How the reverse supply chain enables original equipment manufacturers to compete on low price

Larsen, Samuel Brüning; Jacobsen, Peter

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Abstract
Low price is perhaps the most widely present competitive parameter forcing firms to continuously reduce their operating costs. While much literature has investigated how firms can use their reverse supply chain (RSC) processes to comply with regulations or offer RSC-enabled product-attached services, the purpose of this paper is to examine the relationship between the firm’s RSC processes and overall operating costs. The paper asks the question of how a firm’s RSC processes enable continuous operating cost reductions. The paper’s research method combines a literature review of known RSC-enabled cost reduction opportunities with a multiple case study that explores unknown opportunities. The most used cost reduction opportunity among the six firms in the study’s case sample is reducing operating costs by replacing purchasing of virgin materials and internal production with recovery of used products returned through the firm’s RSC.

Keywords: Competitive advantage, reverse supply chain, reverse logistics, operating costs, original equipment manufacturer, literature review, multiple case study

Introduction
Competing on low price is one of the most important competitive parameters in industry (Porter, 1985; Slack and Lewis, 2011). Typically, competing on price is not associated with environmental sustainability in manufacturing and supply chain management. However, this study shows that take-back and reuse of products through integrated reverse supply chain (RSC) processes can support a firm’s competitiveness, even if the order winner is lowest price.

Although some research, for example within the operations research field, has focused on optimizing cost parameters of operating the RSC, the overall understanding of RSCs is limited (Kocabasoglu et al., 2007) and a specific research need is examining how a RSC can provide the firm with financial value (Huscroft et al., 2012). The RSC can provide financial value by enabling new revenue, cost savings, or both. Cost savings constitutes the scope of this paper. The objective of the paper is to understand the relationship between a firm’s RSC processes and its overall operating costs. The study examines this relationship by identifying the set of RSC-enabled opportunities for continuous operating cost reduction. The study’s research question is: How can firms reduce their operating costs through RSC processes?

The concept of the RSC by Guide and Van Wassenhove (2003, 2009), which is prevalent in the theoretical field, serves as theoretical foundation for the study. In the concept, see Figure 1, five connected processes constitute the RSC. The five processes begin with acquiring used products from primary high-end markets, continue with reverse logistics, inspection and sorting, and end
with recovery operations and then remarketing of recovered products and components. This paper includes reuse in the final process of the RSC in addition to remarketing.

Guide et al. (2003) state that RSC-profitability depends on the quality and quantity of returned items and the demand for recovered items. This statement hold true for resale of recovered items, i.e. generation of new revenue, where the cost of the RSC processes is compared with the market value of the recovered items. When the objective is cost savings through internal reuse rather than resale, the firm’s cost of purchased materials and internal production costs replace the market value as a variable in the comparison. Avoiding costs through RSC-enabled internal reuse can be profitable (Katenopoulou and Taragas, 2011) and becomes more and more attractive for OEMs as material prices increase.

There are several papers in extant literature that indicate the cost savings potential inherent in RSC processes. Thierry et al. (1995) describe a copy machine manufacturer, who remanufactures copy machines for use in leasing agreements, where customers pay on a per-copy basis. The firm also remanufactures modules and components for spare parts. The RSC saves the firm both procurement and production costs. Ferrer and Whybark (2000) describe the potential in remanufacturing modules for large machines, e.g. planes, cranes, and subway cars. The automobile manufacturer Volkswagen uses remanufacturing to replace the more costly manufacturing of spare parts (Volkswagen, 2010).

To identify the set of cost reduction opportunities the study combines a literature review of known opportunities with a multiple case study that explores possible unknown opportunities. The methods of how the literature review and case study are conducted are detailed later in the paper. The paper is organized as follows: First, the paper limits the domain of the study and conducts the literature review. Second, research methods are detailed for the case study and case firms are presented. Third, the paper presents and discusses findings and presents conclusions.

**Domain limitation and theoretical foundation**

The paper does not look at the cost parameters within the firm’s RSC itself, but rather at how the RSC can reduce operating costs in the firm’s forward chain. Figure 2 illustrates the scope of the study. An example of a cost reduction opportunity, which is out of the paper’s scope, is “reduced cost of holding returned goods inventory through decentralized inspection and sorting processes”.

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**Figure 1 – The reverse supply chain (Guide and Van Wassenhove, 2003)**

**Figure 2 – The scope of the study**

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**Figure 2 – The scope of the study**
The set of RSC-enabled cost reductions identified in the paper applies specifically to original equipment manufacturers (OEMs), which the study defines roughly as Karlsson (2003): The firm assembles end-products and produces some components in-house, while the remaining components and all materials are sourced from suppliers. The firm serves an aftermarket in addition to the market for complete end-products, and the firm’s products are durable and recoverable.

