Challenges and opportunities for reverse logistics initiatives in the automotive industry

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Abstract
This paper investigates the main strategies automotive companies adopt to address the issue of dealing with end-of-life vehicles and spare parts. Furthermore, it investigates the reasons behind take-back strategies, i.e *how* and *why* automotive companies undertake initiatives in reverse logistics. The research findings indicate that companies are trying to respond to the end-of-life legislation based on cost-effective approaches as well as corporate environmental responsibility. Outsourcing is used when expertise is found to extract value from scrap and there is cooperation with suppliers and vendors to facilitate the dismantling of cars and recycling of parts.

Keywords: automotive industry, reverse logistics, end-of-life, environmental management.

Introduction
The automotive industry is a key sector of the economy in almost every major country in the world (e.g. Japan, USA, China, Germany, South Korea, France, Brazil) and it continues to grow, registering a 30 percent increase between 1995 and 2005 (Oica, 2008). OICA (2008) reported that the world's automotive industry produced over 66 million vehicles in 2005.

Only a few years after leaving the factories where they are made most cars reach their end-of-life. In Europe alone over 9 million tonnes of automotive waste is generated each year (Coates, 2007). Although 75% of the content of cars is reused, recycled, or recovered, the remaining share, referred to as the Automobile Shredding Residue

(ASR),[1], is disposed of by landfilling (Bellmann and Khare, 2000) , causing serious threats to the environment.

The increasing number of cars on the road worldwide and the environmental impact associated with them has made the final destination of end-of-life vehicles and parts a global concern.

However, the solution for the problems associated with the end-of-live of vehicle is not obvious. Cars are complex products consisting of several types of materials (steel, aluminium, plastics, precious metals, etc), which can create difficulties and significant environmental impact if having inappropriate final disposal. Table 1 shows the environmental aspects and impacts from end-of-life of cars.

Table 1 –Environmental aspects and impacts of end-of-life vehicles (Nunes and Bennett, 2010)

Activities	Environmental Aspects	Environmental Impacts	Category	Type
End of life				
Collection, dismantling, reusing, remanufacturing and recycling	Energy consumption	Depletion of natural resources and pollution	Regional	Negative
	Avoidance of irresponsible disposal Re-use of materials	Conservation of natural resources	Regional	Positive
End-of-life disposal	Landfill disposal	Depletion of natural resources and Soil contamination	Regional	Negative

Given the complexity and importance of the global automotive industry and the dearth of research on this topic, further investigation on the way automotive companies engage in reversing their supply chains is needed. In addition, it is also important to understand the reasons behind the decision for engaging in how to deal with end-of-life vehicles (ELV), i.e, what are the ELV initiatives in the context of the automotive industry and why are they carried out?.

This investigation is relevant for both theory and practice. Considering that automotive companies operate through large and centralised manufacturing plants that are globally dispersed, what are the best practices to foster appropriate treatment of ELVs and their parts?

Literature Review

Although environmental issues are somewhat mature in relation to the manufacturing processes, new demands towards end-of-life vehicles and their parts are of more recent concern within automotive manufacturing companies Discarded cars have many reusable components and materials, but they are often simply scrapped because it is too expensive to recover them. Thus, criteria are needed to identify what can be reused.

[1] ASR is composed of plastics, glass, textiles, rubber and various hazardous substances.

Fleischmann et al. (1997) suggested a number of criteria based on (1) reuse motivation, (2) type of recovered items, (3) form of reuse, and (4) involved actors.

According to Fleischmann et al. (2000), product recovery networks comprise the following functions: (1) collection; (2) inspection/separation; (3) re-processing; (4) disposal; and (5) re-distribution. Dowlatshahi (2005) considers the strategic factors for reverse logistics, explaining the implications of cost, quality, customer service, environmental concerns and finally, political/legal concerns.

The European Working Group on Reverse Logistics defines the concept as:

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

End-of-life policies for automobiles have indeed attracted the attention of a number of scholars (Giannouli et al, 2006; Seitz, 2007; Smink, 2007). Nonetheless, because of the complexity of this issue it is far from clear how companies should approach the problem and how governments ought to design environmental policies with little harm to companies' cost structures and their competitiveness. Smink (2006), for example, has assessed whether government regulations have been a driving force for car dismantling in Denmark, while Seitz (2007) considers the remanufacturing of engines as a possibility to reduce environmental impacts. The intention of extending vehicles' life as a way to reduce end-of-life environmental impacts is raised. However, this approach can be ecologically adverse if the 'old' cars are much less efficient than the new models launched onto the market. Given the complexity of life-cycle analysis and environmental impact assessment, in Switzerland Spielmann and Althaus (2007) note that it is not possible to provide any general recommendation to car owners to extend the use of their cars in the short term.

