Interactive resources and recycling

- A case study of the Norwegian deposit system for PET bottles

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Abstract

This paper applies a study of the eco-efficiency of Norwegian deposit- and recycling system for one-way PET bottles (Resirk-system) as starting point. In order to explore what influences the eco-efficiency quantified in this study, a focus on resource interaction as understood within the IMP-approach is suggested. An analysis of a selected focal resource of the Resirk system, the sales product returned baled PET bottles, reveals which resources (products, facilities, business units and business relationships) and corresponding resource interfaces that influence significantly on the eco-efficiency of the recycling system.

Introduction

The consumption of the plastic polyethylene terephthalate (PET) for beverage bottles purposes has increased considerably every year during the last decade. In the year 2000, 150 billions, or 6 billions kg, one-way recyclable PET bottles were consumed on the global basis (Tomra annual report 2001). In order to take care of the resources represented by the used bottles, and in order to avoid that these bottles will cause littering

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in streets or take up space at landfills, recycling systems are established. These systems are usually established as a result of deposit laws or (voluntary) agreements based on extended producer responsibility for producer and importers of packaging.

In Norway a deposit and recycling system for one-way PET bottles (the Resirk system) started up in May 2000. In 2002 1800 tones PET bottles were consumed, which 1150 tones of these, or around 70 %, were returned to store by consumers and further transported, sorted and compacted into 300 kg quadratic PET bales for sale to recyclers in Europe and Asia (Grytli 2003)

In a previous study from Eik and colleagues (2002), *indicators for environmental- and economic efficiency* (eco-efficiency) were developed and applied on the Resirk system. This study was very much based on the life cycle system approach (e.g. ISO 1997). The first indicator, *net costs,* which is the overall costs of bringing used bottles from consumers to baled bottles minus the sales price of the bale, was around 20000 NOK (= 2500 EUR) per ton in the Resirk system in 2002. The *material efficiency* when producing PET bale from used bottles is given by the return rate of bottles, which was 70 % in 2002. The eco-efficiency indicator *Global warming contribution* is calculated as sum of CO_2-emissions from transport, sorting, re-processing and, not at least, so-called avoided emissions when recycled PET is applied as an alternative raw material to virgin PET resin. In 2002, this indicator was calculated to be -0.9 ton CO_2 per ton baled material produced. This means that for every ton baled material produced from used bottles in the Resirk system 900 kg CO_2 can be saved. In the study, the eco-efficiency of the Resirk

system is also compared with another system for recycling of plastic packaging. By doing this *quantification* and comparison, a picture of *how* eco-efficient a recycling system for production of PET bales is found. However, in order to explore *why* the eco-efficiency is like it is, and in order to acquire a deeper *qualitative* understanding of the influence on the PET bale, the product of the Resirk system, it is not sufficient to quantify the cash- and material flow *within* the manufacturing system only. It is also needed to understand the context, or network, of the bale which may reach far beyond the defined manufacturing system borders. For this purpose we have selected to focus on resource interaction as developed within the industrial network approach. This perspective has been developed and applied in a number of studies (e.g. Håkansson and Waluszevski 2002a, Wedin 2001, Von Corswant 2003), however, as far as we know, it has not been applied to study recycling. It should though be mentioned that recycling was an issue in Håkansson and Waluszevski (2002b) study of development of IKEA's green catalogue paper.

The purpose of this paper is to apply the perspective of resource interaction within the IMP-approach in order to acquire a deeper understanding of what influences the quantified eco-efficiency of the deposit and recycling system for one-way PET bottles in Norway.

The paper starts with a presentation of resource interactions and resource interfaces, continues with a short discussion on dissimilarities between the system and the network

approach, proceeds with a short presentation of Resirk case, before we eventually apply the theoretical framework to analyze the case.

