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**Interorganisational learning in the green transformation  
A resource based explanation**

**1. Introduction**

This is a, somewhat hasty, state of the art report of a ph.d. dissertation now two years underway. The purpose of the research project is to apply evolutionary economic theories to the study of the greening of industry, with emphasis on resource based explanations. The theme and research questions have their source in the scientific environmental debate. The focus is, however, on the analysis on the nature and determinants of innovation processes, with greening as a case, rather than studying greening in its own right. Still, there are several hidden green agendas, of which the most important one is the search for adequate theories to address the environmental degradation process. My main point is the need to view greening as an innovation process and address it as such. The explanatory power of evolutionary economic theory towards greening, to which it has so far only been applied to a very limited extent, is thus the underlying agenda of the dissertation.

The study focuses on possible interfirm green learning dynamics. Based on in-depth case studies, the interfirm learning processes of two focal firms (Danish paper mills) are being explored.

The dissertation is presently at a stage where the empirical material is being written together. From the depth of the detailed unfinished empirical analysis, it is somewhat difficult to surface and come up with overall trends and conclusions. On the other hand, this is also the stage where serious decisions concerning the structuring and weighing of the analysis has to fall into place. I have therefore tried briefly to touch upon the main themes of the dissertation, rather than focusing on a singly aspect.

In section 2 there is a brief argumentation for the chosen approach. A short introduction to greening and what I postulate are key elements in the green transformation is given. The main research questions are presented.

In section 3 we dive into a theoretical discussion on evolutionary economic theories contribution to the concept of interorganisational learning. Hypothesis are formulated.

In section 4 there is a short presentation of methodological considerations.

In section 5 a few main points on the case setting are drawn.

In section 6 examples of the empirical analysis is given, focusing on the identified three main elements of interorganisational learning (IL): a) the shaping of demands, b) the coordination of interrelated innovations, c) knowledge exchange.

## 2. Greening as an innovation process

Above I claimed, that I am going to treat greening as any case of innovation. Still, I believe, or at least I want to investigate if, greening is a special kind of innovation process: extreme in its radicality as well as in scope. Some researchers are speaking about the emergence of a new green techno-economic paradigm, with expectations of thorough structural effects for the whole economy. (Kemp & Soete 1990, Summerer 1989, Gladwin 1993, Freeman 1992).

Freeman and Perez (1988), key representatives of evolutionary economic theory, have made a taxonomy of innovations which clarifies this concept:

*Incremental innovations* - are continuous small changes often resulting from learning by doing/using rather than a deliberate effort.

*Radical innovations* - are discontinuous events, typically as a result of R&D.

*Changes of "technology systems"* - affect several branches of the economy and give rise to entirely new sectors. They are based on a combination of incremental and radical innovations together with managerial innovations and are affecting more than one or a few firms.

*Changes in "techno-economic paradigm", or technological revolutions* - have a major impact on the entire economy. It includes many radical and incremental innovations requiring parallel institutional and organisational changes; this turbulent process needs time adjustments. A number of new technology systems may emerge from this.

In Freeman and Peres notion of paradigmatic change the main emphasis is on scope. We are dealing with overall societal change. Although their concept also covers radical innovations, this is mainly oriented towards technological innovations (notice the focus on R&D as sources of innovation). Little emphasis is put on cognitive (though this may be a part of radical technological change (Dosi 1982)) and especially normative change, very important aspects in the greening discussion.

In the green transformation, many fundamental assumptions of western industrialised societies are being questioned. Assumptions such as time calculus, efficiency, consumption, growth and progress are ascribed new meanings. (Daly 1974, Summerer 1989). Greening also gives rise to epistemological discussions. The immense complexity of the environmental problems gives new dimensions to the notion of uncertainty (Simon 1978, Beck 1987). Greening thus involves not only first order learning (exploitation), but also second order learning (exploration). (Fiol & Lyle 1985, Argyris & Schön 1978, Nootbaum 1996). The role of legitimacy therefore becomes a key issue.

Generally speaking, evolutionary economics is focused on first order learning processes.

The main theme is firms ability ~~to~~ react to a changing selection environment. Adaptability is seen in the light of technology development and knowledge/competence accumulation. Shifting the focus to include second order learning, however, means adaptability should be seen both in the light of changing technology and competence demands as well as changes in legitimacy demands.

Greening is fundamentally about the human regulation of the common good we designate the natural environment. We rely on this to extract our material and energy resources (the source

function) and to deposit our wastes (the sink function). Traditionally, greening is seen as being promoted by state intervention and grassroot initiatives, where as firm response is obstructive or, at best, reactive. Internalising firms environmental externalities is normally being associated with extra production costs and must be forced through via various forms of environmental regulation. (e.g. Peace & Turner 1990, Daly 1994, 1991a, 1991b)

These issues give some additional important features to green innovation processes:

- Greening is a *secondary* agenda to that of a firms *primary* profitseeking agenda. Green innovations are therefore disturbing phenomena that are, when internalised, sought added to the primary routines of the firm. I therefore see green innovations, as starting point, as *secondary innovations*. The degree of "fit" between a firms primary agenda and their environmental agenda (in content and form) is therefore a crucial factor for greening at the firm level.

- Environmental regulation is a key agenda setter and sets constraints on firm environmental behaviour.

- Information problems seems to be greater than in other cases. There are numerous analysis, pointing to the slow or lacking diffusion of environmental technologies, even in the case of well-proven and codified innovations. (Skou Andersen & Jørgensen 1995, Malaman 1996). Also at the consumer level, there are evidences that rising environmental awareness only to a limited extent translates into ecologically sounder behaviour. (Kemp 1993)

I will attribute this strong inertia to the fact that second order learning is involved and therefore the presence of immense uncertainty and cognitive bottlenecks.

To conclude, studying greening as an innovation process entails studying aggregate, systemic and therefore highly complex innovation processes. Also, it includes the study of not only first and second order learning, but specifically the relation between these. In other words, the relationship between technological, organisational and normative/cognitive change.

### **An interorganisational focus on greening**

My focus on interorganisational learning processes may be derived from the above discussion. We are, presumably, dealing with *systemic* change processes, and the question is therefore, how such processes proceed; i.e. could one expect that many actors simultaneously/co-evolutionary will respond to the emerging new norms and challenges? If so, will the market response be chain wise, sector wise or perhaps in regional networks - or is it rather a stochastic, individual process?

