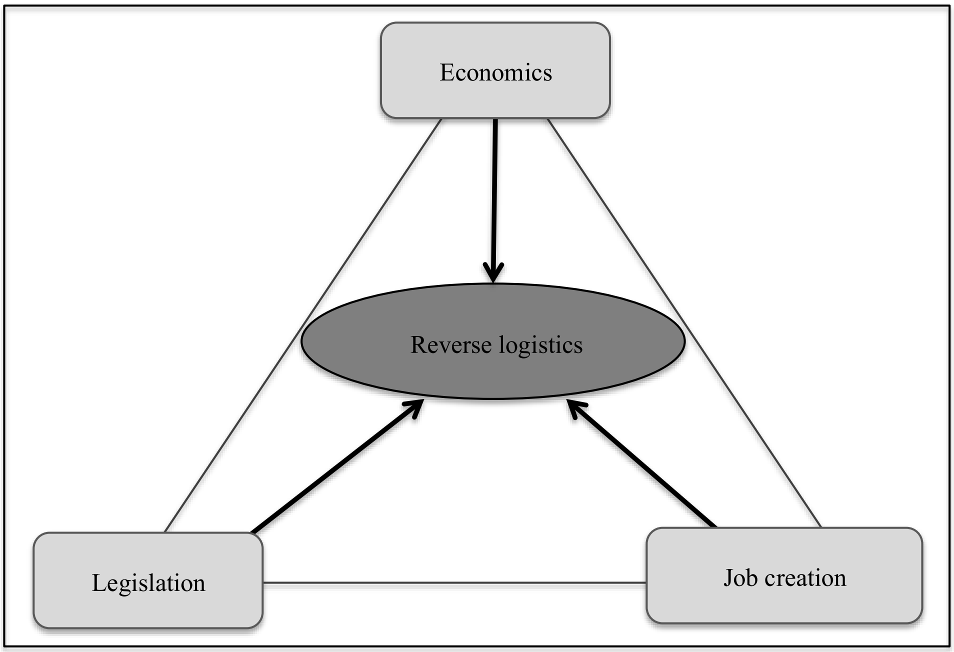
Barriers	Cost of collection, transportation, and reprocessing	Stock (1992); Byrne & Deeb (1993); Rogers & Tibben-Lembke (2001); Dhanda & Peters (2005); Ravi & Shankar (2005)
	Operational difficulties due to returns uncertainty	Ravi & Shankar (2005); de la Fuente et al. (2008); Carbone & Moatti, (2008); De Brito & Van der Laan (2009); Georgiadis & Athanasiou (2010)
	Lack of interest from top management	Rogers & Tibben-Lembke (2001); Ravi & Shankar (2005); Carbone & Moatti (2008)
Solutions	Integrate reverse logistics into forward logistics	Fuller (1978); Kopicki et al., (1993); Stock (1998); Dowlatshahi (2000, 2005); Fleischmann (2003); El Korchi & Millet (2011)
	Centralize returns	Dowlatshahi (2000); Rogers & Tibben-Lembke (2001); Fleischmann (2003); El Korchi & Millet (2011)
	Develop strong information systems to support returns management	Raimer (1997); Dowlatshahi (2000) Chouinard et al. (2005); Dhanda & Hill (2005)
Motivations	Respond to customer expectation and increase satisfaction and loyalty	Ellinger et al. (1997); Rogers & Tibben-Lembke (2001); Stock (2001); Dowlatshahi (2005); Carbone & Moatti (2008); Olorunniwo & Li (2011)
	Comply with existing environmental regulation	Thierry et al. (1995); Carter & Ellram (1998); Rogers & Tibben-Lembke (2001); Dowlatshahi (2005); Ravi & Shankar (2005); Carbone & Moatti (2008) ; Kumar & Putnam (2008)
	Environmental protection/“green attitude”	Srivastava (2007); Carbone & Moatti (2008); Mazahir et al. (2011)
	Revenue generation	Jayaraman et al. (1999); Dowlatshahi (2000); De Brito & Dekker (2002); Sahyouni et al. (2007); Mazahir et al. (2011); Olorunniwo & Li (2011)
	Expense reduction	Thierry et al. (1995); Donald (1999); Rogers & Tibben-Lembke (2001); Olorunniwo & Li (2011)