**Definition of a RSC-enabled cost reduction opportunity**

For the purpose of this paper a RSC-enabled cost reduction opportunity is “a possibility for a firm to reduce the operating costs of its forward supply chain through the use of the firm’s RSC”. The objective of this study is to identify the set of cost reduction opportunities available for OEMs.

One particular distinction relevant for this definition is between a) a cost reduction opportunity and b) an opportunity for new revenue. If a firm takes back a product for refurbishment and resale, and the resale does not result in cannibalizing the sale of a virgin product, then the firm realizes new revenue and not a cost reduction. However, if the resale cannibalizes the sale of a virgin product, then the firm achieves a cost reduction by avoiding production of the virgin product as well as purchasing the products components. A cannibalizing resale may result in a loss of revenue if the resold product is sold at a discount. This loss should be included to assess whether the cost reduction should be pursued.

Whether utilizing cost reduction opportunities is profitable for a firm or not is not the scope of this study. It may well be that utilizing some RSC-enabled cost reduction opportunity may result in losses, while utilizing others will result in profits.

**Literature review**

The review looks for known opportunities for OEMs to reduce their operating costs through their RSC. To locate papers that address the subject the study applies the following search string: "reverse supply chain" OR "reverse logistics" AND "cost saving*" OR "cost reduction*" OR profitability OR "costs of goods sold" OR "cost of goods sold". The database applied is Web of Science. The search string results in 93 hits. Titles and abstracts were read and 20 papers emerged for full review. Although many papers within the 93 hits address cost reductions within RSC-processes, e.g. Niknejad and Petrovic (2014) and Litvinchev et al. (2014), only few papers directly address RSC-enabled reductions of operating costs. However, a number of papers among the 93 hits do indirectly address the subject, for example by mentioning a cost reduction opportunity in the paper’s introduction.

If a firm takes back products in the End-of-Life (EOL) stage in their product life cycle and disassembles the products, a cost reduction opportunity lies in reducing procurement costs by reusing used components and thereby replacing virgin components purchased from component suppliers. A study by Fleischmann et al. (2003) showed that savings in procurement costs largely outweighs the costs of the RSC processes that take back and reuse personal computer components for IBM. Other studies confirm the procurement cost reduction potential (Senthil et al., 2014; Souza and D’Agosto, 2013; Sasikumar et al., 2010).

Refurbishing or remanufacturing components and/or complete end-products enables savings in production costs in addition to savings in procurement costs. Kapetanopoulou and Tagaras (2011) mention the ability of reducing production costs by substituting virgin components with recovered components as driver of RSC activities. The paper refers to Toffel (2004), who names Xerox Corporation, Mercedes Benz, and Ford motor Company as three examples of firms that realize significant costs savings through the substitution of virgin items with recovered items.

One particular motive for recovering components that has received some attention in literature is the replacement of virgin components that used as spare-parts in the firm’s servicing of installed base products in the period between end-of-production and end-of-service of the parent products. A traditional way of securing components for this period is placing one last huge order of components
to cover future spare parts needs, which results in large holding costs and obsolescence risk. Remanufacturing parts from returned products is an alternative option for spare-parts acquisition (Inderfurth and Kleber, 2012). Automobile manufacturers are examples of OEMs, who replace virgin spare-parts with remanufactured version, e.g. complete engines (Seitz, 2007).

The most effective way of profiting from RSC processes is through direct reuse of non-defective products. Only 6-15% of OEMs returns are defective items. The remainder includes overstock inventories, damaged packaging, cancelled orders, obsolete wholeseller inventories, products with missing parts, products perceived as defect, etc. By reselling an item the OEMs saves the write-off cost (Lee and Lund, 2003). In addition, direct resale of an item can replace production of a new item, which can reduce the firm’s cost per product as much as 60% (Dhanda and Hill, 2005).

Fassoula (2005) states that RSC processes can reduce the firms cost of quality by integrating the firm’s RSC management with its quality management system. The RSC takes products back and the results of inspection and sorting processes can be used in the quality management system to avoid future defects.

The set of opportunities for reducing operating costs identified in this literature study are summarized and discussed later in the paper.

**Case study research method**

The objective of the case study is to explore cost reduction opportunities in industrial practice by a case study. Each opportunity is constituted by an explanation of how one or more RSC processes give lower operating costs for an OEM. The case study method is applicable when looking for explanations of contemporary events, where the researcher has no control over behavior of actors (Yin, 2014).

**Sampling technique**

The case study examines the RSCs of five firms, whose characteristics all fit the OEM-definition described under the study’s domain limitation. In addition fitting the paper’s OEM-definition, the five firms are all global companies and collectively represent a variety of industries including medical devices, water distribution equipment, and industrial measurement equipment. So while the applicability of the study’s results is limited to OEMs, it is not limited to particular industries of geographies. Table 1 displays the five firms participating in the study. The table includes information about industry, materials and product type.

