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Greening products: a framework for product chain management

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Abstract

Diminishing the ecological effects of products has become an important focus of corporate environmental strategies. Based on empirical research by the author and published sources, this paper presents a conceptual framework of six types of product chain management. By looking at several categories of costs and benefits for different actors (suppliers, producers, distributors, consumers) associated with each of these types, the framework focusses on their differential nature. In addition, the diversity in strategies open to each of these actors in the product chain is a main focus of the paper. The use of the framework as an analytical as well as an interventionist tool is discussed. © 2002 Published by Elsevier Science Ltd.

Keywords: Product chain management; Green products; Public policy

1. Introduction

Over the last decade, products have become an important focus of environmental policy programs [1]. Rather than looking at individual production processes, a product oriented approach calls for an integral perspective that looks at the material streams tied to the production, consumption, and disposal, i.e. the entire life cycle, of a product. In taking such interrelations as a starting point, it is a form of Industrial Ecology [2].

There are at least two barriers to overcome with a product oriented approach. First, there is the problem of assessing the ecological effects throughout the product life cycle, and comparing them between products. The development of standardized techniques for measuring these effects has at least partially solved this problem [3]. However, concluding that one product is more eco-efficient than another does not automatically lead to product substitution. According to Ayres and Ayres [4], this is due to 'freeze in' of inferior technologies; in the competition between alternative technologies, timing is important and can lead to the victory of a technology that is not optimal. This so called *path dependency* is a general phenomenon in technological innovation [5], but applies also to 'ecological' innovations [6].

More generally, this phenomenon is referred to by economic sociologists as the *social embeddedness* of economic activities [7]. The production and consumption of a good involves the activities of a number of actors, and the relations between these actors can lead to activities that are different from rational behavior as modeled by economists. From this perspective, changing a product is a social process involving several actors, namely consumers, suppliers, governmental agencies, and environmentalists. Each of these actors has their own interests. The difficulty of coordinating the activities of these actors is a second problem associated with processes of product chain management.

Over the years, researchers who have studied cases of product stewardship, ecodesign, and integrated chain management, have been rather optimistic about the possibilities of cooperation between these actors [8]. They have thus downplayed the importance of this second problem. However, some indications are present that there is an important coordination problem related to such initiatives [9].

Rather than adding more case studies to the literature, I will present in this paper a framework of product chain management. This framework is intended to explain the way in which such initiatives come about. Thus, it differs from prescriptive models, which aim at the development of management tools that can help companies to implement product chain management. In the following section, I will present the building blocks for this framework, after which it is presented in working order (section 3). It is based on my own research [10] as well as case studies from others. Section 4 contains a dis-

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cussion on how to use this framework. Throughout the paper, I will use the term of 'product chain management' as the general label for initiatives of actors, within or outside the product chain, related to the reduction of the environmental impact of the product during its life cycle. This includes initiatives taken by one company, such as Product Oriented Environmental Management [11] and Ecodesign [12], as well as initiatives involving several or all of the actors in a product chain.

2. Three building blocks

The framework consists of three building blocks: (a) the product chain as a network of actors, (b) the options available to reduce the ecological impact of a product, and (c) assumptions about the behavior of actors in the product chain. These will be discussed in turn.

(a) The product chain as a network of actors. As discussed above, material streams in the life cycle of a product are the result of the (inter-)actions of social actors. The first building block of the model is the *product chain*, that is, the set of actors, and their relations, that are directly responsible for these material streams. To simplify things, I will divide this product chain into six phases: (1) extraction of raw materials and production of intermediate products, (2) production of end products, (3) distribution, (4) consumption, (5) recycling, and (6) disposal of (re-)used product. The product chain is broader than an industrial system [9], which is limited to the pre-consumption part of the product life cycle.