1.4. Reverse logistics and sustainability

Sustainable development has been defined as “paths of progress which meets the needs and aspirations of the present generation without compromising the ability of future generations to meet their needs” and that “it is not only a new name for environmentally sound management, it is a social and economic concept as well” (Brundtland, 1987, p. 4). Recently, some authors make the connection between reverse logistics and sustainability by assuming that returns management could be seen as a means to operationalize sustainable development at the company level (De Brito, 2004; De Brito & Dekker, 2002; Ijomah et al., 2007; Linton et al., 2007; Pourmohammadi et al., 2008; Richey et al., 2005; Seitz & Wells, 2005; Vasudevan et al., 2012). According to the definition previously stated, this assertion would mean that reverse logistics could represent an opportunity to achieve the famous triple bottom line of environmental, economic, and social benefits. An analysis of this literature shows that there are some gaps and divergence in the way those studies consider sustainability. If authors mostly agree on the economics and environmental benefits of reverse logistics that we previously mentioned, they do not all agree on the social aspect of reverse logistics, which could make it sustainable. The first part of these studies focuses on the economic and environmental benefits of reverse logistics but does not consider the social aspect of sustainable development (Ijomah et al., 2007; Pourmohammadi et al., 2008; Vasudevan et al., 2012). The second part of the literature considers that reverse logistics can be seen as part of sustainable development because, in addition to providing economic and environmental opportunities, it meets a driving force of corporate citizenship. According to de Brito and Dekker (2002), “corporate citizenship concerns a set of values or principles that in this case impel a company or an organization to become responsibly engaged with reverse logistics" (p. 8). They add that "one could regard reverse logistics as the implementation at the company level by making sure that society uses and re-uses both efficiently and effectively all the value which has been put into the products" (De Brito & Dekker, 2002, p. 4). Linton et al. (2007), Richey et al. (2005), as well as Seitz and Wells (2005) agree with De Brito and Dekker because they consider that reverse logistics is used to extend the life of a product and thus that it is involved in the struggle against resource depletion and more generally that it "works against the design for obsolescence typical in a consumption-oriented society" (Linton et al., 2007, p. 1078). Finally, De Brito (2004) considers that the drivers for implementing a reverse supply chain are the same as those for sustainable development because it generates savings and revenue on the one hand and allows compliance with environmental legislation on the other hand. Finally she considers that it can present social benefits of job creation (De Brito, 2004). Lund and Hauser (2010) support this statement because they consider that "remanufacturing provides a number of important benefits: greater availability of products and lower prices to customers, employment and industrial skills training to workers, and conservation of material and energy resources to society" (p. 1). They review remanufacturing activity in the United States and come to interesting conclusions concerning the opportunity of job creation: according to them, the activity of remanufacturing provide opportunities for local jobs because in the United-States, the majority of used products are collected, sorted, reworked, and reconsumed locally. They conclude their study by stating that "a remanufacturing industry tends to stay at home, a domestic industry that provides local employment and training" (Lund & Hauser, 2010, p. 6).

Our review of the literature shows that beyond the economic and environmental benefits traditionally discussed in the literature, reverse logistics could present a social stake for companies: an opportunity to create or preserve local jobs. Reverse logistics implementation would therefore be motivated by three major drivers, which are economic benefits, environmental legislation, and job creation (figure 1). However, these findings lack empirical evidence and to our knowledge the literature doesn't provide any case studies that show that economic, environmental, and social drivers can simultaneously emerge from a project of reverse logistics implementation. Based on a case study of IBM Montpellier, this work aims to contribute to the empirical grounding of the viewpoint that reverse logistics could be an opportunity for sustainable development. After presenting the model implemented in terms of processes and structure, we will focus on the economics, environmental, and social challenges of such a model.

Figure 1: The driving forces of reverse logistics implementation



Source: authors; adapted from De Brito and Dekker (2002)

2. CASE STUDY – REVERSE LOGISTICS AT IBM MONTPELLIER: FRAMEWORK CHARACTERISTICS AND STAKES

Research context and methodology

IBM is often cited in the literature as one of the pioneers in the field of reverse logistics (Arensman, 2000; Dhanda & Peters, 2005; Ferguson, 2000; Fleischmann et al., 2003; Grenchus et al., 2001) and turns out to be a suitable organization to use for a case study to examine reverse logistics processes and drivers. The case study is a methodological approach that enables (1) an in-depth understanding of the phenomenon studied (Miles & Huberman, 2003) and (2) an examination of "a contemporary phenomenon in its real-life context" (Yin, 1981, p. 59). This approach is thus particularly adapted to the purpose of our study, which consists of bringing empirical evidence to a proposal that, for now, remains mainly theoretical.