Some empirical findings on the present greening situation may shed light on some possible developments. One may translate the notion of product innovation cycles (Abernathy & Utterback 1978) to the paradigmatic level, and speak of stages of paradigmatic transformation. My starting point of analysis is that greening is emerging a stage of consolidation (at least in Northern Europe/Denmark). Much indicates that the green transformation in the 1980's and especially the 1990's is undergoing an intensive phase where firm response is changing drastically. Environmental issues are on the brink of becoming internalised into firms. Environmental technologies and practises are becoming more numerous and radical, and just the last years a rapid formalization of environmental management is taking place in many firms.

We need to take a closer look at taxonomies on green firm behaviour. Within environmental management literature, firm response towards environmental regulation and demands is normally seen as a continuum ranging from:

a) defensive (obstructive or evasive), b) complying (reactive, obeying and accepting) and c) co-opting (proactive, ahead of environmental regulation, greening as a market opportunity, shaping norms and criteria).

Similarly, it is common to make distinction based on differences on the environmental impact of the technological behaviour/strategy of firms:

a) 0-strategy. Unrestrained resource use and emission outlet (solid, fluid and airborne).

b) Add-on technologies (also called secondary treatment or End-of-Pipe), where emissions are treated ->. A firm perspective on pollution treatment.

c) Integrated technologies (by some called clearer technologies), process innovations, autonomous product innovations -> A firm perspective on pollution prevention.

d) Integrated product development. Product innovations are made based on environmental impacts of the whole life-cycle of the product. Management systems are also designed “product stewardship” or “integrated chain management”. ->A systems perspective on pollution prevention.

If one allows for the possibility that greening is a discontinues process, we should be careful not to treat the above strategies/patterns of behaviour as simple stages of development, but as phenomenon which are taking place simultaneously (except for the 0-strategy which has been obsolete in Europe since the beginning of the 1970's). Also, recent investigations point to the fact that Danish firms (i.e. their environmental- or production managers) do not distinguish between add-on and integrated technologies. (Skou Andersen & Jørgensen 1995) The above mentioned categories, should therefore be seen as largely tacitly understood (possibly ill understood) patterns of behaviour rather than formulated strategies. It is, however, also a clear trend that environmental initiatives are shifting towards pollution prevention and more recently product stewardship. (e.g. Skou Andersen & Jørgensen 1995, Madsen& Ulhøj 1995, Malaman 1996).

In order to define greening at the firm level I prefer to use some more general parameters (continuums), related to the general relation between profitseeking and environmental strategy/behaviour:

*Shifts in cognition* A focus on costs (extra costs or savings) towards focusing on environmental issues in their own right. I.e. a shift of attention, bringing environmental strategies closer, at level or above the profitseeking initiatives.

The below mentioned factors may be seen as indicators of such a cognitive shift, but not necessarily, as many environmental initiatives are direct win-win situations in accordance with the profitseeking strategy. I.e. a great part of greening may be first-order learning, but this is none-the less important greening trends.

*Shift in time & risk perspective* The employment of short, medium or long term perspectives as well as more or less uncertain/risky environmental investments and policies.

*Shifts in environmental impact perspective:* Going from a firm/neighbours, to chain of production, lifecycle perspective, production and reproduction systems and global system.

Given that we are, at least in Western industrialised countries, approaching a stage of paradigmatic environmental consolidation, two important issues arise:

The first one is that there seems to be strong discrepancies with respect to firms' attitudes and competencies on green issues. (Madsen & Ulhøi 1995) Many firms still see environmental issues as a threat, and have a reactive, conservative stance, while the few progressive firms see it as an opportunity. (Porter & Linde 1995) Given this asymmetry in environmental response and the interdependency of production systems, could this mean that interorganisational learning is working as a self-regulatory mechanism, where the advanced, progressive firms (on environmental issues) are influencing/pushing the less advanced/reactive firms?

The above mentioned discrepancy in firm response seems to indicate that greening develops gradually and asymmetrically, i.e. it is not (dominantly) a shift systemic process. In any case, there is a need for studying the nature of the discrepancy and the consequences of this for the greening process. Are firms held back because some conservative firms function as bottlenecks? Or are branches and/or chains of production swept forward together in a common learning process?

The one is the role of possible major qualitative changes in interorganisational relations in the manufacturing industry caused by the ongoing green transformation. My starting point of analysis was, and still is, a hypothesis that the systemic nature of the production system is increasing. The increased interdependence could lead to stronger incentives for firms to engage in cooperative learning on environmental issues.

This increased interfirm dependence is due to:

- Increased material dependence:

a) The (still more frequent) green product and process innovations will be of such a radical nature, that raw materials and practices of the suppliers may have to change.

b) Recycling is fundamentally systemic. There will be increased functional interdependence in the primary processes as the materials cycles are closing and one firm's products and waste products become another firm's input.

- The need for information, proof and legitimacy:

c) With the emerging "life cycle perspective" a firm has, in principle, to answer for the environmental performance of all firms lying upstream in the chain of production. This issue is complicated by the difficulty in proving and marketing that a green product (in its whole lifecycle) is green. Each part in the chain has to get, understand and trust the information of previous parts in the chain. Existing structures of information exchange between manufacturing producers have hitherto not entailed environmental information.

New formal tools are emerging that are meeting this (among firms ill perceived) need: Environmental Management and Auditing Systems, Environmental Product Profiles, Life Cycle Analysis, Environmental Accounting and Environmental Labels, Integrated Chain Management.

d)The emergence of collusion and “collective action” as firms, sectors, regions or the whole industrial sector? are facing legitimacy problems on environmental issues. The question to be addressed is the location of these legitimacy problems.

In all, the above points indicate that the green transformation will lead to an increased interfirm coordination and communication need. This may, however, take on many forms.

These interorganisational changes are not the object of this study as such, but they are relevant for two purposes:

- They make, I believe, my choice of theme of current interest. It may prove that interorganisational learning is becoming a significant change dynamics in the green transformation, an issue that just a few years ago would have been of little importance.
- They provide an interesting background for studying innovation, as they allow for the study of the shaping and formation of new and/or changing learning relations.