The actors in the product chain (firms, consumers, governmental agencies responsible for waste collection) are distributed over these different phases. Their actions are coordinated by mechanisms such as markets, joint ventures, cooperative networks, collective agreements, etc. [13]. Of course, the specific distribution of actors over the product chain, and the nature of the mechanisms coordinating their behavior, differ with the product studied as well as the country in which the product chain is situated. Moreover, these characteristics evolve over time [14]. For the purpose of this model, the following two points are relevant. First, relations between actors can be situated on the continuum between *strong* (structural, involving different activities, formally agreed upon) and *weak* (incidental, around specific activities, informal). One of the basic ideas to learn from organizational sociology is that the nature of these relations influences the behavior of the actors involved. A second point is that a distinction should be made separating relations *within* a phase of the product chain (i.e. distribution) and relations *between* phases of the product chain (i.e. between production and distribution). Thus, the structure of a product chain can be described by assessing for each phase the number of actors and their relation (i.e. a large group of producers organized into a trading association) as well as the mechanisms connecting different phases (i.e. vertical integration between extraction of raw materials and production of product).

(b) Options available to reduce the ecological impact of a product. The second building block is the set of *options* to reduce the ecological effects of a product. These are listed in Table 1.

(c) Assumptions about the behavior of actors in the product chain. The third building block of the framework concerns two assumptions about the behavior of individual actors in the product chain. The first assumption is central to resource dependency theory [15]. This theory sees organizations as systems that are never in control of all the resources (financial, cultural) needed for their goal attainment. This means that some resources must be obtained from other organizations. According to Pfeffer and Salancik, organizational behavior can be understood as the attempts to reduce the dependency on other organizations. This is the assumption of *dependency reduction*. This can be done by starting to produce the resource itself. Another strategy is to reduce the importance of a resource. Within the scope of this paper, this assumption implies that organizations will, when looking for ways in which to develop initiatives for product chain management, seek options that do not increase their dependency on other organizations, and prefer options in which such dependency is reduced.

The second assumption is basic to economic approaches to firm behavior, and is reflected in the rational choice perspective in sociology [16]. It states that economic actors will choose actions that bring about desired results with a minimum of costs. This is the assumption of *utility maximization*. In terms of this paper, this can be translated into types of costs and benefits that options for product chain management can have for individual actors. Such costs and benefits can be of the following nature (Table 2). In the overview of costs and benefits I have included increased and reduced dependency. This stresses that the potential change in dependency is weighed together with other costs and benefits in choosing an action.

2.1. Putting the building blocks together

The three building blocks (product chain, options, and assumptions about individual behavior) are linked in the following way. The product chain, as the set of relations between actors in different phases of the product life cycle, forms an initial situation. From this situation, an initiative to reduce the ecological impact of the product emerges. How a certain situation leads to a certain outcome is explained by the behavior of individual actors. Their behavior is influenced by the situation in which they find themselves, and leads to the outcome, which can be categorized as one of the options of product chain management.

Table 1
Options for product chain management

Material reduction	Reducing the amount of one or more materials necessary for producing the product
Material substitution	Replacing one or more materials for ones that have less negative ecological effects
Material recycling	Recycling a material which constitutes the product
Product substitution	Replacing the product with another one which fulfils the same function
Product recycling	Collecting and reusing the product
eliminate function	Stop fulfilling the function of the product

Table 2
Categories of costs and benefits for individual actors

Costs	Benefits
1. Costs of developing and introducing new production techniques (including behavioral change)	1. Increased sales
2. Costs of coordinating changes with other economic actors	2. Decrease of input/production costs
3. Opportunity costs as a result of decreased sales	3. Reduced dependency
4. Increase of production costs	
5. learning costs	
6. Increased dependency	

For the moment, I propose that the trigger to the actions of individuals can be either external pressure (from government and/or environmentalist groups), or the wish to use ecological arguments in marketing. In other words, the framework does not include actions based on ethical considerations. Testing of the framework in systematic empirical research will show whether this is a virtue or a vice.

3. Six types of product chain management as collective outcomes

In this section, I will analyze the six options for product chain management. Each subsection starts with a figure, showing what parts of the product chain are involved. Also, the basic costs and benefits for each of these categories of actors are shown (benefits in italics). Then, I discuss the strategies actors are likely to choose. Given the basic costs and benefits, their choice depends on the specific structure of the product chain. Throughout, I will present existing research results to elaborate on the analysis provided by the framework.