As part of activities of operations function, the state-of-art in reverse logistics is ultimately linked to studies of industrial symbiosis and ecology. Both concepts have been theoretically derived in the late 1980s by Frosch and Gallopoulos (1989) in their seminal paper 'Strategies for Manufacturing'. Industrial symbiosis and ecology can be understood *as manufacturing systems having behaviour analogous to a community of biological organisms in which everything produced, either living or dead, is used by some organism for its own metabolism* (Martin, 2001).

Ironically, industrial ecology was suggested when there was a massive push for global trade through the opening of new markets, reductions in tariffs, technological gains resulting in lower trade costs, and consequent higher production output in globally dispersed large manufacturing plants. As a consequence, dispersed production systems were seen to provide competitive advantage, while industrial ecology projects in the 1990s were rarely meeting the economic viability standards required for their implementation in the market place. Chertow (2007) has reviewed the efforts to replicate Denmark's success with an industrial symbiosis system, noting that few of the attempts have indeed proved to be economically viable. Therefore, new policy proposals are necessary to make the idea thrive as a viable alternative to the established concept of manufacturing networks. However, as oil prices increase and global demand adds to the risk of scarcity of raw materials as well as threatening our ecological environment, the practices of industrial symbiosis and ecology are again gaining attention (Mirata, 2004).

Research Methodology

The research problem was addressed using a qualitative methodology and by gathering both primary and secondary data. Being a contemporary issue and dealing with '*why*' and '*how*' questions, the case study method was chosen as the research strategy due to its benefits when investigating complex issues within their current operations context (Yin, 2003).

Its first phase,semi-structured interviews were conducted within divisions of the three largest global automotive companies (GM, Toyota, and Volkswagen). In the second phase, these companies were assessed using their environmental reports in order to understand their worldwide state-of-art practices.

Two more companies were investigated through personal interviews with environmental and waste managers. The interviews were guided by a semi-structured questionnaire covering the decision drivers, environmental performance measures, origin of ideas, and finally the process by which these managers take environmental decisions. Besides personal interviews, secondary data about the company's environmental initiatives were also collated in order to contextualise better the external pressure and possible drivers for the green operations strategy for end-of-life vehicles.

For the environmental reports analysis, the complete environmental reports of each company were printed, and notes were taken about their environmental initiatives. These initiatives were then classified according to the Green Operations Practices Framework developed by Nunes and Bennett (2010). For this particular paper, the scope of the analysis is only of reverse logistics initiatives.

The case studies for collecting primary data were accessed through the industrial contacts of the research team. It is important to highlight that this paper is part of a wider research project aimed at understanding environmental decision making within the operations function in automotive companies. Thus, a case protocol was developed consistent with other cases investigated as part of the wider research. In both the cases, notes were taken from the interviews, observation, and internal documents. Afterwards, a report for each case was written and sent back to interviewees for accuracy check. The techniques used for analysis of the primary data looked at the emerging themes in the case reports. Recommendations for making case study research rigorous were found and followed as suggested in several qualitative research studies (Yin, 2003; Bryman, 2008; Eisenhardt, 1989; Miles and Huberman, 1984).

Findings

This section will present the findings from the environmental reports analysis and from the case study research.

Findings from the environmental reports

Table 2 summarises the reverse logistics initiatives from the 3 largest automotive companies of the triad. From the analysed reports, it can be inferred that companies are legislation-driven and the product recovery issue is also being dealt with by the design team (e.g. initiatives such as design for recycling, dismantling, etc). Major efforts are related to end-of-life vehicles and particular components such as air bags. Toyota specifies its concerns with components such as airbags and ozone-depleting gases from ELVs and the role of dealers and parts distributors in the product recovery network. GM's report highlights its response to European legislation and its goals related to reusing and/or recovering materials as well as the dismantling guides. Volkswagen's report mentions its concerns in avoiding landfilling and developing new processes to increase the recycling rate. The scarcity of landfills in Europe and Japan may have contributed to the development of advanced technologies by Toyota and Volkswagen.

Table 2 – Reverse Logistics Initiatives in the Automotive Industry

	Reverse logistics		
	Toyota	GM	Volkswagen
Compliance to ELV laws and directives	X	X	X
Advanced recycling systems			X
Bring recycling rate to 95% of vehicle weight		X	X
Ozone-depleting gases from ELV	X		
Collaboration with dealers and parts distributors	X	X	

Due to the extension of automotive supply chains, collaboration with dealers and parts distributors (including authorised and licensed garages) emerges as an external solution to tackle the environmental issues from ELVs and their parts. Both GM and Toyota provide dismantling guidelines and information about the legislation to their supply chain partners in order to encourage the recycling of critical parts such as batteries.