More fundamentally, the theme is thus a part of the basic discussion within environmental research on the role and nature of environmental regulation as well as environmental management. The chosen learning perspective implies that (green) behaviour is regulated by more than governmental regulation and pure market mechanisms; there exists a wide range of more or less active feed back mechanisms. By focusing on interfirm dynamics I want to address the question that many different actor groups (than i.e. just state -firm - consumer) are possibly regulating each others behaviour. I see a need for approaching the role of economic activity for the greening process with a more open perspective; i.e. from a dynamic evolutionary perspective (firms as profitseeking social institutions, shaping and shaped by their surroundings) rather than the orthodox neoclassical perspective (firms as mechanic profitmaximisers). The hidden agenda of the project is thus whether firms (the market mechanisms) possess a self-regulatory potential on green issues, and how strong it is/could become.

The overall theme of this project is thus whether firms make each other go green. This can be translated into a theoretical question within innovation theory of the role of *interorganisational learning*. By focusing on interorganisational learning I want to add to the theoretical discussion within innovation theory on the innovation process as an interactive venture. That is, viewing the learning process as a social intersubjective process, and therefore also address it, not just from a firm perspective, but in the broader perspective of associated productive activities (chains of production and sectors) as well as the wider institutional set up.

The mechanisms of possible co-evolutionary systemic change is, however, poorly understood. The concept of interorganisational learning (IL)- also called interactive-, or user-producer learning-, appears today rather vague and undefined. Basically, the current innovation theories either have not sufficiently addressed the issue on when (under what circumstances) IL is a significant innovation mode and the structuring factors of IL. I therefore want to explore further into the concept of interorganisational learning, its content and relevance as a learning mechanism.

The overall research questions are:

- a) Given that learning is asymmetric (you have variance in incentives and competencies) and that firms/production systems are interdependent, does interorganisational learning lead to greening?
- b) What is the significance of IL as an innovation mode? More specifically, what determines the nature and configuration of the interfirm learning processes?
- c) How does the multifaceted green issues (secondary innovations) enter into the general (primary) IL processes?

The emphasis is on b and c, i.e. a study on the microprocesses of the shaping of IL. We now turn to a discussion on evolutionary economic theory, for a closer examination of this question.

### **3. Towards hypothesis on IL**

#### **An evolutionary theory of the firm**

Evolutionary economic theory and neoclassical economic theory differ fundamentally in their ontological basis. Two basic assumptions define this difference: Disequilibrium (evolution) versus equilibrium and heterogeneity versus a means (there is no means in the population). The main point of the prime promoters of evolutionary theory, Nelson and Winter (1982) was a need to redefine the nature of the competitive struggle by including the features of change. The main theme is the response of firms to exogenous change in market conditions. Ungoing innovation and technological change are central factors. Uncertainty prevails and rationality is bounded (Simon 1959). Economic actors cannot comprehend the complexity of the changing environment and therefore “satisfice” rather than optimise.

A key element is the introduction of the concept of routines.(Nelson&Winter 1982) Routines are institutionalised patterns of behaviour, that is behaviour that is executed with limited deliberation, involving customs or habits. These routines form the corporate memory of the firm. Routines are on the one hand adapted (selected) behaviours and therefore effective, on the other hand they are also sources of rigidity and inertia and thus obstacles to change. Behaviour is thus cumulative as path dependent on the one hand while economic actors, on the other hand, engage in search processes to keep up with changes. It is a view of the “activist firm“. Firms try to modify the demand and develop new technologies rather than merely reacting to market conditions by choosing the most appropriate technology. “Creative destruction” is an important part of changing/learning. The focus is both on firm behaviour and market structure.

Also the concept of institution is , and increasingly so, attached importance, and seen in close relation to the concept of routine. Hodgson, a contributor in the attempts of combining evolutionary and institutional theory, defines institutions as:

“a social organisation which, through the operation of tradition, custom or legal constraint, tends to create durable and routinized patterns of behaviour.”  
Hodgson 1988 p.10)

The wider institutional context is seen as shaping firms innovation process in decisive ways. The institutions (sets of routines, norms and laws) works first of all as reducers of uncertainty and therefore also of the amount of information needed. In other words, the institutional set-up partly determines a firms search space. (Johnson 1992) Dosi's (1982) concept of "technological trajectories" as well as Freeman and Perez's (1988) techno-economic paradigm discussion both point to the firm search space as being confounded to certain paths/ institutionalised ways of thinking. Dosi (1982) defines a "technological paradigm" as a pattern of solution of selected technological problems. A "technological trajectory" is the pattern of "normal" problem solving activity based on a technological paradigm, thus determining the field of inquiry. According to Dosi, the economic forces, together with social and institutional factors, will operate as selective devices. Gradually the determinateness of selection increases, as more and more trajectories are ruled out.

Also the discussion on product innovation cycles confirms this. The claim is that innovations processes proceed in stages from more open processes to becoming increasingly narrow and consolidated, compare Abernathy and Utterback's (1978) concept of "dominant design". I am arguing that innovation cycles may also be seen at a paradigmatic level and that greening paradigmatic change is at a stage of growing consolidation, compare the first section of this paper.

As the institutional setting is gaining increased attention within evolutionary economic theory, the focus is shifting from the firm/sector level to an "innovation systems" perspective, notably the discussions on regional and especially national innovation systems.(e.g.Lundvall 1992)

### **The resource based perspective**

The resource based perspective takes the same starting points as the evolutionary economic theories, but puts much greater emphasis on firm heterogeneity. It can be seen as an organisational theory of firm behaviour and innovation.