3.1. Material reduction

The reduction of a material used in a product is the action for which a producer alone is responsible. This organization must make some development and introduction costs, but as product and production technology essentially remain the same, they are relatively small. Potential benefit is a reduction of the dependency on the material supplier, as well as reduced input costs. At the same time, this means that the supplier is the one who faces serious costs (reduced sales), especially when all producers decide to reduce the use of a material in their product.

In reaction to a producer who chooses material reduction, a supplier has several strategic options: she can reduce her dependency on the producer either by searching for new markets, or by gaining control over the producer by forward integration. The latter strategy could have an impact on the outcome of material reduction. The viability of each of these strategies depends on the characteristics of the product chain. For instance, if production is performed by a large number of small companies, while supply is concentrated in a few large companies, forward integration is not a feasible strategy.

It is possible that supplier and producer of a product are integrated, as in the production of glass milk bottles in the Netherlands [17]. Then, material reduction involves coordination through the internal decision making of the firm. Material reduction then becomes identical to a measure to increase the efficiency of production.

In all, material reduction (Fig. 1) is an option that is common to normal business practice, and involves the—non-cooperative—actions of a producer and its supplier; other parts of the product chain are not affected. As will become clear below, material reduction is relatively simple and costless option, both from a narrow economic perspective, and from the perspective of network relations and the development of new knowledge.

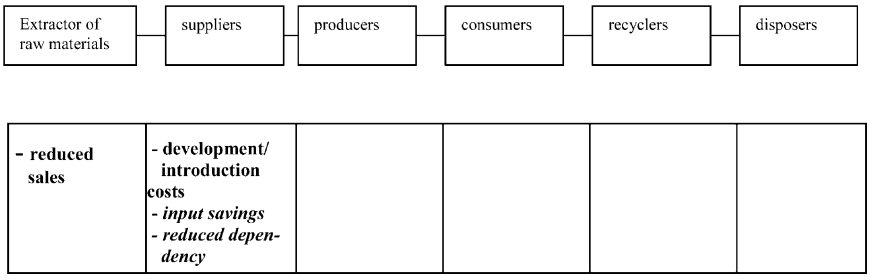

Fig. 1. Material reduction.

3.2. Material substitution

A lot of actions that are implemented to reduce ecological effects of products can be seen as the substitution of a material (Fig. 2). One major example is the replacement of CFC's during the 1980s due to strong political pressure. Assuming that an alternative to the existing material must be developed, this option minimally involves the producer of the end product as well as a supplier. This option involves development and introduction costs, as well as the coordination costs that result from getting a supplier for the alternative material. Due to the fact that material substitution often leads to changes in product and or production technology, these costs will generally be higher than those associated with material reduction (Section 3.1).

For a producer, it is usually a rational strategy to involve his current supplier in a comakership relation in which an alternative is developed. As Ostlund reports, this was the dominant pattern with CFC substitution in Sweden: "when forced to change, actors cooperated to find solutions within established relationships that did not alter the existing technology and production systems to any large degree" [18]. Although it perpetuates the dependency relation with this supplier, it is less costly than searching for a new supplier and developing an alternative with this new partner. Moreover, as the supplier of the original material is threatened with the opportunity cost of reduced sales, she is a willing partner, thus reducing coordination costs.

With the assumption that the stimulus to such action is external pressure, it follows that all producers are faced with similar demands. This gives the opportunity for a collective action strategy, which can increase the power of the producers towards their suppliers. Whether such collective action occurs depends on the structure of the product chain. A case in point is the development of phosphate free detergents [19]. Although producers negotiated with government about legislation concerning the elimination of phosphates, the competitive relation between producers also stimulated research and development, with Henkel as the company that gained a competitive advantage. In addition, it substituted phosphates with a substance it produced itself, thereby eliminating its dependency on a major supplier. In other cases, such as that of CFC-producers, actors can reduce development costs by cooperating [9]

Apart from governmental pressure, it is possible that actors from within the product chain exert pressure on producers to substitute a certain material. In the Netherlands, this mechanism operated in the substitution of CFC's in polystyrene meatplates [19]. For these actors (distributors and/or consumers), this involves coordination costs only. The rules of collective action [20] imply that these costs are difficult to overcome for large groups. This is indicated by the relative lack of consumer pressure in these issues. For distributors, i.e. retailers, such costs are often negligible, while such action provides interesting marketing opportunities. Often, market leaders find it in their interest to put pressure on suppliers; while accepting that smaller competitors profit from their activities (an instance of what Olson calls "the exploitation of the great by the small").