Resource interactions and resource interfaces

In the eco-efficiency study of the Norwegian Resirk system (Eik et al 2002) the life cycle system approach is applied to study PET bottles along a recycling chain. However, within the NETLOG approach at Norwegian School of Management, the basic idea is that is not sufficient to study actors, activities and resources along one supply-, distribution- or recycling chain if the purpose is to acquire information about how a focal actor, activity or resource is connected to other actors, activities and resources (Gadde et al 2002). The reason is that an actor (e.g. recycler), an activity (e.g. transport) and a resource (e.g. bottle) often belong to more than one chain or system, and their participation and interdependencies with actors, activities and resources in other production, distribution and recycling chains will influence their performance in the defined chain/system. A *network* focus is needed.

Networks have until recently mainly been studied from an activity (and actor) perspective. However, according to (Gadde et al 2002) it can be argued that resources are the foundation of activities and thus a very interesting factor to study. Resources are regarded as "facilitators of operations" in supply and distribution networks, including reverse logistics- or recycling systems. Additionally, while actors are connected to identity, and activity to efficiency, resources are connected to potentials for change,

development and innovation (Håkansson and Snehota 1995), which are central aspects when studying influences and potential improvement of recycling.

Resources in industrial networks can be divided into four types: While "products" and "facilities" represent the technical/physical dimension, "business units" and "business relationships" represent the organizational aspects (Gadde et al 2002). All four types of resources are highly dependent on each other. In order to produce a product, we need a facility owned by one or more business unit and in order to sell the product we need a business relationship. If the intention is to understand resource development in an industrial setting, all of them must be included.

The framework for analyzing how resources and resource features are interactively used and developed, how they influence each other, as well as how they are currently embedded into each other, is illustrated in a network triad in figure 1 (Wedin 2001). In order to study resources in network it is necessary to define a starting point, a focal resource (in the figure chosen to be a facility). The resource interfaces (illustrated by thin arrows) between the focal resource and the other resources are created and developed as a result of interaction between the resource elements. Hence, the characteristics and features of the focal resource and related resources are developed. The characteristic "sales price" of a product will for example be developed through interaction and establishment of resource interfaces with resource items such as the business unit customer and the facility for producing the product.

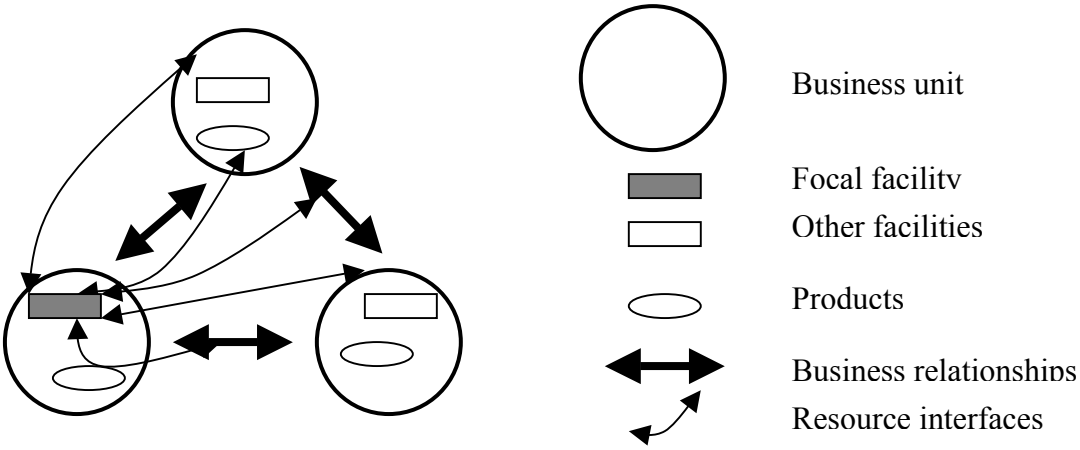

Figure 1: A framework to analyze resources in a network triad

Life cycle system approach vs network approach

In order to be able to both evaluate and understand recycling, we are applying a combination of the life cycle system approach (Eik et al 2002) and an interactive resource network approach (this paper). However, there are conflicting views as to whether or not the system approach and the network approach in general are different fields of research areas. According to von Corswant (2003) the industrial network approach has been inspired by the open systems theory (Scott 1998). Within the NETLOG-approach (Gadde et al 2002), however, the basic idea is that actors, activities and resources belong to more than one chain/system. Influence from resources "outside" the defined system or chain should thus be considered and analyzed in order to understand the development of resources and the performance in the defined system.