Data were collected at the IBM European Return Center located in Montpellier, France. For more than fifteen years, this site has been developing reverse logistics activities to reuse, recycle, or remanufacture used products recovered from customer sites. Between December 2009 and November 2011, we conducted 41 semi-structured, in-depth personal interviews of one and one-half hours' duration on average, 16 with local senior managers, 15 with operational managers, and 10 with employees (table 2). Based on the literature review presented previously, we constructed an interview guide to focus our interviews on the following questions: (1) what is the model of reverse logistics implemented and (2) what are the motivations and challenges of such a model? We therefore questioned practitioners about the various recovery processes, about the way they overcame the barriers to implementation highlighted in the literature, and finally about the economic, environmental, and social benefits of reverse logistics for IBM and especially for the Montpellier site. The 41 interviews were recorded by tape and subsequently transcribed. We then read and reread each interview before moving on to coding them in order to classify and analyze our data according to the main themes discussed (Savoie-Zajc, 2000).

We also collected secondary-order data such as press reports, financial reports, and company internal records. In addition, we also relied on full-time in situ observations through a three-year research contract signed with IBM. This allowed us to become involved in various projects led by local management teams and participate in strategic decisions at a senior management level. Our position of research-participant immersed in a research field allowed us to grasp the information richness generated by the social context of the firm. Observing and meeting actors during their daily working situations and not only during formal and isolated interviews provided additional empirical data. Finally, we presented the findings of our study to some managers of IBM Montpellier in order to meet a target of internal validity.

Table 2: Interviews conducted

Interviewees	*Number of interviews*	*Duration*	*Data/information collected*
Local senior managers	16	27h	Site and company history
			Local strategy
			Social stakes of job preservation
Managers/employees	25	39h20	Reverse logistics processes
			Economic issues and opportunities of reverse logistics
			Environmental issues/regulations on waste management
	41	**66h20**	

2.1. Returns reprocessing options

Since 1995, IBM has been developing business solutions for collecting and processing end-of-life hardware items. Initially each IBM European site had its own customer return center and thus had its own resources, infrastructures, and partnerships with brokers and recyclers.

At the end of the 1990s, to improve economies of scale, IBM chose to apply a centralized model in Europe consisting of combining and consolidating all reverse logistics operations and flows within a single European center. From this perspective, the IBM Montpellier site became the European return center, in charge of collecting and processing returns from all European IBM entities.

Two different types of flows return to the Montpellier site:

Component returns:

- Defective components from IBM repair centers
- Operative components of customers subjected to a configuration upgrade
- Components from various IBM storage locations because of surplus or obsolescence

Machines returns:

- Servers from customers after end of lease
- Servers from customers after contract renewal

Once collected and back at the IBM Montpellier site, used products are then submitted to reprocessing options (see figure 2):

Remanufacturing/refurbishing: When servers come back after end of their lease, they are tested and, according to their model and customer demand, they go through a refurbishing or remanufacturing process before being resold on the secondhand market. Remanufactured servers are composed entirely of used components and modules. They are reworked (parts added or remove), tested, and finally resold as IBM-certified machines without any warranty. Refurbished servers are composed of used components but can be supplemented with new ones. These machines are then labeled as "hybrid machines." They are reworked and then tested to finally be sold on the secondhand market with the same contract and the same guarantees as new products. Defective servers or the obsolete ones are redirected to the recycling process.

Reuse: According to their value and depending on the needs of IBM's worldwide production, when compliant parts come back from customers after an upgrade, they can be reused internally in two different ways:

- Reuse in a new market: once they came back, used components are reworked (internally or by an external provider), tested, cleaned up, and relabeled as "equivalent to new components." They can then be reused in the production chain of new servers.
- Reuse in a secondhand market: used components can also be reused "as is" by IBM production of secondhand servers.

Low-value components or the obsolete ones are redirected to the recycling process.