3.3. (External) material recycling

I will consider only material recycling (Fig. 3) where regenerate is input into the same production process (so-

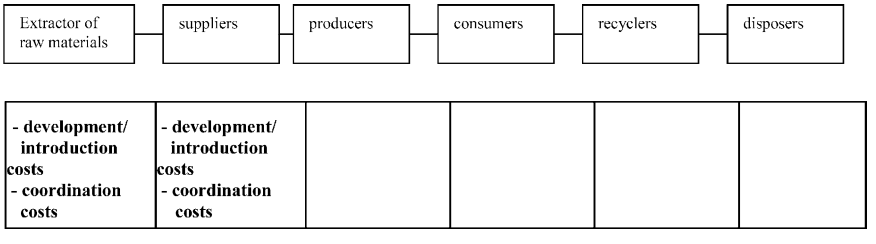

Fig. 2. Material substitution.

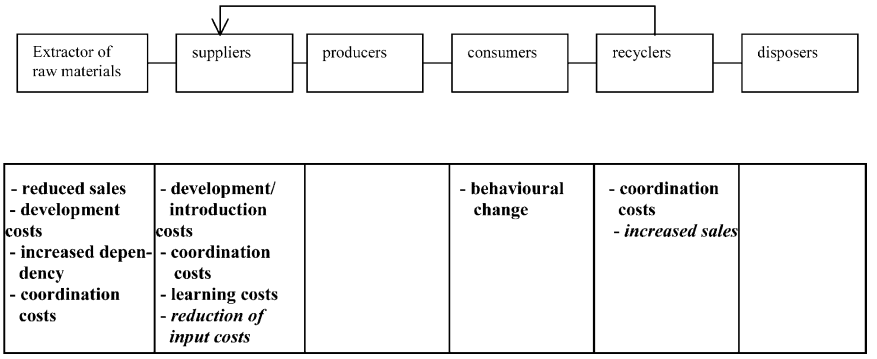

Fig. 3. Material recycling.

called type B recycling [21]). With material recycling beyond the boundaries of production waste, the material supplier is the central actor. For them as well as for the producer(s), this option implies substantial development and introduction costs, for instance because the product has to be designed for disassembly. Also, substantial coordination costs result from the organization of collection of used products. In addition, consumers can be confronted with the necessity of altering their behavior. Even though the regenerate is used in the same product, learning costs occur because new activities must be performed (collecting and recycling), and the input of regenerate in the production process will also bring with it learning costs. In addition, the supplier becomes dependent on collectors of used materials.

Given the fact that almost all stages of he product chain are involved, and incur costs rather than benefits, it is understandable that material recycling does not occur too often, unless considerable external pressure is exerted. One example is the recycling activities of car manufacturers [22]. As a result of—anticipated—governmental legislation, these companies have started to take disassembly into account in their product design. Recycling of the—increasingly used—plastics is one of the dominant strategies. As Den Hond [23] explains, in the development of such strategies, partnerships with plastics manufacturers occur only during a short period. For the remainder, car manufacturers stand alone. The position of material suppliers is straightforward [24]. Some of these companies are rethinking their position as suppliers in the direction of material leasing. However, most of them see recycling as a threat to their business. Although they participate in studies to assess the possibilities of recycling, they are reluctant to put it forward as an economically feasible solution.

A similar process took place with respect to the dismantling of used cars. In the developmental phase, car manufacturers themselves looked into the possibilities of dismantling. They cooperated on a project basis with actors in the post-consumption phase, such as car dismantlers. After obtaining the necessary information, contracts replaced cooperative relations to coordinate dismantling.