The basic idea is to view the firm not just from the product side as stated in neo-classical theory, but also from the, more basic, resource side.(Penrose 1953) The hypothesis is that firm performance may be explained by the endowments of resources possessed by the firm. The main theme is therefore to account for the creation, maintenance and renewal of competitive advantage determined by the characteristics of the internal resources of the firm. The firm-specific resources must be valuable, rare, imperfectly imitable and not substitutable to create sustained competitive advantage.(Barney 1991)

Knowledge is seen as the most fundamental resource. The key concept of competence (here used synonymously with capabilities) defined as consisting of knowledge and routines, is basically an expression for the degree of resource specificity a given firm holds compared to its competitors.(Teece 1986)

Knowledge is the key resource because of its special characteristics. It is difficult to trade, compare Arrow's paradox, (you do not know the value of the information you buy until you possess it), and it is difficult to transfer as it is partly embedded in individuals and/or in groups.(Nonaka 1994) Polanyi's distinction between tacit and codified knowledge is widely used to discuss this issue. Tacit knowledge is knowledge which is rooted in action and hard to formalise and communicate. Codified knowledge is formalised knowledge, (often used synonymous to texts) and easily transmittable.(Polanyi 1966)

In innovation studies great emphasis is put on the role of tacit knowledge. Implicitly it is assumed, that as soon as knowledge is codified it is diffused. In resource based theory a similar assumption predominates. Tacit knowledge is seen as the contributing part of knowledge to sustained competitive advantage, in other words, only tacit knowledge is held back. This seems to me a very idealised picture of learning processes as being shift and complete, and does not really stem very well with the basic resource based notion of firm specificity and thus asymmetric learning in firms. Whereas I see a need to discuss the definition as well as the significance of tacit knowledge further, I recognise it as an important concept, because it puts emphasis on the social embeddedness of knowledge. But rather than putting emphasis on the fact that some knowledge may not be codified, I find it more fruitful to focus on the role of the codification process itself. This implies, however, a very evolutionary/learning perspective on firm behaviour and development itself, not always undertaken within this tradition either.

There are basically two strands of theories within the resource based perspective. The management strand dominating the field, a strand I put little emphasis on, since I am questioning the whole notion of firm behaviour and learning as being a managed affair.

The other, more true to the original ideas of the founder Edith Penrose (1953), is an economic theory of the firm rather than a management theory. The perspective is on the firm as a dynamic setting of continuously interacting resources. The firm is seen as a portfolio of resources, where the ongoing integration and association of the resources make the firm specific. Within this field one may include the strand of theorists combining resource and transaction cost perspectives. (Especially Teece 1986, Teece and Pisano 1994, Langlois 1991). The fundamental assumption of Penrose was the limited capacity (practical as well as cognitive) of individuals as well as organisations, and therefore the need to division labour and cooperate; within organisations (firms) as well as in-between them. Whereas the traditional evolutionary perspective with the same arguments conclude that firms satisfice, the emphasis here is explicitly on the importance of coordination and cooperation.

I am arguing, that one may interpret and define this continuous association and integration process as a learning process. In this way the resource based theory makes up the basics of a micro theory of learning and institutionalisation. This perspective has several advantages compared to the traditional actor-structure dichotomy used in much institutional theory. (e.g. Scott 1987). Instead of the blackbox "actor" you have the association of human as well as physical resources (where physical resources are normally overlooked as a learning factor), shaping and reshaping the organisation. The whole notion of adaptation and specification indicates an on going institutionalisation process. Specification takes place through a codification process from which homogenous organisational routines and corporate culture and belief systems emerge. The resource based theory is thus a theory of endogenous change and of the activist firm.

In contrast to this, remains much traditional evolutionary theory exogenous in their perspective on innovation, despite Nelson and Winters argumentation for the "activist firm". It is for the same reasons that the concept of routine has a more positive connotation in the resource based approach. Routines is seen as allowing for an efficient exploitation of the resources, where the specification process promotes inimitability- as opposed to routines leading to inertia. (Wegloop 1996) Also routines allow the firm to deal with the uncertainty and turbulence effectively, so as

to liberate excess (of the limited) capacity for exploration. I.e. efficient exploitation routines gives potentially room for explorative activities.

As with traditional evolutionary economic theory, the perspective is one of long run economics. The difference, and strength, here is the focus on firm specificity and the (specific) learning capacity of the firm relative to the market at a given time. Competitive advantage is having the right competencies at the right time.(Langlois 1991)

So, although the focus is very much inside-out, the relationship of endogenous and exogenous change is a central issue.

## **IL**

If one reverses the fundamental issues within the resourcebased approach, the question of core competence and firm specificity, the issue of firm transparency and transferability of competencies arises, in other words; the role of IL. This concept has, however, so far only been little studied from this perspective. The question on IL is not just a question of cooperative learning, but on why a firm should cooperate rather than undertake contractual research or integrate.

From a pure competence explanation the organisational mode is determined by the relative availability and criticality of competencies between the firm and the market at a given time.

A transaction cost explanation, on the other hand, focuses on the relative governance costs of firms and markets, that is the bureaucratic costs of internal organisation and the transaction costs of market relations.

These explanations are, however, closely interlinked. The use of available competencies on the market may be hampered by high transaction costs. A firm can then choose to integrate or to teach others on the market the needed competencies. This strategy is also necessary when the competencies are not present on the market, as in situations of rapid technology development. These costs of transition, the transaction costs involved in promoting these competencies in outside suppliers, Langlois designates dynamic transaction costs. They are the costs of persuading, negotiating, coordinating and teaching firms in adjacent steps of production, that is, of not having the competencies when you need them.(Langlois 1991)

The resource based argument is, that in the long run, transaction costs diminish with learning, and it is therefore competence explanations that are determinant.(Langlois 1991, Foray1991)

Also, it is necessary to pay attention not only to the negative side of exchanges (frictions) but also the positive side. A positive side of firm exchanges is the learning that accompanies it.

Lundvall, from the neo-schumpeterian perspective building on Arrow, puts great emphasis on this in his development of the concept of “interactive learning.” (Lundvall 1986,1988,1992, Arrow 1974) Arrow argues that IL per definition is important in any producer - user relation because of a reciprocal interest in information exchange in such relations.(Arrow 1974). Anonymous price signals do not suffice to this kind of coordination activities. Both parts need to gain knowledge of and continuously monitor respectively the quality of the product and the nature of the demands of customers. Because of the Arrow paradox (information is a commodity you cannot value until you possess it), this information exchange is based on the establishment of trust relations. Any trade is an act of cooperation.