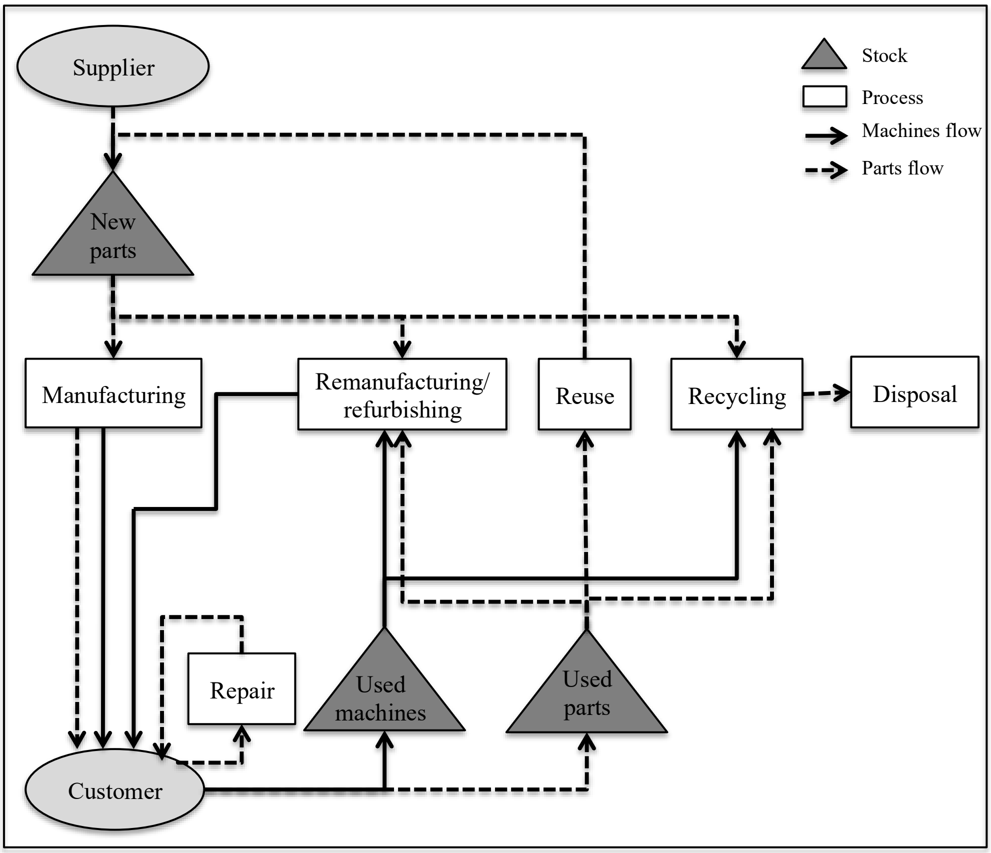
Repair: When defective parts come back from customer sites to IBM repair centers, they are first tested in order to determine the failure causes. They are then sent to the original manufacturer to be repaired and, after, sent back to the Montpellier site for a final test before being transmitted to repair centers. Non-repairable components are redirected to the recycling process.

Recycling: Used products that are not candidates for the reprocessing process described previously are dismantled and can then be recovered in three different ways: (1) parts sales to brokers, (2) precious metals revalorization, or (3) raw material recycling.

Disposal: Some raw materials or chemical products cannot be recycled and are then incinerated with energy recovery. Doing this, no residual waste is sent to a landfill.

Figure 2 shows how these processes integrate the traditional supply chain for closing the loop. At the IBM Montpellier site, the classical linear model of the supply chain thus gives way to a circular pattern through which recovered products are reincorporated into the traditional supply chain. This integrated model that many authors call a *closed-loop supply chain* thus includes forward and reverse logistics flows (Fleischmann et al., 2003; John et al., 2007; Krikke et al., 2004; Seitz & Wells, 2005).

Figure 2: The closed-loop supply chain: Integrating forward and reverse logistics



2.2. Minimize economic and operational barriers by integrating reverse logistics into the existing supply chain

Since 1965, IBM Montpellier's plant has produced and assembled servers so it gradually developed the core competencies, resources, and infrastructures required in a traditional supply chain. The choice of implementing reverse logistics at the Montpellier site allowed many synergies in terms of infrastructures, resources, and information systems.