Another example of material recycling is the reuse of PVC piping systems in the Netherlands [25]. Such systems are used extensively in the Netherlands, both in sewage systems and in water supply systems in buildings. Due to the pressure of both government and environmentalists, the main producer of PVC piping systems in the Netherlands WAVIN decided to develop a material recycling scheme. They found that cooperation with other producers in operating a recycling system was necessary to recover the used material for an economically feasible recycling unit. An existing organization for information exchange within the sector became the coordinating unit of the recycling system. The members agreed to work together in the collection of used PVC piping systems, urging their customers to return used material and waste from building sites. Also, the three leading companies agreed to develop a recycling unit, which would also process the material recovered by the three smaller companies. In addition, there was an agreement between the three leading companies to exchange knowledge on different recycling techniques. As a result of this coordinated initiative, an economically feasible recycling system was developed. Furthermore, the three leading companies developed products (piping systems) in which the recycled material could be used again. In this mix of individual actions, temporary coalitions, and structural collective action, it is important to note that existing collective action arrangements can be especially helpful; once established, they can be extended to cover other goals [26]. Then, the substantial costs of developing material recycling can be shared by producers with a similar fate. The example also shows that material recycling is more feasible when several phases of the product chain are integrated into one organization. WAVIN, a producer of piping systems, developed in-house facilities for processing the collected waste into regenerate, and thus incorporated supply, production, and recycling phase within its organizational boundary. Thus, it is not the activities of autonomous actors that

have to be coordinated, but rather the activities of different parts of one company. This could be called the strategy of incorporation.

3.4. Product substitution

A radically different situation occurs with the option where an existing product is replaced with an alternative (Fig. 4). In this case, the central actor is often the distributor or consumer, which chooses to buy from a different producer, although the producer may decide to substitute its original product by a different one. First of all, this implies large costs to both producer and suppliers of the existing product in the form of elimination of sales. At the same time, there is the benefit of increased sales for the producer and suppliers of the new product.

At first sight, this seems to be normal business practice. In standard economic models, with every purchase, consumers decide between alternative products. In reality, there is often the distributor as an intermediator, who influences these decisions. In addition, when ecological effects of products are used as a criterion for deciding for or against a certain product, the individual decision of a consumer is sometimes transformed into a societal decision between certain products.

A final complication occurs when the alternative is a new product. Here, the existing producers and suppliers have the advantage of having established relations with each other and with distributors/consumers. Producers of an alternative product face substantial coordination costs, because they must form a viable alternative by presenting themselves as a complete product chain to the consumer/distributor (see [25] for an example).

For the actor initiating the substitution, there are search and coordination costs, as well as possible costs of adaptation. On the positive side, benefits can result when the dependency of the new producer is less than that of the old supplier.

As in the case of material substitution, distributors are a part of the product chain from which pressure can be expected. They face coordination costs only, while opening up marketing possibilities. The case of B&Q [27] is interesting in this respect. This large Do It Yourself-retailer has developed a screening program for its suppliers in the form of a questionnaire. This activity does not seem to be directed towards cooperation with suppliers, however. Green and Morton cite B&Q's mission statement, which states that it will strive towards better products by "creating awareness and accountability in the supply base and giving real commercial incentives for excellence.". Suppliers that do not improve their performance are de-listed. With its position as market leader, and numerous companies willing to replace existing suppliers, it is sufficient to put pressure on suppliers. A similar situation occurs in the policy of British Telecom towards its suppliers.

3.5. Product recycling

Product recycling (Fig. 5) may be one of the most difficult options to bring about, given the position of actors in the product chain towards this option. To begin with, product recycling involves costs to both producers and suppliers in the form of reduced sales. For the distributor, it involves both coordination costs necessary to develop a collection system, as well as increased production costs as a result of the handling of returned products. Furthermore, this product recycling typically increases the dependency in the product chain. Lastly, consumers must alter their behavior in order to make the collection successful.

An important example of this situation is re-usable packaging, such as milk bottles. Their use has diminished steadily over time, parallel with the growing importance of supermarkets. For retail organizations, re-usable milk bottles imply substantial handling costs, and thus they prefer disposable milk cartons.