We would argue that another important difference between life cycle (system) analysis and analysis of industrial network is the degree of rigidity. In life cycle analyses clear

system borders, system performance and functional units are defined, while there seems not to be the same degree of pre-determined fixed starting point when analyzing networks of actors, activities and resources. 'A network has no clear boundaries, nor any centre or apex' (Håkansson and Snehota 1989, p.40). Or as Gadde and Håkansson (2001, p.181) put it: 'From an analytical point of view it would be possible to find an optimal solution provided we could define a clear-cut network with one specific boundary. But network boundaries are always arbitrary – they are based on perceptions and are continuously changed' Further they argue that it is '…. impossible to come up with a 'master network strategy' taking every aspect into consideration….strategies are always partial and they are valid only for the time being, and must continuously be changed and altered (p.183).

Presentation of PET bottles in the "Resirk system"

The increasing use of one-way recyclable PET bottles in recent years in Norway is mainly a result of the Norwegian Ministry of Environment's decision to reduce environmental tax on one-way beverage packages to a lower level which is dependent on the national recycling rates of the current packaging type. This tax reduction as well as the basis for calculation of recycling rates only applies for PET bottles that are participating in the deposit and recycling system "Resirk". This system is organized and operated by the brewery- and retailer owned non-profit organization Norsk Resirk Ltd, launched in 1998, and approved by the Norwegian Pollution Control Authority.

Today the Resirk system includes more than 130 different types of PET bottles and more than 200 various cans. In 2002 1800 tones PET bottles were consumed, while 1150

tones, or around 70 %, were collected for recycling purpose. As we can see from figure 2 several actors are part of the Resirk system for one-way bottles. Norsk Resirk Ltd gets its incomes from administration fee from producers and importers of beverages, from sale of the product baled PET to foreign recyclers and from non-claimed deposit. Their costs include, among others, handling fee, pick up fee and baling.