2.2.1. Integrate reverse logistics to forward logistics: Reduce implementation cost and operational difficulties by pooling infrastructures and resources

When reverse logistics was implemented at IBM Montpellier, the site already had developed facilities and equipment necessary for storage, assembly, and testing of new servers. Synergies could therefore be operated and reverse logistics could now using the same assembly chain, the same test rooms, and the same warehouse as the ones in the traditional supply chain. In the same way, when reverse logistics started at IBM Montpellier in the 1990s, the site already had required resources and skills for new server manufacturing. Hence, resources synergies developed and today, the same executive team manages, on the same production line, new and used machines. A similar observation can be done at production support functions: people in charge of finance, engineering, accounting, and production control for new components and machines are also in charge of these functions for used materials. The integration of reverse logistics within a traditional logistics chain enables reusing the infrastructure and resources already available, and thus minimizes the cost of implementing reverse logistics. This integration also enables minimizing operational difficulties related to the implementation of such a process by reusing knowledge and experience already acquired during forward logistics operations.

2.2.2. Integrate part return forecasts in inventory management

When an upgrade is installed on a customer's machines, new components replace others, which are then dismantled and returned to the Montpellier site. This is when the reworking process starts leading to an equivalent-to-new (ETN) status and reuse of new machines. To optimize reuse, IBM Montpellier integrates these component returns in the planning system: the total coverage of need calculation[1] component inventories already refurbished, and also three forecasted stock levels:

- Short-term inventory forecasts that rely on components already returned to the site but not yet refurbished. This stock is valued as 100% in need coverage.

- Middle-term inventory forecasts that rely on upgrades that have already been shipped to customers and for which the associated returns are known but not yet received at the site. Of this stock, 80% is included in coverage letting and there is 20% of uncertainty about the final quality or quantity.

- Long-term inventory forecasts that rely on upgrade shipping forecasts. Only 50% of this stock is included in the coverage, allowing 50% of uncertainty about actual volumes shipped and final quality or quantity of returns.

The integration of these three levels of forecasted returns allows IBM to maximize return anticipation and to prioritize reuse over purchasing or new components manufacturing.
In a same vein, IBM developed information systems that take into account worldwide IBM manufacturing needs and to compare them with worldwide inventory of reworked components ready for reuse. Hence, components reworked in Montpellier can be shipped to a Singapore plant for manufacturing purposes.
The case study of IBM Montpellier reveals that a reverse logistics channel is widely integrated into forward logistics in terms of processes, resources, skills, information management, and infrastructure.
This integrated framework allows the Montpellier site to overcome operational and economic barriers often experienced by firms during reverse logistics implementation and thus to consider economic, environmental, and social opportunities.

2.3. An economic opportunity: Reduce expenses and generate revenue

Our case study highlighted three types of economic opportunities related to reverse logistics activity:

(1) Developing additional revenue through the sale of hybrid and remanufactured machines

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[1] Needs calculation is a process that uses a manufacturing program, BOM (bill of materials), and inventory levels to calculate components needs

As the European center of IBM returns, the Montpellier site has a stock of used servers and components. We described in the previous section that with this stock, IBM Montpellier proposes two types of reworked machines for the European market: remanufactured servers and hybrids servers. Each of them targets different markets: remanufactured servers are slightly reworked and sold on the secondhand market without warranty. They cater to customers with small budgets or no need for a brand-new model. Hybrid machines are customized and combine new and used equipment in a special configuration. They do not always have an equivalent new model. They have the same guarantees as a new machine and cater to customers who need a specific configuration that only these hybrid machines can satisfy.
Both types of machines, reworked from used components and servers, allow IBM to better adapt its products to customers' needs and thus to enlarge its target market.

(2) Reduce company's expenses through parts reuse

In the previous section, we explained how IBM Montpellier manages compliant part returns coming back from customers after a configuration upgrade. Through the reuse process, components are reworked and added into the supply planning. So, if the Montpellier site has a stock of ETN components that are necessary for IBM worldwide server manufacturing, then this stock use will be prioritized over new component purchasing. The case of XY processors illustrates how the company achieved cost savings because of reverse logistics. In 2009, 72 of these processors came back to the Montpellier site after customer upgrades. The same year, the Dublin (Ireland) manufacturing plant needed 100 XY processors to cover its production plan. The 72 used processors stored at IBM Montpellier were thus taken into account as coverage during the calculation of Dublin's needs. Throughout 2009, Montpellier's plant thus reworked these processors and became Dublin's main source of supply for processors. In 2009, 72 processors were reused, which generated up to several million dollars of cost savings for IBM.