Following this, Arrow argues for the need to develop stable relations allowing for an effectivisation and rationalisation of the communication and cooperation process. The continuous exchanges may lead to the development of learning channels and common codes. Hereby the uncertainty and costs of the exchanges are reduced. Some degree of organisational rigidity is thus a fruitful element in the learning process. On the other hand there is a need for flexibility in the relations in order to open up for the organisational and normative breaches of the radical innovations. This often involves exchanges of the participant firms (given the embedded nature of much knowledge) or inputs from other sources. Radical learning is thus associated with a broad platform of interaction (number of participant) and thus flexible interfirm relations. (Arrow 1974) According to this argument, there is a contradiction between efficiency and radicality in learning, as they are bound up with respectively stable and flexible customer-supplier relations. From this you would conclude, that IL follows trade relations, and where these are long lasting, IL is most important, but also that IL may lead to breaks in interorganisational relations.

Using the resource based terminology on this, one would call the development of learning channels a specification (and routinisation) of the interorganisational relation; i.e. a great part of market relations are not anonymous, they need to be made specific. The specification processes is not restricted to firms, though it is purposefully sought in firms to build up core competencies.

One may, however, also argue, that it is necessary to distinguish between quasi integration (IL) and internalisation. Whereas Arrow takes IL activities for granted, Foray sharpens the discussion by asking to the difference between engaging in cooperative learning rather than integrating. He points to a fundamental contradiction between resource exploitation and exploration: The contradiction between the necessity for firms of integrating and associating resources in order to render them specific on the one hand and the necessity of leaving these resources on the market to maintain the condition of technological reversibility on the other hand.(Foray 1991) Interorganisational learning presents a possibility of reconciling this contradiction, thus allowing for a possibility to learn both in the short and the long run and open up for radical learning. So where as Arrow addresses the issue of fidelity to linkages, Foray asks to the role of IL at all, as opposed to internal resource mobilisation. Furthermore, there may be incentives for IL beyond the “obligatory” information exchange directly connected to the trade act.

So far, we have a theory of why IL may take place. Now we need to look at what form and variety IL may take. The works of Richardson and Teece are helpful in this respect. (Richardson 1972, Teece 1980,1986, 1996)

Richardson (1972) has made an important distinction on the nature of productive activities (and thus competencies), contributing to the coordination discussion between “specific” firms. These activities may be “*similar*” (fitting in with the core competence) or “*complementary*” to a given firms activities. When firms activities are similar and complementary, it is likely that they will be coordinated internally. When they are non-similar and closely complementary cooperative efforts are necessary. The degree of complementarity of competencies is decisive for the level of interdependence.

When innovations are systemic, that is when they involve more than one production unit, complementary competencies specialised to the innovation need to be coordinated.(Teece 1986)

This coordination may be very difficult and hamper innovations, or possibly lead to vertical integration.

The degree of interdependence may, at least partially, be derived from different kinds of complementary competencies. Teece distinguishes between generic- (general purpose), specialised- (unilateral dependence) and cospecialized competencies (bilateral dependence). (Teece 1986) With generic complementary competencies contractual relations should suffice. In cases of cospecialized competencies, the hazards of contracting are high and integration is likely.

There are risks of opportunism on both sides (on imitation and exaggeration). And it is difficult to persuade the firms with complementary competencies to making specialised investments or organisational changes, which means they are carrying a part of the risk of the innovator. The innovator firm needs to be in a very strong bargaining position relative to the owners of the complementary competencies or come up with good argumentations that they will also be able to attract some of the profits from the innovation. The dynamic transaction costs may therefore be high indeed, especially in the case of high uncertainty and turbulence.

The character of the interorganisational relations decides the size of these transaction costs and in general the willingness to cooperate.

From the above discussion it is clear, that there from a resource based perspective may be strong incentives for coordinating and learning in *vertical* relations for interdependent firms in a changing environment.

But one could similarly argue for *horizontal* IL. Firms may need to gain access to similar competencies through interfirm cooperation. In situations with rapid technology development, or in the case of radical innovations, competitors may be the only other owners of (nearly) similar competencies, given the idiosyncratic nature of the innovations. Strategic alliances between competitors is a possibility in these situations or, even better, cooperation with other firms which possess related similar competencies, but which are not in a direct competitive position with you. In this case the IL is not connected to existing trade relations; there may not be any prior relations between the firms involved at all. The role of routines is here very different.

Generally the concept of IL raises questions as to the definition of the boundaries of the firm. If/when IL is a significant innovation mode, then the competencies does not lie only within the firm itself, but also or more in its interorganisational learning relations. It may then be more fruitful to discuss the competitive advantage of firm specific innovation systems rather than the firm. We need to ask not only where are the boundaries of the firm but also what is the nature of the boundaries.

### **Evolutionary/resource based hypothesis on IL:**

The following factors have been used as key explanatory factors on the nature of IL in the analysis of the empirical findings.

structuring factors:                    routines/institutionalisation  
    codification process (cultural & geographical distance, tacitness)  
    capacity limitations (cognition, resources)->intro-extrovertness  
    dynamic transaction costs

incentives:                      coordination need on innovations(vert.)  
   knowledge access (vert. and hor.)  
   dynamic transaction costs  
   hold up, bargaining power and dependence  
   legitimacy (hor.,vert., firms as such, professional roles)

As the analysis progressed, I have had to revise my hypothesis and conception of the concept of IL. Below is listed the main hypothesis (which are also the preliminary conclusions) in (nearly) chronological order of their emergence:

Basic ones:

- a) The relative criticality and availability of competencies functions as key incentives for, and therefore structures, IL activities.
- b) Some degree of information exchange is a part of any trade act.

Green & vertical ones:

c) If greening is a paradigmatic, systemic change process, then vertical coordination needs (between firms with complementary competencies) will be considerable. Given the asymmetric response to greening, the IL will be of a *conflictual* nature. The proactive firms, or the environmentally more stressed firms, will be pushing/voicing the more reactive firms. Dynamic transaction costs are high, integration or organisational shifts is likely or the innovations will be hampered.

in opposition to this:

d) If interdependence is high (bilateral) (and rising because of greening), and integration does not take place, then IL may play a significant role and become strongly institutionalised (specific). Or one could argue that the integration or organisational shifts do not take place because the emerging IL consolidates the present interorganisational learning relations. The nature of the IL process will be *cooperative*, based on trust, consolidated learning channels and codes.

