

# PERFORMANCE OF REVERSE SUPPLY CHAINS

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## **Abstract**

Globalised trade and pressure on resources require supply chains to become more sustainable, which includes the need for material flows to become closed loops. Reverse Supply Chains (RSC) recover parts and products from end customers or any other stage of the supply chain and feeds them back into the supply network for reuse, remanufacturing, recycling or proper disposal. In this way, RSCs contribute to manufacturing becoming more sustainable ecologically, economically and socially. However, most companies are unaware of their RSC and therefore miss out on beneficial opportunities. This paper explores the current situation in industry and refers to relevant literature. A first version of an RSC framework is suggested, together with examples and discussion.

## **Introduction**

In recent times increasing pressures from both within and beyond organisations have led to a rise in interest in evaluating the performance of supply chains in terms of sustainability, which includes economical, ecological and social aspects (Svensson, 2007). The aim of this work is to contribute to a better understanding of RSC, encouraging companies to engage. To this purpose, a framework for modelling RSC and their performance is being developed.

## **Definitions and terminology**

Reverse Logistics concerns itself primarily with the transportation and storage of materials (Guide and Van Wassenhove, 2002), whereas the RSCs take a wider and more holistic perspective. Prahinska and Kocabasoglu (2006) offer a definition of RSC management that implies co-ordination with customers (of the forward supply chain) and subsequent activities beyond the transportation and storage of materials such as material recovery or recycling. They define it as 'the effective and efficient management of the series of activities required to retrieve a product from a customer and either dispose of it or recover value'.

The reverse supply chain deals with products returning to the manufacturer or third parties. Returns (or diversion to third parties) may be necessary because of a variety of reasons:

1. Products 'as new': Too many items were ordered, or items being damaged, faulty or wrongly delivered. Products becoming obsolete.
2. Used products: Damage and faults occurring during the product life time, requiring repair or overhaul.
3. Products at their end of life: No longer useful or wanted.

The destination of a product in the RSC depends on several factors, including the remaining value (damage, size, material), the ease of disassembly or dismantling, the possibilities for reuse or recycling, the number of products at hand, and their nature. Products simply going to landfill is not typically considered an RSC, although it also is an end of life solution. RSCs usually include elements of reuse, recycling and second markets. Figure 1 illustrates how the forward and reverse supply chains relate to each other. Together, they form a closed loop supply chain, which is highly desirable.

Green supply chains are environmentally sustainable, without necessarily and explicitly considering their economical and social dimensions. They typically include an RSC, as products going to landfill is usually not considered particularly green. RSCs are ideally green, but it is not a necessary requirement. Sustainable supply chains are often closed loops, which means that they include an

RSC. However, some supply chains are socially, environmentally and financially sustainable although they do not include a reverse element. Similarly, not all RSCs are sustainable in all aspects.

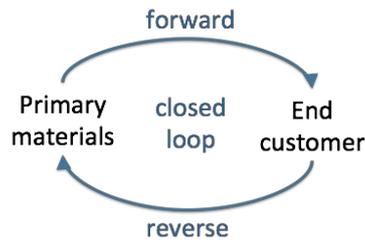


Figure 1: Forward and reverse supply chains form a closed loop supply chain

### **Methodology**

The approach taken in this research consists of literature research, logical analysis, as well as interaction with companies across industries. Several case studies are being conducted, including: ship dismantling, military vehicle repair, pharmaceuticals, medical equipment, and packaging.

### **Literature Review**

Ample literature exists on sustainable and green supply chains, yet there is relatively little on RSCs. Research carried out on the environmental performance management of supply chains suggests that little agreement exists as to what should be measured nor indeed how it should be carried out. Furthermore, although significant numbers of metrics have been identified in reviews of the literature such as that of Hervani, Helms and Sarkis (2005), performance measurement focuses most strongly on those metrics that can be quantified especially in terms of finance.

Organisations create unique supply chains and for that reason, the number of individual environmental performance metrics has been found to be large even if many are quite similar in nature. Therefore, it is likely that each organisation will adopt a different process when considering what to measure and why. Indeed, Jasch (2000) argues that many organisations decide upon measures and then attempt to evaluate improvement rather than identifying targets using previous data to only then develop metrics for used in monitoring progress. In other words, the process of identifying metrics as part of a coherent and useful environmental performance management system can be unreliable at best.