The link to product design is also clear; but paradoxical. Although design teams are oriented to reduce the weight and size of components as well as looking for more environmentally-friendly materials, cars are nowadays accumulating increasingly more items of equipment, particularly, electronics. The choice of lighter material may favour fuel consumption as part of the product environmental strategy but might also create problems when for dissembling, dismantling, and eventually, recycling parts.

Findings from case study research

The two cases explore the question of environmental management, and in particular reverse supply chains in the context of warehouses.

Two staff members were interviewed belonging to two different companies that work closely in an industrial "symbiosis". One is a French automotive manufacturer (here called FAC) that operates a spare-parts distribution centre in UK. The other is a British waste management company (called WMC) that operates in conjunction with the parts distribution centre in a layout that resembles the "plant within a plant" model.

Profile of Interviewees and firms

The **first interviewee**, who has been working in the automotive firm for about 21 years, is a stock controller in the Parts Division located in Coventry, UK. He has worked previously in other departments at FAC, such as engineering, personnel, and finance.

In his responsibility of controlling the stock in the warehouse, the main problems he recalls is the flow of information that allows him to predict and visualise the stock levels. The stock controller believes that improving the information management systems and communication between FAC and the supply factory in France would increase the visibility of the parts in the warehouse. FAC in Coventry receives 80% of its items from France, with the remainder coming from different local suppliers (although not necessarily British firms). FAC deals currently with 66 thousand references and a total of 180 million individual pieces. Time and motion measures are used to assess the performance of the warehouse. Most of the equipment used in the site is rented (e.g. computers, photocopiers, etc).

The **second interviewee** has been working at the Waste Management Company (WMC) for about 4 years. He started in the Waste and Recycling Department dealing with destruction and data security. Most of the items were high value products like cameras, CDs, remote controls; but he also was involved with waste from L'Oreal processing shampoos and cosmetics. Today, he is the waste manager for at the Parts Distribution Centre. He has an educational background in logistics.

WMC has 5 people working in the FAC site. WMC started dealing with the waste from a car manufacturing plant in 2002 but the plant was shut down in 2006. The portfolio of WMC was substantially reduced with the plant shutting down, although it could take advantage of managing the parts waste when the plant was demolished. Since then, it receives FAC's wastes from its logistics, warranty services, unsold parts, and the general waste from the site.

Environmental initiatives at FAC's Parts Distribution Centre

FAC is in the process of implementing ISO 14001 environmental management standards for its Parts Distribution Centre. An activity already in process is the Japanese 5S system. One of the main environmental risks in the operation of the warehouse is handling some of items that contain toxic substances, such as anti-freeze oils and fluids, paints, solvents and batteries. These materials, together with airbags and other high-value items receive special attention and have separate stock areas. Spills of hazardous materials are not often found in the warehouse.

Another problem mentioned with enabling the warehouse to be managed well is space availability. According to the interviewee, it is almost impossible to predict demand and supply of items. Moreover, commercial decisions imposed by legislation, such as making product recalls, create great pressure on the occupation of the warehouse. Those demands from recalls are predictable and they are informed 1 or 2

weeks in advance. Nevertheless, they are usually part of extraordinary demands that is why they tend to create problems.

The stock manager believes that the central location of Coventry in England influenced the decision by FAC about where to build the site. From the point of view of logistics sustainability he regrets that the parts arrive at the FAC site by lorry rather by train. “In France, there is a rail station and it would be much convenient and greener if we had one here as well”, he says. All the parts that are in the warehouse are related to warranty issues, but there are also some items kept for legal reasons (e.g. end of life batteries). The warehouse is basically divided in two areas: one for smaller parts (i.e. less than 12,5kg and smaller than 600,5mm) and another one for everything else.

The warehouse currently is working at full capacity (and sometime over). The interviewee understands that SAP systems would be an important aid to material control and forecasting. He admits that FAC may not be responsive enough to handle some orders, which can have customer service implications.

According to the interviewee, the importance of environmental issues has increased dramatically over recent years. For example, he points out that environmental, health and safety issues are reaching the forefront of businesses, through not only legal actions, but also through internal initiatives. He affirms:

> *“There is much more attention today to reduce parts waste and the use of solvents, for example. Also, we see people’s attitudes and perception changing because everyone is speaking about the environment.” (Stock manager, FAC)*

Environmental initiatives at WMC

The primary service of WMC at the FAC site is waste segregation and processing (dismantling, cutting, and balling). Cardboard, wood pallets, metals, and catalytic converters are the main material that WMC receives from the automotive company.