Green & horizontal:

e) Because of the idiosyncratic nature of the innovations, *cooperative* learning between firms with similar competences is important.

d) Firms are facing legitimacy problems mainly sectorwise. Horizontal information flows and strategies are therefore significant. The is *partly cooperative* (“collective action”) *partly conflictual* (voicing towards the reactive firms), and institutionalised, possibly involving industrial associations or similar institutions.

basic ones:

e) Advantageous conditions for the interorganisational codification process is crucial for IL; both for the establishment of IL relations and for the intensity and scope of the learning process.

f) Cognitive capacity limitations of individuals and organisations are restricting IL in two ways.- Greening is to a large degree still perceived and handled tacitly in firms and is therefore a muddled affair. The ongoing strong codification process is associated with great uncertainty. - Systemic effects of innovations are seldom perceived or reacted to.

### On the concept of IL

In order to operationalise the concept of IL, I have divided it into 3 elements, differing fundamentally in their incentives:

- 1) Voicing/demands shaping. The shaping and reception of environmental demands on product and increasingly also on general environmental behaviour (process innovations, lifecycle demands and demands of environmental management systems).
- 2) Coordination of systemic innovations. Strong coordination needs between firms with complementary competencies a) within established trading relations. b) outside established trading relations
- 3) Knowledge exchange/access. Achieving access to other firms knowledges/competencies. a) complementary b) similar competencies - with respect to process, product and environmental management innovations.

Answering the major research question on page 5, how the multifaceted greening enters IL, means I need to address the issue of how the above 3 processes possibly relate to one another.

Also, I distinguish between two different forms of interorganisational learning:

- a) interactive learning (direct exchanges/ coordinations between firms)
  - b) co-active learning (indirect firm learning, mediated by some kind of an industrial institution. (i.e. the role of industrial associations, formal industrial networks).
- of which interactive learning is by far the most dominant in my case material.

Finally, I discern between IL and co-evolutionary change. In the latter case, the behaviour of more firms seems to change simultaneously, presumably not as a direct result of IL, but because of other factors or the presence of overall (shared) perceived rules.

## **4. A methodological shortcut**

The analysis is based on in-depth case-studies, carried out in 2 corporations within the Danish paper industry.

The unit of analysis is the major green interactive innovation processes between the paper industry and their suppliers, customers and competitors. This means I am consciously downplaying the relations between firms and other surrounding institutions.

In an attempt at practising a critical realist research design, I have tried to employ a very open approach, both towards defining the unit of analysis and the method of interviewing. I have used a "snowball" methodology: The firms have defined who they thought it was relevant for me to talk to, these people have told me of other people to talk to and so on. What was green has been defined by the respondents themselves, as far as possible.

The unit of analysis has thus emerged under way. As I identified green innovations of some interorganisational significance, these were pursued in greater depth and in a few cases (5) contacts were taken to the firms my focal firms (the paper industry) were interacting with. The analysis of these firms are no where as detailed as that of the focal firms.

There was thus no predefined actor types or innovation types. Both the development of management systems as well as technology development were treated as innovations. As it turned

out a wide range of actors within the firms are involved in these processes. I thus spoke with 6 to 9 people within each firm, such as the environmental manager, production manager, development manager, technicians, sales and purchasing people, top managers and people from the technical customer service. In all, 30 interviews have been carried out. About half of these, the key interviews, very long, the other considerably shorter. The only non-firm interview is with a leading technical paper researcher.

My empirical findings will soon be validated by the respondents and, hopefully, the mentioned paper researcher.

In the interviews I basically followed to approaches: Firstly, I traced the development process/emergence of (all) specific (green) innovations: sources of inspiration and competence accumulation, method of exchange, what gate and gatekeepers, the creation of contacts and channels, the degree of openness, appropriability conditions, the possible choice and search for sources of innovation. This was accompanied by general information (not innovation specific) on the mode of innovation and knowledge accumulation at the organisational level and the individual level (the personal learning network of the respondent. Secondly, I traced the key respondents perception of the overall greening process, possible incentives, key actors and events and stages of development.

Finally, I tried to map their knowledge (though nowhere done completely) of other firms, their suppliers, customers, competitors, their sectors competencies/reactions on environmental issues, as well as how they perceived their own competence in relation to their competitors. I am using this as an indicator of IL activities, tracing back where they had this knowledge from. It is also an indicator of the intro- or extrovertness of the firms/respondents cognitive horizon. And finally, it sheds light on the concept of core competence and the role of greening as a strategic issue. Are they aware of where they stand in relation to the market?

IL aspects of the mentioned phenomena were investigated in depth. But also learning between business units within the same corporate group was studied. Although I have tried to make longitudinal analysis, the older data are hard to get, (the respondents have not been in the firm long enough or do not recall the events very well) and to quite a large extent, the findings are about more recent phenomena.

Additional written material is used in the analysis, including environmental data supplied by the focal industries.

## **5. The case setting**

The Danish paper industry has been chosen as case because it is an environmentally advanced industry and because it is a traditional recycling industry. The paper industry, generally speaking, has earlier faced severe environmental problems, because of heavy emissions from the production process. Also the products, very visible, close to the endconsumer and decisionmakers and causing very bulky waste, have received considerable environmental attention (recycling policies, Nordic, German and EU environmental labelling on paper products..). For this reason, and because it has been technologically possible and economically feasible, the paper industry is the traditional recycling industry. Green marketing and demand has thus relatively early been an issue here. I thus expected a fairly high amount of systemic activity in connection with their greening process.

The focus on one focal sector, means that the study mainly allows for suggestions on IL in the specific given industry structure, given the sector specific nature of innovations (Pavitt 1986). The paper industry is a scale and capital intensive sector, with a mature manufacturing technology and low research intensity. For the Danish paper industry the market is largely foreign, but European. By some innovation studies the paper industry has been characterised as a “supplier dominated industry”, that is an industry where the suppliers supposedly play a major role in the technological innovation processes, as opposed to research intensive, scale intensive, specialised suppliers or user dominated industries. (Von Hippel 1988, Scherer 1982) This indicates that suppliers may play important roles in the accumulation of green competencies in the paper industry.(which I was not aware of in the beginning of the study).