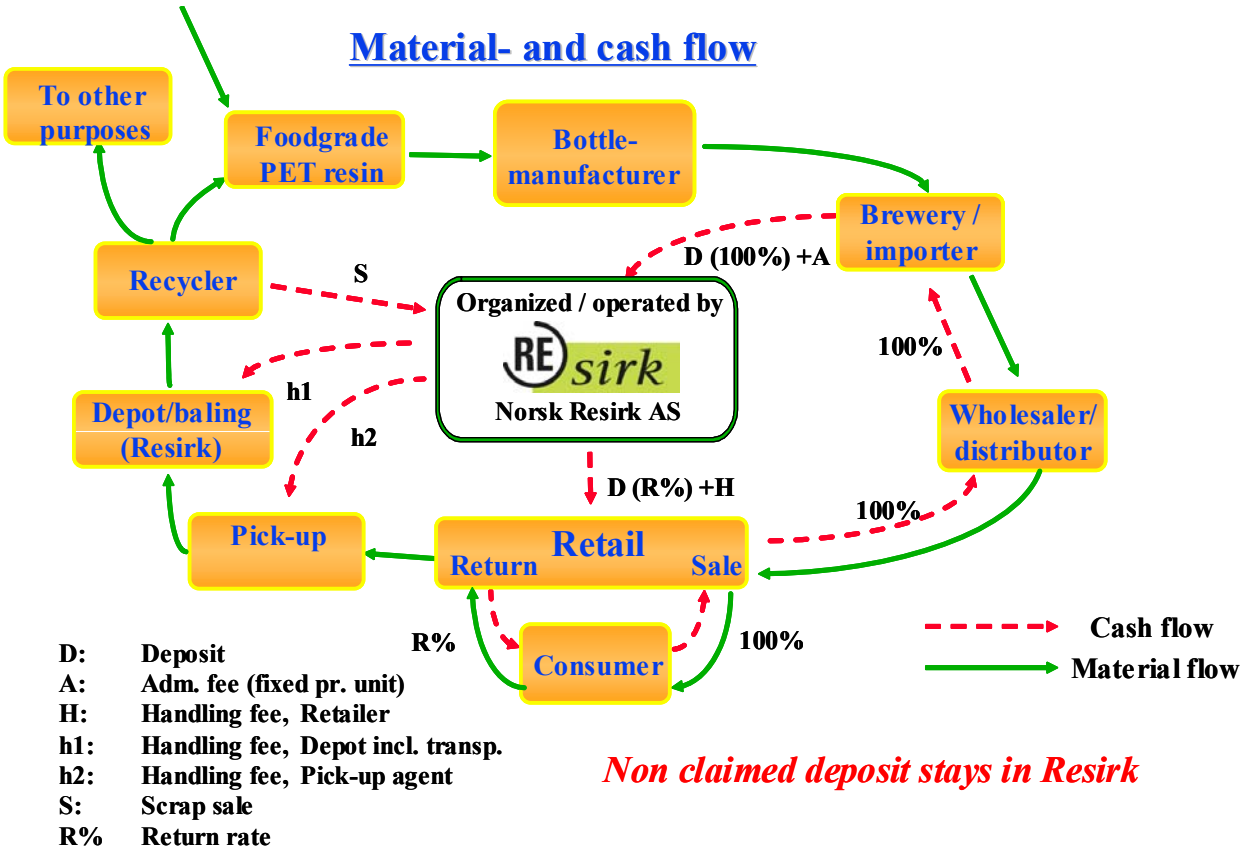

Figure 2: Material- and cash flow in the PET bottles part of the Resirk system.

Analysis of resource influences on eco-efficiency

Activities influencing most on the Resirk system's eco-efficiency

Base on the previous eco-efficiency study of the Resirk system we have identified *the design of the bottle*, what is done in the *post consumer phase*, *compaction of bottles* in reverse vending machine, and the *final sorting* are the activities that influences mostly on the eco-efficiency indicators of the system. The design of the bottle influences the sales price of the bale, which is included in the *net cost* indicator. The post consumer phase is very important because this is where consumers choose to return or not return the bottle to reverse vending machines in supermarkets or to other bringing point. This influences both the *material efficiency* and the *Global warming contribution*. The bottles are compacted in the reverse vending machine, and the degree of compaction contributes highly to the pick-up costs and thus the *net costs* of the system. The final sorting at the baling depot is very important in order to produce a high quality bale. This influences the sales price and thus the *net costs.*

Focal resource and its eco-efficiency characteristics

In the IMP-approach there are no strict rules or criteria on how to select a focal resource when carrying out an analysis. The focal resource is chosen on the basis of what product, facility, business unit or business relationship the researcher or manager is interested to know more about, independently on whether this is regarded as an "important" resource or not . The selection of focal resource is off course important for the outcome of the analysis since each resource has a unique network of connected resources. Here we

define the focal resource as the (sales) product of the recycling part of the Resirk system for PET bottles, namely the *baled PET bottles* sold to recycler (from now on called *PET bale).* Based on the eco-efficiency study of the Resirk system (Eik et al 2002) we are defining the PET bale to have the three following characteristics: *Net cost to acquire, material efficiency in production* and *global warming contribution.* In the following we will present the resources and resource interfaces we have found to have the greatest impact on the *net cost to acquire*.

Interactive resource influence on PET bale

Through more than ten qualitative research interviews with actors that have to do with the PET bale we have discovered interaction and resource interfaces between the focal resource and other resources. The ones that have had most influence on the net cost of the bale sold to recycler are given in figure 3. Direct influence is illustrated with ordinary two-ways arrow, while indirect influence is given by similar dotted arrows.