Gunasekarana, Patel and McGaughey (2004) argue that the basic reasons behind embarking on performance measurement are: identifying objectives, evaluating performance and subsequently decision making regarding future action. Hervani, Helms and Sarkis (2005) argue that performance measurement is carried out for two broad reasons, namely external reporting and internal analysis / control, which means to aid the understanding the business and to allow continuous improvement. These two reasons imply reporting to two different types of audiences i.e. internal and external audiences i.e. stakeholders although it should be noted that they will not always require entirely different metrics are used.

Internal audiences will include management and employees whilst external audiences will include regulators, pressure groups, customers and investors and so on. These audiences will change depending on the supply chain in question and the context it operates in. That is, the wider environment beyond just the participants in the supply chain. Therefore, to effectively report on reverse supply chain performance it is essential to identify the audiences to with an interest or stake in the performance: the stakeholders.

Ahi and Searcy (2015) developed a framework based on their literature review that attempts to direct performance measurement using a number of categories of metric around a 'Sustainability Context'. This sustainability context is a high-level representation of the typical participants in a green supply chain. The external circle includes the reporting categories i.e. the generic categories of metrics for reporting purposes.

## **The suggested framework**

Creating a generic model, applicable to any kind of reverse or closed-loop supply chain, is very challenging due to the very diverse nature of the difference scenarios across industries. The suggested model aims to include all possible entities and processes. Some scenarios will correspond to most of them, whereas others will only include a small selection. For instance, RSC for electronics typically include disassembly, remanufacturing, re-engineering, reusing, recycling as well as disposal, whereas the RSC in the second markets in the food industry will be limited to charity, animal feeding and energy creation (anaerobic digestion or combustion).

A unifying framework could help companies understand and analyse their RSC. It is essential to identify the following elements:

- 1) Stakeholders:** Who is interested in this RSC?  
Typically company owners / shareholders, employees, any kind of business partners such as suppliers, buyers, wholesalers, retailers, end-customers, environmental agencies, governments, local residents, society, etc.
- 2) Drivers:** What are the objectives of the identified stakeholders?  
Typically return on investment, corporate image and responsibility, laws and regulations, employee satisfaction, trust amongst business partners, production lead time, etc.
- 3) Dimensions:** Where is the focus?  
Internal to one department or company, a chain of companies, a product life cycle, etc.
- 4) Metrics:** What metrics or key performance indicators to monitor?  
Based on the first three aspects, suitable metrics need to be identified. The Global Reporting Initiative provides a framework for metrics relevant to sustainability, many of which will be suitable for the RSC as well.

### **Stakeholders**

A useful tool to identify stakeholders is that of Soft Systems Methodology (SSM). Checkland and Poulter (2006) describe SSM as an organized flexible process for dealing with situations regarded as problematic and that require action to improve them or make them more acceptable. It differs from some management tools like Systems Engineering as it allows for differing views of the world or situation and is suitable for solving soft problems (as opposed to hard or systems problems) often associated with human behaviour.

SSM employs diagrams or 'rich pictures' to understand situations and to help with this. It can be used to identify the Stakeholders and their relationships for reverse supply chain activity. To that end, Sadri and Sadri (2014) make the connection between SSM and corporate responsibility that guides strategic decisions. Using SSM, it is possible to identify the stakeholders in any given reverse supply chain including those who are not direct participants. Furthermore, the relationships between the stakeholders becomes much clearer even when in more complex situations it is possible that stakeholders are found in more than one location of the rich picture.

### **Drivers**

Once stakeholders are identified, the task of satisfying their reporting requirements becomes essential. Drivers are the motivation or reason for an action such as measuring and reporting reverse supply chain performance. The nature of the reporting will vary in nature in accordance with the composition of the supply chain and its stakeholders.

Trowbridge (2001) categorised drivers as internal and external. Internal ones are those that are derived from within the organisation itself, such as increasing profit. This might be through greater material recovery or reducing material recovery cycle times. External Drivers in contrast may derive from customer demands or those from investors, NGOs (Non-Governmental Organisations) or even legislation. The list of drivers will reflect the stakeholders that have been identified and will therefore reflect the nature of the supply chain in question.

Perhaps the most notable driver for the increased environmental focus of organisations in recent decades is that of community and consumer pressure (Zhua, Sarkis and Lai, 2008). In more

developed countries, consumer pressure has pushed legislators such as national governments or the European Union to impose regulation of organisational activity and the reporting of it.