(3) Generate revenue through revalorization of precious metals

Some components contain precious metals such as gold, silver, palladium, and copper. After being dismantled, these components are then sent to specialized eliminators that extract precious metals and sell them back to IBM. Revalorization allows Montpellier's site to generate additional revenues and thus to fully recover the costs of dismantling, sorting, and recycling.

2.4. An environmental challenge: Preserving resources and integrating requirements of environmental directives

(1) "Maintain environmental leadership"[2] and preserve resources

In 1971, IBM established its first corporate policy on environmental protection. In line with this socio-political strategy, the corporation developed IBM's global environmental management system (EMS). An end-of-life product management program has been developed

[2] Mr. P., IBM environmental responsible for France, Italy, Greece, Cyprus, and Malta, interview January 2, 2011.

through this EMS and one of its objectives is to reuse and recycle products in order to limit the volume of residual wastes sent to landfill to 3%. Mr. P., environmental manager for IBM France explains:

"Montpellier's site does not send any waste to landfill (...) it has therefore developed partnerships with a large channel of recyclers, specialized in glass, plastic, paper, or ferrous metals. These recyclers were selected and certified by IBM according to environmental criteria in accordance with legal requirements."

Source: Mr. P. interview, January 2011

Reverse logistics thus provides IBM component traceability ensuring that disposal is carried out in a responsible way.
As we presented previously, the reverse logistics process implemented at IBM Montpellier aims to maximize the reuse of used servers and components. Prioritizing reuse enables IBM to reduce purchasing and manufacturing of new components and thus reduces natural resources consumption.

(2) Comply with environmental regulatory requirements

Since 2000, in response to the worrying increase of EEE waste, environmental directives have been implemented in order to make producers responsible for their products' end of life and to minimize their carbon footprint. The WEEE[3] directive entered into force on August 2005 and forced manufacturers to collect and to recycle end-of-life EEE.
Before, the responsibility was on the back of the last product owner. This directive transferred the responsibility for the collection and reprocessing of end-of life equipment to the manufacturer for material put on the market after August 2005. Nearly at the same time, the RoHS[4] directive (Restriction of Hazardous Substances) entered into force in Europe on July 1, 2006, and aimed to limit the use of certain hazardous substances in EEE.
These directives revealed that in recent years, an environmental approach is thriving and requires that EEE manufacturers reconsider their ecological responsibility.
Since the 1990s (50 years before the RoHS directive), IBM abandoned the use of certain substances in its products such as cadmium, polybrominated biphenyls (PBBs), and polybrominated diphenyl ethers (PBDEs) (substances noted in the RoHS directive). Since 1995, (10 years before the WEEE directives), IBM developed a solution for the collection and the reprocessing of end-of-life hardware. This activity enabled IBM to comply with European ecological policy about EEE waste before related directives entered into force.

2.5. A major social stake: Preserving local jobs

In the early 1990s, similar to many others multinational companies, IBM evolved toward a global strategy. The group decided to centralize its manufacturing activities and established new plants in emerging countries representing incentives in terms of labor cost or tax savings. With the emergence of these new sites, internal competition intensified and Montpellier's site

[3] WEEE directive 2002/96/EC.

[4] ROHS directive 2002/95/EC.

faced a decrease in its initial manufacturing activity. It thus quickly became confronted with a major social issue: how should it cope with the downsizing of its manufacturing activity? How should it maintain local jobs? As explained by Mr. B., plant manager in the mid-1990s, to survive, the Montpellier site had to diversify its business and to find new missions to generate income justifying the preservation of local jobs:

> *"We had to ensure that the site did not remain only a manufacturing plant. Because manufacturing business was prone to relocation, we were competing with other sites likely to challenge our core competencies. It was therefore necessary to put a kind of lifeline around the plant to keep it from sinking, to fix it locally."*