Packaging, however, is a complex product to recycle because of its highreturn-velocity. For other, more durable products, recycling occurs in a different loop, which is separated from the product chain. Examples are the re-use of furniture, clothes, and electronic equipment through second-hand stores. Typically, such loops catch only a small portion of the total products produced. They are based on either government subsidies, or on individ-

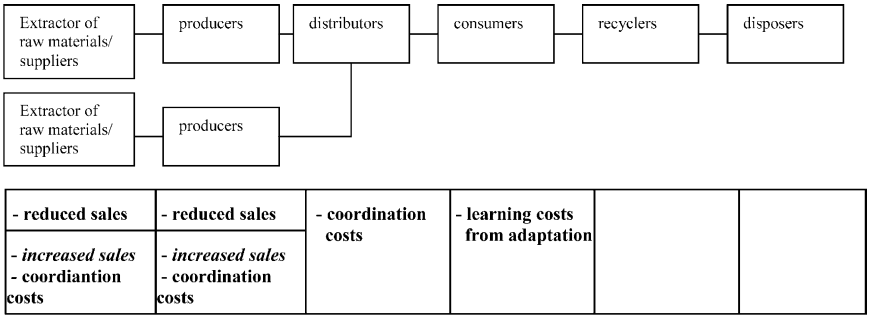

Fig. 4. Production substitution.

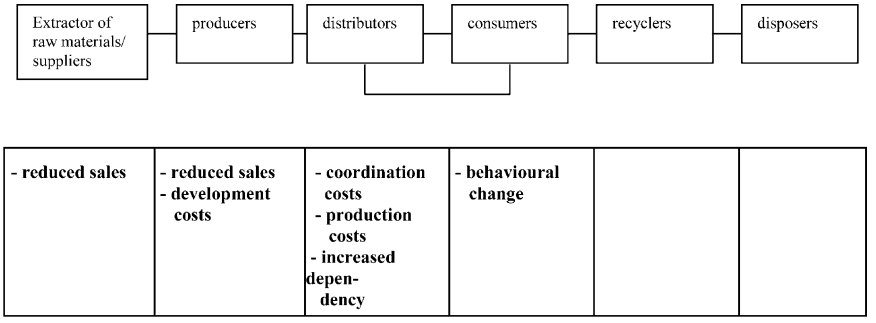

Fig. 5. Product recycling.

ual economic strategies of second-hand stores. An exception are cars, which are re-used extensively, to a great extent through the normal distribution channel of the product chain.

3.6. Eliminate function

A final option, at least theoretically, is to eliminate the fulfillment of the function for which a product is used (Fig. 6). Rather than discuss the different ways of traveling overseas by either airplane or boat, the traveling itself is eliminated. This option depends upon the altered behavior of consumers. For each of the other parts of the product chain, this option involves substantial costs as a result of the elimination of sales. Essentially, marketing is the strategy these actors (sometimes collectively) employ in order to prevent consumers from altering their behavior in this way. I do not know of case studies of this type of product chain management, maybe with the exception of campaigns of environmentalist groups and consumer organizations. But even these are not often directed at the elimination of a function.

3.7. Strategic interaction within the product chain

Above, I have looked at the six options of product chain management, discussing their characteristics. In order to be able to explain the occurrence of such options, and possibly intervene in product chains to stimulate such occurrences, it is useful to look from a different angle: that of the strategic possibilities each of the categories of actors has. Table 3 gives an overview.

With respect to the reduction of ecological effects of products, each category of actors has its own strategic repertoire. *Disposers* are not crucial. If they have a problem, it usually is an excess of supply. Occasionally, a specific substance in their supply can become subject to discussion (such as PVC causing dioxin in waste incineration), but their role is marginal.

Recyclers have a growth interest in the recycling options. For material recycling, a comakership strategy can be fruitful. At the same time, there is the threat of a takeover (see subsequently). As far as they are independent actors, their role as prime movers in a product chain is limited, at best sustaining a limited product recycling loop.