Examples include sectors such as that of automotive manufacturing which has been subject to increased environmental regulation. These include Regulation (EC) No 715/2007 (light vehicle emissions) or the End of Life Vehicles (producer responsibility) regulations 2005 statutory instrument 2005, no.263 derived from EU directive 2000/53/EC which requires manufacturers to provide a convenient network of facilities receipt of end of life vehicles. These vehicles can be taken to these facilities for dismantling and recycling at no cost to the final owner (UK Gov, 2012). Porter and van der Linde (1995) acknowledge the need for regulation as a driver for improved environmental performance but also argue that external pressures exerted by customers on suppliers as well as market competition drive innovation. This suggests that organisational economic objectives and environmental improvement need not be mutually exclusive. Furthermore, improving the environmental impact of products can contribute to a competitive advantage (Zhu and Sarkis, 2006). Srivastava and Srivastava (2006) observe that societies play an important role in driving organisational environmental performance improvement. In work carried out in India, it was seen that local consumers were price sensitive and to a lesser extent quality sensitive when making buying decisions. However, customers and consumers of products and services were not seen to be environmentally sensitive. The authors argue that this has restricted environmental regulatory activity. The effect is that the authors found little desire from organisations to focus on environmental aspects of their supply chains. This lack of interest has resulted in an uncoordinated effort to recycle materials such as aluminium and paper as responsibility for this is not considered that of the manufacturer. The prevailing social attitude toward corporate environmental responsibility and the lack of regulation in India because of it, suggests that differences in societal values in any given country or region may affect the degree to which any environmental performance measurement will be adopted.

Lee and Rhee (2007) who look at organisational environmental management strategy in terms of its level of development or influence on management strategy. They found organisational focus on the environment fell into one of four potential categories: (1) Reactive with little emphasis on the environment, (2) Proactive where the latest environmental knowledge and practices are applied on a proactive basis, (3) Focused with high levels of environmental management, and (4) Opportunistic as a medium level.

Whilst regulation in some industrial sectors especially in advanced economies has become increasingly important as an external driver for improved environmental performance, the effect of pressure by procurement departments on their suppliers has also become increasingly important (Lee, 2008). This has in part led to the growth in adoption of the Environmental Management System Quality Standard ISO14001. Indeed, Zhu and Sarkis (2006) note that some 40,000 companies have implemented this standard globally. It should be noted that whilst, there has been increased adoption of environmental quality standards such as that of ISO 14001 and ISO14031, these standards do not offer metrics nor for that matter do they recommend specific metrics or indicators (Jasch, 2000). Furthermore, there is no minimum standards of reporting required nor minimum performance levels specified. However, the standards do require a commitment to continuous improvement using Demming's 'Plan-Do-Check-Act' (O'Reilly, Wathey and Gelber, 2000).

Lee (2008) observed that procurement departments are requiring potential suppliers to adopt the ISO Environmental Management Standard to even be considered for transactions. Whilst, Lee (2008) noted the reactive nature of some supplier-customer relationships, Rao and Holt (2005) noted that proactive decision of management in order to secure a competitive advantage through cost reduction also played a part in the adoption of this standard. The contrast of these two types of management reinforce the work of Lee and Rhee (2007).

Drivers are therefore the internal and external motivations or reasons behind performance measurement and they have a relationship with the respective stakeholders. The attitude of organisations to involvement and development in the area of environmental performance

management is guided by organisational strategy that ranges from proactive/ reactive and opportunistic/focused.

### **Dimensions**

To measure performance, it is prudent to use a framework that guides the choice of metrics within a measuring system that is appropriate for the organisation's objectives. Caplice and Sheffi (1995) identified six dimensions of a framework to do just this: comprehensive, causally oriented, vertically oriented, horizontally oriented, internally comparable, and useful.

These dimensions prompt the questions of why something should be measured and how it should be done. This was later built upon by Bjorklund et al. (2012) who employed a slightly modified version of the dimensions framework (omitting the 'useful' dimension as they considered it too subjective for their work) in a reverse supply chain case study.

Arguably the most important aspect of the 'horizontally integrated' dimension is that it encourages would seek to reduce the sub-optimisation of a supply chain through simply considering what is best for the focal organisation. In other words, the reduction in externalities. It is notable however that Hervani, Helms and Sarkis (2005) argued that measuring beyond the focal organisation can be difficult and would require cooperation by other organisations in the supply chain.