<table>
<thead>
<tr>
<th>Case</th>
<th>Industry</th>
<th>Materials</th>
<th>Product type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>Ship engine equipment</td>
<td>Metals</td>
<td>Electronic and mechanical</td>
</tr>
<tr>
<td>Case 2</td>
<td>Electronic audio equipment</td>
<td>Plastics</td>
<td>Electronic</td>
</tr>
<tr>
<td>Case 3</td>
<td>Medical equipment</td>
<td>Plastics</td>
<td>Mechanical</td>
</tr>
<tr>
<td>Case 4</td>
<td>Hearing aids</td>
<td>Plastics</td>
<td>Electronic</td>
</tr>
<tr>
<td>Case 5</td>
<td>Industrial measurement equipment</td>
<td>Plastics and metals</td>
<td>Electronic and mechanical</td>
</tr>
</tbody>
</table>

Table 1 – The five case firms

**Data collection and analysis**

The data of the case study is a mix of focused interviews with key informant, written descriptions of products and firms, and observations (e.g. through a factory tour). The first step of each case is mapping the firm’s RSC to examine what processes each RSC contains and which functions the totality of RSC processes perform for the firm. To avoid researcher bias informants are asked to explain their RSC processes, flows, and sources of used products without prior explanation from the researcher. Second, the purpose of each of the RSC’s functions are divided into a) generation of new revenue (e.g. through resale to secondary markets) and b) reducing costs (e.g. through replacing internally produced items with refurbished items). Previous studies have revealed that this particular distinction is often not intuitively obvious for informants, so the distinction is clarified.
Finally, all cost reduction opportunities are noted. During interviews informants are asked to evaluate whether currently unused cost reduction opportunities identified in literature could be relevant for their firm.

**Case study findings**

The following paragraphs briefly describe the supply chain of each case and then explain each identified RSC-enabled cost reduction opportunity. While some cases result in cost reduction opportunities that have not been identified in the literature review, other cases only support the findings of the review.

The first case firm produces and sells a variety of modules and components for ship engines. The items are produced in one central factory and shipped to one of two warehouses. From the warehouses items are shipped directly to customers, who are either shipping companies, whose ships need parts, or ship engine manufacturers, who use parts to service their customers. Return flows include either items that may or may not be defect. Non defect items are restocked immediately and replace the production of virgin product manufacturing. For one engine type a segment of defect component are remanufactured and restocked, and thereby also replace virgin product manufacturing. For one particular type of defect component information from the RSC enters the quality management system for reduction of future defects, which saves the firm external quality costs.

The second case firm is a producer of electronic audio equipment for both business and consumer markets. The firm sells its products through distributors and retailers. Reverse flows of items come back through the same chain. The firm has divided its returned used products into two groups of which one group is refurbished, the other scrapped. When a customer returns a defect product, the retailer ships the products back to the distributor, who stocks the products on “defect-product pallets”. When a pallet is full, it is shipped back to one of the firm’s centralized hubs for refurbishing. Refurbished products are then sent forward to distributors. When a retailer returns a defect product to the distributor, the distributor swaps the defect product with a refurbished product. Swapping a product is an order qualifier in the industry. The use of refurbished products when swapping products saves the firm production of new products and purchasing parts for them. In addition, scrapping products locally is cost incurring for the firm. Their RSC, however, realizes a cost reduction by gathering scrapped products and shipping them to a recycler, who takes the products without costs for the firm to recycles materials.

The third case firm produces, sells, and services diagnostic equipment to health care providers. The firm sells its products directly to customers without any intermediaries (wholesellers, retailers, etc.). The firm’s RSC realizes cost reductions by replacing virgin product manufacturing of two particular items with refurbished components. One of the replaced components is taken back through the firm’s RSC and delivered to the original manufacturer for refurbishing. Then, the item is used in the firm’s servicing of installed base products. The second item is taken back and refurbished internally for the same purpose.

The fourth case firm produces and sells hearing aids through a network of wholesellers and retailers. Products returned within a short period due to e.g. buyer’s remorse are remanufactured and restocked as new items, which saves the firm the cost of producing a virgin product. Items returned after longer periods are remanufactured and restocked as reconditioned products. When a customer returns a defect product, a reconditioned product is issued and swapped for the defect product. The defect product is then remanufactured and restocked as a reconditioned item. Remanufacturing replaces new virgin product manufacturing.

The fifth case firm sells industrial measurement equipment for use in a variety of process industries. The firm remanufactures a small number of components for reuse, which replaces virgin product manufacturing. If a product is defect, it would be possible for the firm to use refurbished
complete products to replace defect products. However, the demand for purchasing refurbished products is so high than none are available.