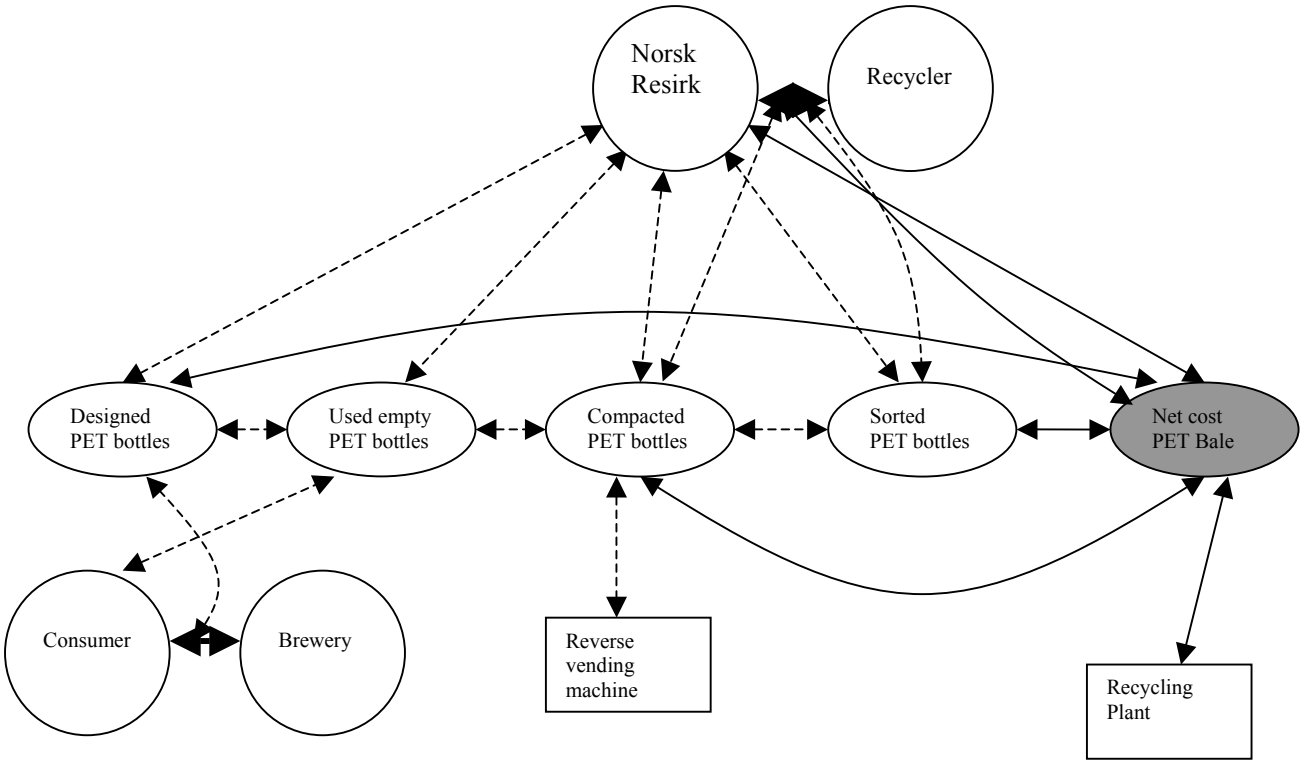

Figure 3: The most influential products, facilities, business units and business relationships and related resource interface on the net cost of the focal PET bale

The net cost to acquire the bale is *directly* influenced by:

- The product "Sorted PET bottles" which is the input material for the focal product. The purity of this material is decisive for the quality of the bale and thus the sales price.
- The product "Compacted PET bottles" since the degree of compaction and degree of filling of compacted bottles are highly influencing on the transport costs and thus the net costs
- The product "Designed PET bottles" because the colour of the PET bottle is decisive for the sales price of the bale.