For *consumers*, there is only one strategic option, collective action. On the positive side, this strategy is flexible towards different types of product chain management. At the same time, for such a large group of autonomous actors, collective action is notoriously difficult to organize. In some instances, existing consumer organizations can play a role.

Pressure from the demand side of the product chain can be expected from *distributors*. For them, collective action is easier to organize. In addition, reducing the ecological effects of a product can form the basis of an interesting marketing strategy. These actors typically choose for substitution. Marketing is also a powerful defensive strategy in the case of eliminating the function of a product.

Producers have the most varied strategic repertoire, ranging from a marketing strategy, through comakership with suppliers, to collective action among themselves. They can even incorporate other parts of the product chain, such as recycling, within their organizational boundaries. These possibilities provide a rationale for establishing producer responsibility for the ecological effects of a product, because it leaves the choice open for the specific way in which such effects are reduced

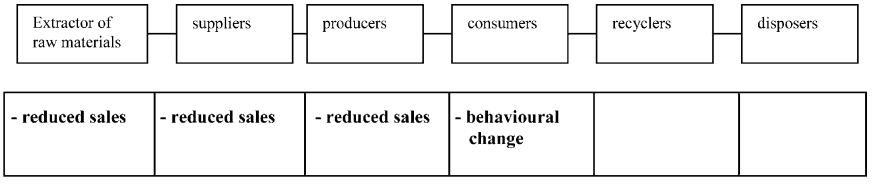

Fig. 6. Eliminate function.

Table 3
Strategic possibilities for actors in the product chain

	Supplier	Producer	Distributor	Consumer	Recycler	Disposer
Material reduction	• Diversificate • Forward integration	Efficiency	–	Collective action	–	–
Material substitution	Comakership	• Marketing • Comakership • Collective action	• Marketing • Collective action	Collective action	–	–
Material recycling	Material lease	• Incorporation • Collective action	Collective action	Collective action	• Growth • Comakership	–
Product *substitution	– Comakership	– Comakership	• Marketing • Collective action	Collective action	–	–
Product recycling	–	–	–	Collective action	Growth	–
Eliminate function	–	Marketing	Marketing	Individual action	–	–

*The first two cells are divided: above are the strategies for supplier/producer of the existing product, below those open to the supplier/producer of the alternative product.

or eliminated. At the same time, however, the different strategies linked to certain options call for different capabilities, which are typically not simultaneously present in an organization. In addition to the differential cost/benefit structure of different options, this indicates the complexity of greening products.

Typically, *suppliers* are in a dependent position. Sometimes, however, they have the power to forward integration. Then, the decisions made by the producer become related to the interests of the supplier. When such power is not available, comakership is a good alternative, because it provides some influence on the producers decisions. A difficult, but promising strategy is material leasing, which transfers the responsibility from the producer towards the supplier.

For all these actors and their strategies, again it must be noted that they can be applied in an offensive way (promoting product chain management) as well as defensive (trying to prevent any of the six types of product management to be implemented).

4. Conclusions and discussion

In Section 3, I have presented six types of product chain management, and the related categories of costs and benefits for actors in the product chain. Together with an analysis of the structure of the product chain, this should provide an explanation for the occurrence of these different types of initiatives. The framework outlined can be used in at least two ways. First, it provides the basis of an analysis of cases of product chain management. Second, it can, to some extent, be instrumental in steering product chains towards reducing ecological impact. I will discuss each purpose in turn.

4.1. The model as a basis for analysis

The fact that current products are not—fully—sustainable can be related to three types of factors [28]: (1) *technical* impossibilities, (2) problems related to obtaining complete *information* about the ecological effects of products, and (3) the fact that the development and introduction of a sustainable product involves the coordination of actions of several autonomous actors. This third problem of *coordination* is the central theme of the model. It identifies causes for the fact that, even if technical and informational problems were eliminated, sustainable products would still not be introduced automatically.