**Findings**

Results show that the RSC enables a variety of operating cost reduction opportunities. Most opportunities revolve around replacing internal production costs through the reuse of complete products or components. One example is avoiding production costs for spare-parts used in the firm’s servicing of products that are no longer produced, but still serviced. Furthermore, for purchased components product recovery can reduce the costs of purchasing components and for components fabricated in-house recovery can save materials purchasing. Besides reduction in production and purchasing costs, reuse can reduce writing off defect products and gathering items for external recycling can save landfilling costs. Table 2 summarizes the study’s findings and indicates whether the source of the cost reduction opportunity is the literature review, the case study, or both. An additional finding in the case study is that although reuse and product recovery is known to most firms, the actual use hereof is, at least with two out of five firms, limited to few components.

<table>
<thead>
<tr>
<th>Cost saving opportunity</th>
<th>Literature review</th>
<th>Case study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacing manufacturing of virgin end-products through direct reuse of returned non-defect products</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Replacing manufacturing of virgin end-products through recovery of used or defect products</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Replacing internally manufactured virgin components through recovery of used or defect components</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Replacing purchased virgin components through recovery of used or defect components</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Reducing the cost of writing off returned non-defective products or components</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Replacing purchase of virgin materials for in-house component fabrication</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Reducing external cost of quality</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Reducing landfilling costs through recycling</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 – Summary of findings

**Discussion**

This section discusses the results of the study. The section includes discussion of 1) whether pursuing reductions in the firm’s operating costs is profitable, 2) the study’s managerial implications, and 3) suggestions for future research.

*Profitability of pursuing operating cost reductions*

Although profitability of each cost reduction opportunity will vary across firms and industries, one could argue for a general trend among opportunities: Complete end-products contain the value of materials, component fabrication, and finished product assembly, which suggests that replacing complete end-products with recovered products will give the OEM the highest operating cost reduction. In general, we propose that the relationship between the choice of reuse opportunity and the cost reduction the firm receives from pursuing the opportunity can be graphically illustrates as in Figure 3.
Whether replacing end-products, components, etc. is profitable depends on the cost of pursuing the reduction, i.e. the cost of implementing and operating the RSC processes that realize the cost reduction. When examining RSC-processes, one could argue that the further to the left in Figure 3 the higher the costs of the RSC-processes. Products are disassembled to a higher degree, more materials handling is required, etc. At the extreme, disassembling the entire product to have all components and materials at hand for recovery and/or reuse is most likely costlier than refurbishing a complete product where few parts are replaced, before the product is cleaned and tested. A proposition built on these this assumption will consequently say that the RSC-costs depends on the degree of disassembly. Figure 4 illustrates the proposition.

On the right hand side of the two figures, where the achieved cost reduction is high and the degree of disassembly is low, the marginal profit will be high. Conversely, when the achieved cost reduction is low and the degree of disassembly is high, the profits are low.
Managerial implications
The results of the study suggest that although product recovery is a known way of reducing operating costs, the case study also indicates a large potential for increased use of recovery to reduce manufacturing and purchasing costs. One current megatrend, that further increases the future potential for profitable product recovery, is increasing virgin material prices. Given that the profitability of implementing RSC processes is assessed by comparing the RSC process costs with the avoided cost of virgin items manufacturing and purchasing, the economic attractiveness of RSC processes will increase with increasing material prices.

Although only one out of five case firms uses their RSC to avoid landfilling costs. This may indicate that many firms presently do not have the responsibility for managing their products’ end-of-life. The case firm that does reduce costs of landfilling through their RSC sells electronic equipment regulated by the Waste of Electric and Electronic Equipment directive (WEEE), which mandates take-back and recycling. The use of RSC to reduce landfilling costs may increase if regulations are enforced on a wider array of industries.

Theoretical implications and suggestions for future research
Relevant for both academia and practice, the results of the study contribute to the understanding of the financial value RSC-processes can provide a firm and which enablers a firm has available for establishing the RSC as a profit center in the organization. Among the possibilities of future research are the following:
- A survey that examines how prevalent the pursuit of RSC-enabled cost reductions is in industry, and to which degree firms achieve profits
- Testing the two propositions of how the size of operating cost reductions relate to the type RSC-enabled cost reduction and how the cost of operating a RSC-enabled cost reduction opportunity is impacted by the degree of disassembly
- Examining which cost reduction opportunities are profitable and which moderating factors are decisive for profitability

Conclusion
OEMs are able to reduce their operating costs through the use of their RSC by replacing virgin product manufacturing and purchasing of virgin materials with reuse and recovery of products and/or components. The literature review and the case study both show that product recovery can reduce operating costs, which supports firms’ ability to compete on price. Among the specific cost reduction opportunities are replacing the purchase of virgin spare parts for products in the firm’s installed base with used items recovered through the reverse supply chain.

In general, the study supports argument that the RSC can provide financial value for the firm, and should not be viewed as a costly sideshow to forward logistics.

References