- The facility “Recycling plant” because the production equipment here will influence on the quality demand (and the price) of the focal.
- The business unit Norsk Resirk which owns the PET material and administrate all cash flow
- The business relationship between “Norsk Resirk” and “Recycler” because they negotiate on quality demand and corresponding price.

Of *indirectly* influence it is worth to mention the business unit “Consumer” which is deciding the return rate of used bottles, and influences the colour of the PET bottles in its relationship with the business unit “Brewery”.

Conclusion

The purpose with this paper has been to acquire a deeper understanding of what influences the quantified eco-efficiency of the deposit and recycling system for one-way PET bottles in Norway (the Resirk system). The product in the recycling part of the Resirk system, the PET bale sold to recycler, is defined to be the focal resource in a network of related resources. The eco-efficiency characteristics net cost of this focal resource is influenced by interaction and resource interfaces with various research items. The most important ones are believed to be the products “Sorted PET bottles”, “Compacted PET bottles” and “Designed PET bottles”, the facility “Recycling Plant”, the business unit “Norsk Resirk” and the business relationship between “Norsk Resirk” and the “Recycler”.

The IMP-approach to resource interaction has proved to be a valuable contribution to supplement the quantitative life cycle system approach in the case of Resirk. Through qualitative interviews interdependencies between resource items can be found. In this paper we have not, as many other IMP-researchers, been concerned about how interaction and resource are established and how resources are developed in relation to each other. We have rather been trying to show how a current characteristic of a product such as a PET bale is related to and dependent of other network resources, often "located far away" from the focal resource. This is a good basis for possible later studies of the resource embeddedness of the PET bale.

We have also experienced some problems when applying the resource interaction perspective. It is sometimes difficult to analytically isolate resources and resource interfaces and justify why one resource interface is more important than another (or at least more worth to dig into). This is especially a problem since we know, from the network perspective, that these two resource interfaces also may be related to each other. It could also be questioned the extent to which the four resource categories cover all types of resources and whether stricter criteria for what a product, facility, business unit and business relationships really is and can be, should be developed.

References

Dubois. A. (1994). *Organising Industrial Activities - An analytical framework.* Doctoral thesis, Chalmer University of Technology, Gothenburg, Sweden

Eik, A., Brattebo, H., Saugen, B., Solem, H., Steinmo, S. (2002). *Eco-efficiency in recyling system*. IndEcol-rapport no 1, 2002, NTNU, Trondheim

Gadde, L.E and Håkansson H. (2001). *Supply Network Strategies*. John Wiley & Sons, Ltd.

Gadde, Lars Erik et al (2002), " More instead of less" - Strategies for the use of logistic resources", *Journal of Chain and Network Science*, Vol.2, No.2, pp. 81-91

Grytli, J. (2003): Personal communication at Norsk Resirk Ltd

Håkansson and Waluszevski (2002a): "Path dependence: restricting or facilitating technological development", *Journal of Business Research* 55 (2002) 561-570

Håkansson, H. and A. Waluszewski (2002b), *Managing Technological Development IKEA, the environment and technology*, Routledge, London

Håkansson, H. and I.Snehota (1995), *Developing Relationships in Business Networks*, Thompson, London.

Håkansson, H. (ed.) (1987). *Industrial Technological Development: A Network Approach.* Croom Helm, London

ISO (1997), *International Standard 14040 – Environmental Management – Life Cycle Assessment – Principles and framework*, Brussels: International Organisation for Standardisation.

Tomra Systems ASA (2002): Annual report 2001

Von Corswant, F. (2003): *Organizing Interactive Product Development,* Doctoral thesis, Department of Operations Management and Work Organization School of Technology Management and Economcs, Chalmer University of Technology, Sweden

Wedin, T. (2001), *Networks and Demand*: The Use of Electricity in an Industrial Process. Ph.D.thesis No.83, Department of Business Studies, Uppsala University