Source: Mr. B. interview, October 2011

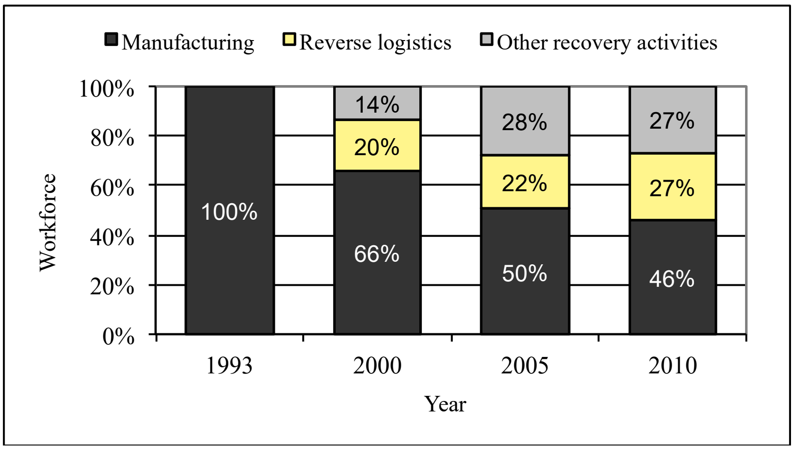
Reverse logistics is one of the activities that was developed in Montpellier in the mid-1990s with the aim of anchoring the site locally and maintaining jobs. As a current representative explains:

> *"For fifteen years, this activity allowed us to accompany the downsizing of manufacturing activity: as of today, reverse logistics made it possible to convert, and thus to save, 25% to 30% of the workforce that was affected by manufacturing activity in the early 90s."*

Source: Mr. D. interview, October 2011

Figure 3 illustrates this local strategy of diversification. It represents the evolution from 1993 to 2010 of the percent of the workforce's activity allocated to manufacturing and the part allocated to alternative activities (reverse logistics included). It reveals that although the whole workforce was dedicated to manufacturing activity in 1993, 17 years later, more than half of the resources were recovered by income related to alternative missions (one-quarter by reverse logistics).

Figure 3: Ratio of IBM Montpellier headcount by business from 1993 to 2010



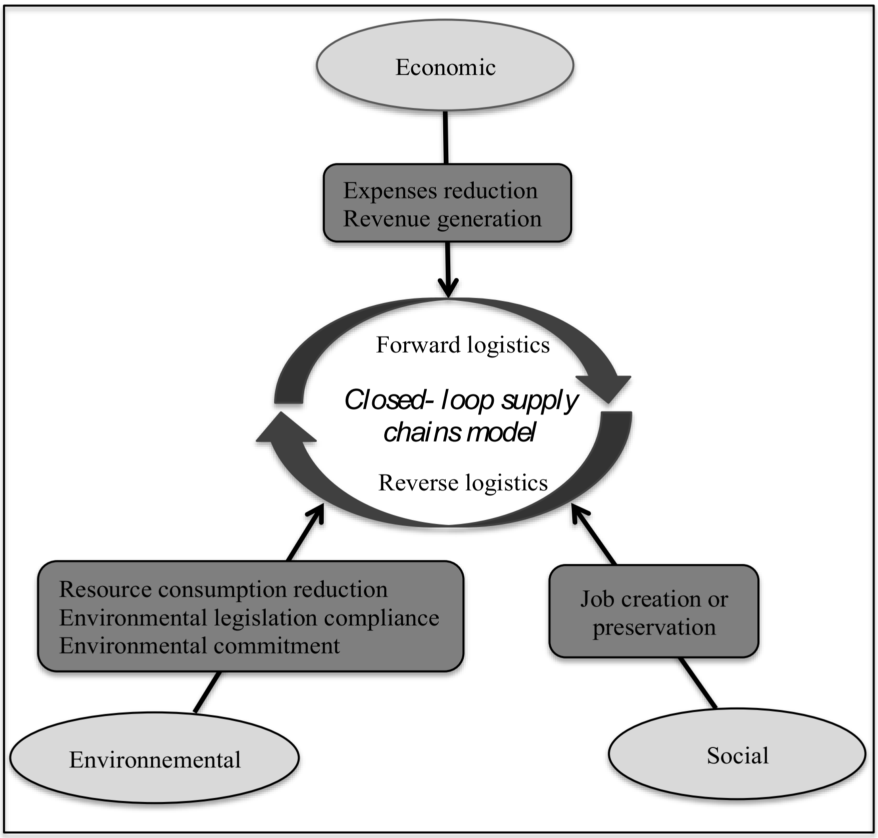
CONCLUSION AND DISCUSSION

The aim of this article was to contribute to the grounding of studies that state that reverse logistics could be an opportunity for sustainable development (De Brito, 2004; De Brito & Dekker, 2002; Ijomah et al., 2007; Linton et al., 2007; Pourmohammadi et al., 2008; Richey et al., 2005; Seitz & Wells, 2005; Vasudevan et al., 2012). To do this, we conducted a case study at IBM Montpellier in which the objectives were to (1) observe the processes and structure of the reverse logistics model implemented and (2) understand the economic, environmental, and social motivations and challenges of reverse logistics activity for IBM and particularly for IBM Montpellier.