The Danish paper industry is very small, made up of 3 (international) corporations and only 5 mills. Each corporation specialises in their type of production, within which they are quite important. The two corporations chosen are:

- Danisco Paper (DP) produces corrugated paper.
- Stora Dalum (SD) produces finer paper.

DP and DS have interesting similarities:

- Both firms are nearly entirely based on waste paper. The Danish 98% reliance on waste paper in the paper industry is unique in a western European context.
- Also their suppliers are basically the same, respectively the recycling industry (=waste paper collectors), the machin- process design- and chemical industry.
- The wider institutional setting (such as environmental regulation)is fairly similar, both being situated in Denmark, but SD has since 1991 belonged to Swedish owners, whereas DP has always been Danish.

& differences:

- DP is an old recycling industry (1956) based on market conditions. SD has introduced recycling lately (1991) as a conscious green strategy.
- Their customers and chain configurations differ. SD has a longer and more heterogeneous downstream value chain than DP.
- SD belongs to one of the biggest (number 5) paper corporations in the world, where as DP is only! a part of a minor multinational corporation mainly dealing with food production. SD has access to the extensive corporate and paper specific R&D, whereas DP does not have such an opportunity within its corporation.
- SD’s environmental policy is a part of the central corporate policy, very top-down. DP relies mainly on its own environmental policy.

## **6. The empirical analysis**

In the following a quick summary account of some of the main themes of the empirical analysis will be given. As already mentioned, the focus is on the identified three main different kinds of interorganisational innovation processes namely:

1. *Voicing/shaping of demands*. Here the demands articulation downstream is followed; demands on products as well as on the environmental performance of firms (though less covered in this paper). Here the role of the customers or firms further down the chain of production in shaping the environmental performance and product development of my focal industries is covered. Belonging to this analysis, is also the study of the focal industries voicing upstream, but this is not included here.

2. *The coordination of systemic activities*. The case here is green product innovations with wide systemic implications. The case is the paper recycling technology itself, having implications for large parts of the production system. The focus here is on the special coordination efforts between firms with complementary products, but no or limited trading relations.

3. *Knowledge access/exchange*. Efforts to achieve access to other firms knowledge appears in connection with most innovation processes (process, product and management systems). Most of the empirical material consist of numerous examples of big and small process innovations leading to greater eco-efficiency. Here will be given an example of just one of these, water closure in DP, quite a radical innovation, keeping in mind that the majority of the process innovations are much more incremental. As it has turned out, the suppliers and especially the chemical suppliers are by far the most important actors in these interfirm learning processes, so the focus is on these in this case. The section ends with some more general comments (not sticking closely to water closure case) on the nature of IL with the chemical suppliers.

In 3 the main focus is on DP, but else experiences from DP as well as SD are included, though only compared to a very limited extent here.

## **1. The role of user demands (downstream IL)**

### **A) Danisco Paper**

Danisco paper is producing what is now largely perceived as a green product: 100% recycled corrugated paper. When they decided to switch to waste paper as rawmaterial in 1956 it was, however, entirely for economic reasons. Indeed it was then and still is, customary for producers of various board materials to use both primary and secondary raw materials, depending on their relative prices. It was then somewhat uncommon to produce 100% recycled corrugated paper, but the technology was known. Since then, the production of recycled paper has rapidly increased especially within board production, but is recently also moving into the production of finer paper. Recycling is the major trend within the paper industry in the 1980's and 1990's. (Clark 1996) In 1970, 52% of the corrugated boxes in Europe were produced from recycled paper, in 1994 this has risen to 67%, in France as high as 81%. In Denmark, however, "only" 42% of corrugated boxes produced are made from recycled paper. According to Danisco Paper the reason for this is the heavy influence of the forest industry (i.e. the producers of primary raw materials) in the Danish corrugated box industry. 70% of this industry is to some extent owned by the forest industry.

Danisco Paper relies to a large extent on exports, mainly to the Scandinavian markets (70%). In recent years these markets have been growing and Danisco Paper has expanded its production. Danisco Paper is profiting from the localisation, being North Europe's biggest producer of recycled corrugated board paper. The Scandinavian markets are traditionally dominated by paper production based on primary raw materials, being heavily integrated with the vast forest industry, so that Danisco Paper holds a niche position in this region.

Generally speaking the image of recycled paper products has changed considerable the last 15-20 years. From being a product of somewhat lower esteem, (where it was not uncommon to hide the fact that it was a recycled product), to being a product strongly associated with positive environmental image. But even though recycling, and paper recycling especially, has been a very important theme in the societal environmental debate in Europe since the mid 1980's, the customers of Danisco Paper do not necessarily see it as a green product.

Danisco Paper have uniform customers, the corrugated box industry, of a relative limited number. According to Danisco Paper they demand DP's product first of all because it is cheaper. It is also a product with somewhat different properties compared to the "conventional" counterpart; in some ways it does not have the same strength capacity, but it "runs" better in the machines. The customers are, however, again according to Danisco Paper, aware that it is a recycled product, and they use this factor increasingly as a sales argument.

There is, however, a growing attention towards the "greenness" of the product coming from the customers of the customers, the very big heterogen group of corrugated box users. Important actors are here the big multinational companies, notably in the food industry who are perceived as trend-setters by Danisco Paper. But still it is a limited amount of green pressure Danisco Paper is receiving from downstream.

Generally, the information channels between Danisco Paper and their customers are weak. Danisco Paper states that they do no marketing, nor green marketing, only the "ambassador" activities of their sales people and the technical customer service. The environmental manager does not deal with customers directly at all. He only responds to the written inquiries on environmental issues. The gatekeepers are the sales people, with little environmental insight and the technical customer service. The main technicians have very little to do with their customers, being oriented upstream rather than downstream (see theme 3).

Technical customer service seems to be a very important factor in this respect. Danisco Paper only started doing technical customer service in 1994, but it is attributed great weight. This is indicated by the fact that they employed a very experienced person in the job ( a technician, an earlier director with 20 years experience). In fact the marketing director of Danisco Paper stresses customer service as an important competitive factor, as prices and quality issues are becoming more or less the same among European producers. Whereas customer communication used to be limited to reclamations, it is now more preventive and broader, and occasionally includes environmental information.