The companies work in what the interviewee considers a perfect symbiosis.

> *“As WMC is the expert in the field of waste management, so they (FAC) would listen to us” (Waste manager, WMC)*

He continues:

> *“We send to them budget and finance reports. They require us to keep the recycling level higher than 92%. Nowadays, we reached 96 to 97%”.(Waste manager, WMC)*

The symbiosis implies that WMC can take responsibility for the waste while FMC can concentrate on its core competence of making cars.

One of the main managerial problems is shop floor personnel buying the “idea” of segregating the waste and avoiding wrong disposal. Cost is still a big concern. For instance windscreens are parts that go as a separately collected consignment to a glass recycler (at a cost) because it is too costly to remove the gel layer between the two glass layers at WMC’s facilities.

Besides the shop floor awareness to segregate the waste properly other major problems for WMC are related to the volume of mixing material they receive from FAC (e.g. packaging mixing plastics and cardboard) and feasible and cost-effective disposal solutions. The interviewee has looked at some solutions provided by National Industrial Symbiosis Programme (NISP), but they are usually cost neutral and sometimes negative. Figure 1 shows the flow of material and capital between FAC and WMC in their reverse logistics system.

WMC is paid by the auto company for the service of waste management. It also receives a 10% commission on recycling, which encourages doing a better segregation and avoiding landfill disposals. The material and cash flows are shown in the Figure 1.