Although costs and benefits of individual actors are at the heart of the framework, it is not assumed that a socially optimal outcome (i.e. a Pareto-improvement) will result from the interactions of actors in the product chain. Instead, the framework provides insight into the ways in which outcomes are generated that are optimal for powerful—coalitions of—actors in the product chain. Power relations are in turn based primarily on the structure of the dependency relations in the product chain. Thus, it is possible to explain why reusable packaging is not introduced to substitute disposable packaging of food products. With the increasing power of retail organizations in product chain of a large number of food products, these actors are in a position to determine the choice made by actors in the product chain. Based on the relative costs and benefits of different types of product chain management *for themselves*, they choose to coordinate the elimination of a product rather than the establishment of a recycling scheme. Thus, one of the interesting conclusions to be derived from the framework is how individually rational behavior leads to an increase in social costs.

The basic assumption of resource dependency also indicates to what extent cooperative relations within the product chain can be expected. Generally, intensifying of relations throughout the product chain cannot be expected because it increases the dependency between the actors, thus limiting their freedom of action. This will only occur if the benefits outweigh this increased dependency cost. If it occurs, it often takes the form of project-based sharing of research and development costs between two stages in the product chain, as in the car industry. Alternatively, there are examples of actors within a stage of the product chain that cooperate. In order for this to occur, the collective action problem must be overcome.

The fact that intensifying relations—cooperation—is not to be expected is not in itself a cause for concern. The need for cooperation is to a great extent a construction of policy advisors that saw it as the best way to close ‘leaking’ product chains. As the examples in Section 3 show, activities of single actors in powerful positions can be as instrumental to this end as cooperation throughout the product chain.

It should be noted that the framework does not provide an exhaustive explanation of product chain management. It is intended as a benchmark for such explanations. When an empirical situation does not answer to the expectations put forward by the framework, it is clear where the explanation for this anomaly should be searched for: in variables that are not part of the framework, such as internal processes within companies.

I would like to mention one important abstraction from reality that could be incorporated. It involves the interplay between the economic process of developing product chain management on the one hand, and discussions within policy networks on these initiatives on the other hand. From the perspective of actors in the product chain, this could be incorporated in the model by including a *defensive strategy*, aimed at resisting the pressure from governmental agencies, environmentalists, etc. When the costs of such a strategy are less than those

associated with one of the six options discussed above, individual actors will, at least in the short run, employ such a strategy. Minimally, it buys them time to develop one of these options within the bounds of 'normal' business, thus reducing the 'extra' costs. Such a strategy can also be employed if an actor wants to implement an option that is different from the one government expects it to.

4.2. The model as a basis for intervention

Currently, policy makers as well as their advisors are into discovering *win–win situations*. Situations in which economic motives and ecological demands coincide are viewed as a basis for policy development. Theoretically, this is nonsense, because economic actors who find themselves in such situations will, by definition, act in ways that are ecologically beneficial. Therefore, it seems more important to identify the structure of *non win–win* situations.

The framework developed in this paper does so, and points towards some choices that have to be made by actors (governmental agencies, environmentalist groups) determined to influence the economic process within product chains. There are two basic possibilities. First, there is the situation in which none of the actors in the product chain seems to be interested in diminishing the ecological effects of a product. Then, the framework can be used to determine what actor is the most suitable to be used as a lever for change in the product chain. Typically, this is an actor with a powerful position due to the dependence of other actors on its resources. The framework can also be used to predict what type of product chain management this actor will develop when it is left the choice. If this specific type is not the preferred one from the perspective of the interventionist, the intervention should go further than just exerting pressure, and should include directions towards the preferred type of action.

An important dilemma is related to the second basic possibility, that in which one or more of the actors in the product chain is willing to use its resources to implement product chain management, but where this actor chooses an alternative that is not the most sustainable. In such cases, intervening actors have to weigh the advantages of having an actor initiating change towards a reduction of ecological impact, against the disadvantage using its coercive power to implement a type of product chain management that, from their perspective, is optimal for society, but not for the actor itself. It should be noted that this dilemma is made even more complex by the fact that deciding what is optimal for a sustainable society is not simply a scientific calculation. Rather, it involves the interpretation and weighing of quantitative data by involved actors. Throughout the paper, I have consciously abstracted from this issue to make the point about the social embeddedness of product chain management. However, in the end both embeddedness and judging sustainability count in the development of product chain management.

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