Our empirical observations first revealed that synergies between reverse logistics and the existing supply chain, in terms of processes, resources, information systems, and infrastructures, reduce the operational and economic barriers often mentioned in the literature. We then demonstrated that this integrated model of reverse logistics presents economic and competitive opportunities for IBM because it enables the (1) generation of additional sales by offering secondhand material adapted to the needs and the budget of some customers, (2) reduction of expenses by reusing some parts and components and (3) generation of incomes through precious metals revalorization. Our observations are in line with authors who suggest that depending on the way they are managed, various return processing options may present financial and competitive opportunities (Andel, 1997; Jayaraman & Luo, 2007; Rogers & Tibben-Lembke, 2001; Stock & Mulki, 2009). Our study also highlights that reverse logistic allows IBM to deal with some key environmental challenges: (1) ensuring a responsible waste management and (2) complying with various laws and directives about end-of-life product management. These observations are therefore consonant with the work of authors who see in reverse logistics a way for manufacturers to conform with directives on handling the waste from EEE while improving their green reputation (Dowlatshahi, 2000; Kumar & Putnam, 2008; Seitz, 2007; Thierry et al., 1995). Finally, our study revealed that reverse logistics presents a major challenge for the IBM Montpellier site, little mentioned in the literature: the social stake of local jobs preservation. Indeed, in the case of IBM Montpellier, more than 25% of the workforce affected by the manufacturing activity is now assigned to the reverse logistics mission. This activity is thus part of the local diversification strategy, which aims to support the manufacturing downsizing by paying off resources with additional revenue generated through alternative activities. For more than fifteen years, this activity has allowed the Montpellier plant to maintain its workforce despite the decrease in server manufacturing activity.

We can thus conclude that a closed-loop supply chain model, which integrates forward and reverse logistics, can present an opportunity for companies to simultaneously meet the three main objectives of sustainable development: (1) economic benefits through savings and revenue generation, (2) environmental responsibility through legislation compliance and resource preservation, and (3) social challenges of job creation or preservation. Figure 4 summarizes those findings.

Figure 4: The driving forces of an integrated reverse logistics framework



Source: authors

Finally, we would like to moderate considerations that could be drawn with regards to our results. Although our case study reveals that reverse logistics is likely to present economic, environmental, and social benefits, we cannot pretend to assert that there is "convergence of economical, ecological and social interests" (Reynaud, 2004, p. 118) and we thus cannot describe reverse logistics as being a "sustainable activity." Indeed, it is often assumed in the literature that to be qualified as sustainable, an activity not only has to contribute to the "three pillars" but also raise a homogeneous equilibrium among the three components (Capron & Quairel, 2006; Giddings et al., 2002; Lauriol, 2004). Without claiming that we carried out an accurate comparative study of each component's weight, we believe that our two years of observation and interviews allow us to argue that there is a certain hierarchy among these three components. Indeed, we noticed, for example, that the strategic and economic actors are regularly interacting on issues related to reverse logistics perspectives. At the opposite end, interactions with stakeholders related to environmental components were very rare or nonexistent. It thus seems that actors championing environmental issues are very present and active at the Montpellier site but they don't often interact with economic and strategic actors. We can then wonder about the weight of the environmental component in strategic decision making and therefore about the potential balance of economic, social, and environmental pillars. Finally, it appears obvious to all stakeholders interviewed that although a reverse logistics business actually presents a challenge of sustainable development, profitability remains the determinant condition in maintaining this activity at the Montpellier site. Is it

surprising to notice that even though social and environmental components may reduce the overwhelming weight of economic variable, it does not necessary mean that these three components are perfectly balanced? Considering the current model in which economy and finance are widely dominant, can we pretend that we have noted a “harmonious balance” among economic, environmental, and social components?
We even think that it may be interesting to conduct further research that does not seek to find whether such a balance is possible but whether the concept of sustainable development is an illusion. We thus tend to agree with authors such as Latouche (2001), Morin (2009), and Partant (1984), who believe that sustainable development is a utopia, a myth that is only “the last in a long series of ideational innovations that aim at bringing a part of dream in the harsh reality of economic growth” (Latouche, 2001, p. 79).

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