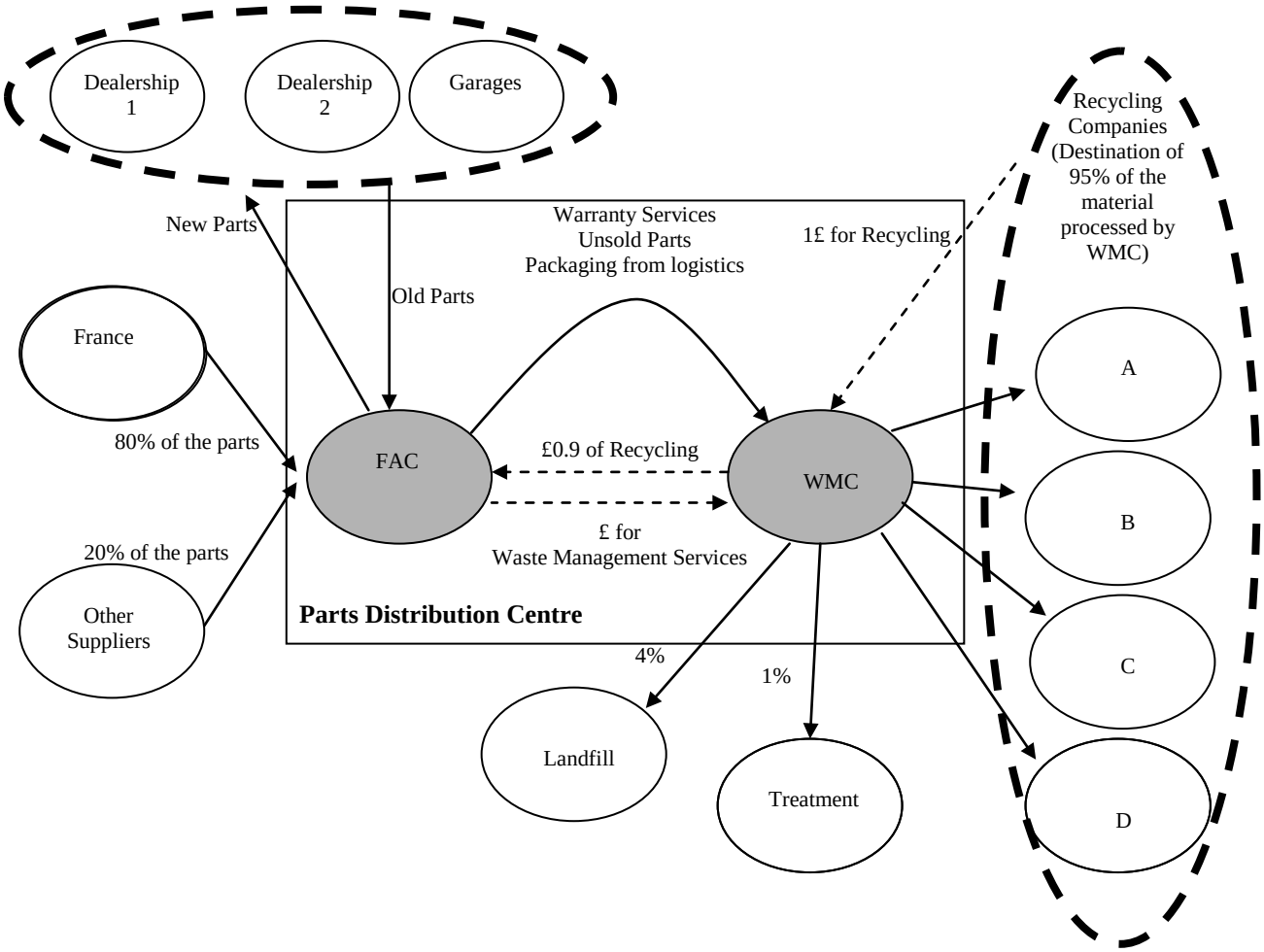

Figure 1 – Reverse Logistics Design at FAC

The contribution to Green Operations Theory of the FAC and WMC case

The contribution of this case to theory resides in the path taken by the automotive industry to deal with legislation-driven and costly activities regarding end-of-life of auto parts. The classical question "to make or to buy" is posed here and outsourcing emerges as part of the environmental strategy in order to allow the company to extract value from scrap, avoid environmental liabilities on the final disposal, and reduce costs with landfill. Indeed, the environmental initiatives were preceded by quality management systems and there is a perception that the integration of IT systems would improve environmental performance.

Again, an important issue for international benchmarking appears which favours companies with global production footprints. By operating in different countries the company is exposed to wider operations management practices that may allow them to seize upon higher environmental gains.

Conclusions

This paper has identified important trends in the initiatives for reverse logistics in the automotive industry. The research findings indicate that companies are trying to respond to the end-of-life legislation based on cost-effective approaches as well as corporate environmental responsibility. Outsourcing is used when special expertise is required to extract value from scrap. In addition, there is cooperation with suppliers and vendors to facilitate the dismantling of cars.

The personal interviews show that despite the initiatives being usually driven by legislation, companies are starting to visualise the importance of staying ahead of legislative targets and think of reverse logistics as part of the operations strategy. Goals such as zero-landfill are being set, although infrastructural barriers may impede the companies' ability to achieve them globally as they like to advertise publicly.

As technology advances and the expertise of waste management companies grows, the opportunities to engage in industrial symbiosis programmes are also enhanced. At the moment the main challenges for auto companies is to engage strategically in reverse logistics initiatives, particularly where the fleet of vehicles is growing rapidly and the legislation is still lenient (e.g. as in some emerging markets such as China and Thailand). Nevertheless, by developing capabilities or strong partnerships for reverse logistics in the more developed markets, automotive companies will be advancing in the learning curve and could apply these strategies in emerging markets as a way to better position them against the competitors – e.g. by doing it at lower costs, extracting more value out of scrap, and building an environmentally responsible image.

Limitations

The secondary data analysis provided a wide view of practices executed by global companies, but this is not without limitations since it may apply well to only high-volume companies. Low-volume manufacturers and even other high-volume producers may need to customise end-of-life solutions according to local legislation or by trying to seize upon the specific location advantages rather than imposing global standard solutions.

From the primary data sources, the limitations are related to use of key informants and restricted access to other areas of operations. This part of the research concentrated on end-of-life parts and adoption of zero-landfill policies in developing countries – further investigation is needed to complete a better understanding of drivers, challenges and opportunities towards reverse logistics initiatives in the automotive industry. For instance, from a holistic perspective, understanding the impact of product design on end-of-life is also vital and would need to be formally included in order to gain depth on the subject as well as for developing effective environmental policies.

Theoretical and Practical implications

This paper carries important practical contributions. Firstly, the list of initiatives in reverse logistics is presented and can help companies, government, and service providers to enhance appropriate solutions for dealing with end-of-life vehicles. Secondly, it shows the role of outsourcing in reverse logistics alongside the barriers created by lack of appropriate infra-structural support. The relationship and contractual map between a waste management company and an auto parts distributor is revealed. Last but not least, the set of challenges and opportunities raised in this paper will help companies to reflect on their end-of-life policies and initiatives.

The combination of secondary data in road mapping the environmental initiatives with personal interviews to gain depth on understanding departmental decisions is

original to the field of reverse logistics. The knowledge contributions are in the field of sustainability in operations management. There are also contributions to operations strategy within the context of environmental issues.

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