### **Metrics**

As the studies of authors such Ahi and Searcy (2015) have concluded, the numbers of individual measures are large to the point that organisations are becoming overloaded with them (Bai, Wei and Koh, 2012). Although Hervani et al. (2005) identified over 40 metrics in use at one company, Ahi and Searcy (2015) identified a total of 2555 unique metrics during their review of the literature. It was also noted that the majority were only found once although many were quite similar in nature. This seems to confirm that no agreement is in place with regard to metrics and reporting of environmental supply chain performance.

McElroy and Engelen (2012) categorises metrics in two ways: Absolute – Performance of overall organisation during a given period of time (e.g. Energy use for Company A); or Relative – Performance in one area of the organisation compared to that of another in the same organisation during a given period of time (e.g. Energy use in Dept. A versus Dept. B).

It may initially be tempting to apply absolute metrics to compare across organisations in the same sector but it is quite possible that the exercise may not be achievable on a like for like basis. This is because of the variety of ways that metrics are arrived at and applied as well as the differences that exist between supply chains and even products that may be in direct competition.

(McElroy & Engelen, 2012) argue that any absolute metrics should be as descriptive as possible to give them meaning or context. For example, this may require using a metric such as annual energy use with the context being the number of employees to give a per capita amount or units of production. That said, as the authors point out, the context should be also be meaningful. For example, it would not be appropriate to use the number of pencil sharpeners available to staff as the context for the amount of Green House Gases emitted. However inter-annual comparison can also be made unreliable given that organisation change sometimes quite radically in terms of size and activity from year to year. The authors go to the extent of recommending the avoidance of any absolute metrics that fail to take into account such organisational changes as they are essentially meaningless for comparison purposes.

Relative metrics tend to be focused on efficiency which is not necessarily the same as sustainability. McElroy and Engelen (2012) refer to them as intensity metrics in that they describe the intensity of use of something. Furthermore, they argue that absolute metrics are essentially a form of relative metric that has been normalised through giving context such as per capita values although they reflect the performance of whole systems rather than a part as would a relative metric. The authors all point to the lack of any wide ranging agreement in terms of metrics as it appears organisations develop their own to meet a requirement as it arises. This is in line with the assertion of Caplice and Sheffi (1995). However, standardisation of reporting metrics is available in the form of the Global Reporting Initiative (GRI), which is a non-profit organisation in the late 1990s with the aim of developing and promoting a framework for sustainability reporting globally.

GRI has a number of strategic partnership arrangements globally such as those with the Organisation for Economic Co-operation and Development (OECD) and the United Nations through their Environment Programme and Global Compact. It also cooperates with the International Organization for Standardization's ISO 26000. This standard has offered social responsibility guidelines since 2010 to encourage sustainable development and corporate social responsibility toward workers, their communities and the environment. In 2013 *The Guardian* reported that over 11,000 companies now use the GRI framework for their reporting of environmental performance and sustainability.

### **Model**

Based on case studies taken from literature as well as direct interaction with industry, a generic model for reverse supply chains has been developed. Figure 2 shows the typical processes involved in RSC. The processes to the left (remanufacturing, refurbishing) have the highest value retention rate and are therefore the most desirable, whereas those to the right retain the least value and should be avoided if possible.

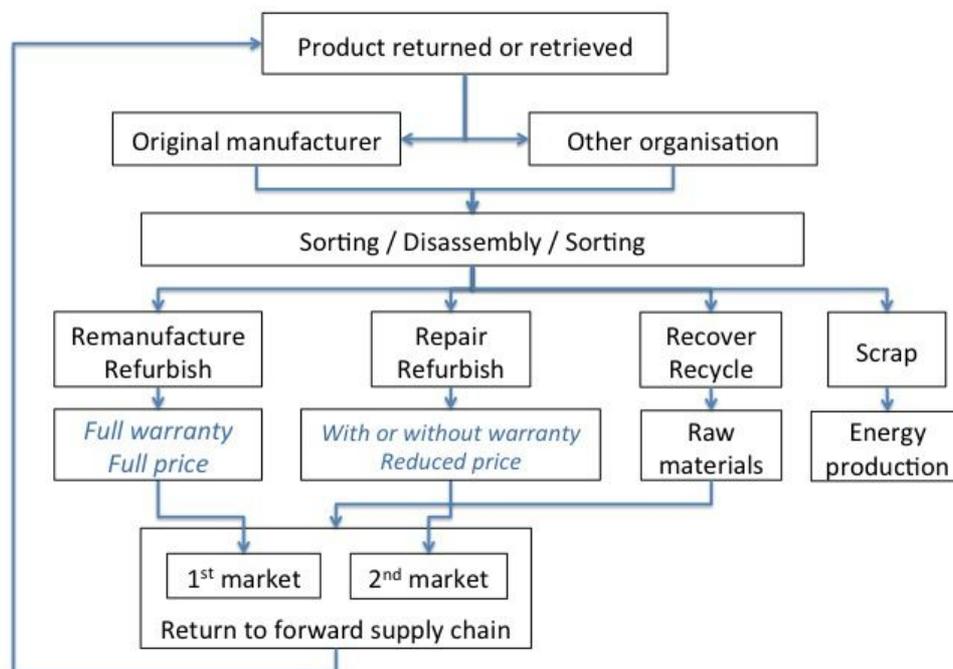


Figure 2: Generic model of reverse supply chains

### **Analysis and Discussion**

For more companies to engage in RSC activities, more products need to be designed for disassembly and remanufacture. The difficulty lies in the fact that the stakeholders are often not the same: product designers are rarely aware of the requirements for dismantling and reuse, and those dealing with RSC rarely have any say in product design.

The service business model, where companies provide a service rather than a product, solves this issue. Rather than selling a product and no longer being responsible for it, companies that sell a service typically provide equipment to their customers on loan and deliver maintenance, repair and periodic replacement. This means that companies keep the responsibility for the equipment and are therefore interested in options for disassembly and refurbishment. The service business model hence facilitates the engagement in RSC and contributes to reducing waste.

### **Examples of RSC**

Whilst the majority of businesses still mostly ignore their RSC, there are many examples where the RSC is fully functional and benefits the companies as well as society and the environment. The following list describe a few cases:

- Dismantling of cars, ships and aircraft: Specialised dismantling plants deal with ships and aircraft once they have reached the end of their useful life. Most ships will be taken apart in India and Bangladesh, but also in China, Turkey and the Netherlands. Aircraft disassembly is done along the border between France and Spain as well as in Arizona, USA. Cars are being demolished in many local plants all around the world, whilst some of them go to second markets in developing countries.
- Combustion gas bottles: Used for camping, mobile business applications and households without central gas supply, gas bottles are refilled in local plants.
- Remanufactured electronics: Some devices are openly declared as refurbished by the manufacturer and sold at 75% of original price, with a full product warranty.
- Remanufactured electronic components: For instance hard drives are often refurbished by manufacturers and then placed in new computers, sold at full price. In this case, the customer is not aware that some components have been used previously.
- Refurbished photocopiers and printers: Some devices have an average of seven life cycles (Chiodo and Ijomah, 2014), with many components being reused whilst others are being exchanged.

### **Reasons for companies to engage in RSCs**

It is a common belief that running an RSC is beneficial for the environment but financially disadvantageous. This is especially the case with products that have not been designed with disassembly and reuse in mind, and when products retain little value. In these cases, companies may operate an RSC because legislation demands it, or because it is favourable for the corporate image. Successful examples of RSCs often retrieve of valuable, scarce or high-energy materials. Some companies use remanufactured components or recycled materials to lower cost.

### **Conclusion and Outlook**

It is necessary to create a tool that encourages managers in engaging in reverse supply chains, helping them understand the mechanisms and choose the right metrics. The models and frameworks identified and brought together create the following steps:

1. Identify the Stakeholders of a reverse supply chain.
2. Identify the drivers arising from each stakeholder that direct reporting to meet their needs.
3. Select metrics and validate them for appropriateness using the six dimensions.
4. Standardised reporting formats given to metrics.

In accordance with 'Plan-Do-Check-Act' and the continuous improvement ethos of ISO standards on the environment, these four stages should be repeated regularly to ensure the metrics being used are both appropriate and accurate. Furthermore, the system should be tailored for individual supply chains so that it enhances management capability rather than hinder it.

The aim of this cycle is to create relevant and useful standardised metrics within a coherent environmental performance measurement system for reverse supply chains. It is also to prevent the accumulation of measures that are not appropriate, obsolete and of limited or no value to the stakeholders they are aimed at whether they be internal or external. The model is also easy to use and along with the growth of GRI it may encourage organisations to begin this form of reporting with results that are more standardised than currently is the case.

This model can be developed and refined further but given its flexibility, it could readily be used across sectors for environmental performance measurement regardless of the supply chain. One area of refinement and research might be to improve the link between stakeholder identification and driver identification. In the short time available for the project, no such model was found. Instead, it appears that simply listing drivers against the identified stakeholders is the only method available. This may lead to incomplete measurement and reporting unless undertaken thoroughly.

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