The technical customer manager was by far the person with the greatest knowledge of environmental issues in relation to customers. (Interestingly enough he was not among the first people I was advised to interview in the firm, indicating that they are not very aware of his importance in this respect). He states that he works to promote the image of recycled paper, teaching the customers that it is a quality product, and not some inferior dirty product.

Also, he from time to time takes the opportunity to inform on the environmental progress of the firm, such as the introduction of EMAS, ("Environmental Management and Auditing System"), so some discrete green marketing is taking place after all. Finally, he answers questions as to the environmental liability of their products.

One may conclude, that before the establishment of the technical customer service there was very limited interactive dialogue on technical and environmental matters between Danisco Paper and their customers.

Most questions on environmental issues towards Danisco Paper, are, however, in the form of written inquiries. These have the later years increased in number, reflecting the general growth of environmental management systems, often integrated into quality management systems. The response of Danisco Paper has been to economise on their environmental transaction costs, producing a standard written environmental declaration on the content of their products. The effect of this has, however, been that the inquiries are no longer registered, being handled routinely by several people (and therefore unfortunately also impossible to map). There is only scattered information in Danisco Paper as to the development of the amount and content of the inquiries. So, ironically, as the green demand is rising and the flow of environmental information rises, routine feedback take over, and the pooling of the signals seems to be decreasing.

A few generalisations can be made on the inquiries. First of all that they are in the form of tentative inquiries, rather than coercive pressures. Most are directed towards the possible toxic content of the paper, and this is not a new issue. At least the last 20 years the customers have been inquiring about heavy metals in the paper, worried because the production is based on waste paper. As a packaging material, the product does get into contact with sensitive materials such as food. Especially American firms are concerned about these issues, because of the great supplier responsibility in this country.

Danisco Paper, however, has no control over the heavy metals in their paper. Only this year, Danisco Paper has found a marked decrease in the content of heavy metals in their paper, presumably because other producers elsewhere in the production system have changed their production methods; but Danisco Paper has had nothing to do with this themselves. (More on this in theme 2) This improvement they happily communicate downstream.

Only in approximately 5 cases, all recent, have the inquiries gone further than mere standard questions, asking for detailed information not only about the product but also the environmental performance of the firm in general.

Only one request has been made which has had direct consequences on Danisco Papers product development, a reduction in paper thickness. As a part of the general environmental debate on the need to reduce packaging, boosted by the introduction of the German “Duales System”-regulation in the end of the 1980’s, some of the big packaging users are requesting a reduction in packaging paper thickness. Accordingly, Danisco Paper has reduced its paper thickness considerable, and are working to push it further down.

There is one recent example of an interactive green product design attempt. One of the corrugated box producers, a member of the same corporate group as Danisco Paper, suggested a few years ago, that should drop colouring the corrugated paper and produce grey corrugated boxes, signalling that this was a different, environmentally friendly product. Recycled corrugated paper is always coloured brown to make it look like the “conventional” corrugated paper, but the natural colour is grey. The box producer thought the time should be ripe for signalling clearly that this was a recycled product and leaving out unnecessarily colouring. Danisco Paper was immediately persuaded into test producing this, but unfortunately there was no demand for the product and the attempt was quickly given up. It is properly no coincidence that this experiment took place within the safe walls of the corporate group, although the two firms involved do not have a close cooperative relationship.

The above story illustrates a proactive behaviour on behalf of a corrugated box producer, but this seems to be the exception rather than the rule. The Danish corrugated box producers were put

under pressure by the Danish Ministry of Environment in the beginning of the 1990's to increase the amount of corrugated boxes being collected for recycling. They signed a voluntary agreement committing themselves to collect 80% of their potential wastepaper (the percentage is by now 63%). Danisco Paper was actively involved in this agreement. Not as an interactive process with the individual customers, but at the sector level, participating in the negotiations. They set a guarantee, promising the corrugated box industry that they would buy all the waste paper they could collect. They did this because of a wish to support their customers, in expectation of an improvement of their green image and thus sales arguments. So without directly voicing greening towards their customers, they have tried to be supportive reducing the uncertainty of the innovation. As the technical customer manager says: "We would like our customers to be green". Voicing is not always downstream. The employees at Danisco Paper do, however, generally perceive of the corrugated box industry as somewhat conservative. An indicator of this is their, as perceived by the Danisco Paper people, very reluctant response to the above mentioned voluntary agreement. Little happened until a "papermaker" (an earlier employee of the paper industry) was employed in their organisation, then there was some change of attitude. They have gradually changed the agreement into something positive, now trying to run a green campaign. With the help of professional consultants they have produced an environmental catalogue enabling them to engage in green marketing. According to Danisco Paper none of them are trying to profile themselves especially on green issues. Their actions have been collective rather than individual; time will show whether this translates into proactive behaviour at the firm level. As it has been hitherto, the direct customers of Danisco Paper are not very active on environmental issues.

The demand on Danisco Paper to become greener has to a large extent come indirectly, basically because it is a recycling firm. The environmental regulation has here played crucial role in creating user requirements, putting paper recycling high on the environmental agenda. In the 1970's and 1980's as a range of recycling policies were made, Danisco Paper was actively engaged in negotiating these. Being the by far biggest purchaser of recycling paper in Denmark and being eager to secure their local deliveries (waste paper is generally only traded within a range of 50 kilometres due to heavy transport costs), they signed an agreement committing themselves to buy the obligatory collected waste paper. Consequently they expanded their production capacity considerably. Through these processes Danisco Paper automatically contributed positively to the environmental debate. The firm appeared as the solution to of a societal waste problem and environmental policy to them was perceived as something that could be positive. Generally, recycling and greening became closely associated in the societal environmental discourse in this period. There are many indicators that this promoted an internalisation of environmental values among the employees of Danisco Paper.

Since then, as the environmental debate has advanced and cleaner technologies and forestry practices have been developed, the environmental advantages of recycled paper products as opposed to other paper product is much less clear, as also recognised by Danisco Paper. (e.g. WBCSD 1996) But their, at least moderately, green image remains, and they appear proactive enough to undertake the expensive EMAS certification.

Danisco Paper's recent decision to introduce EMAS illustrates the firm's need to strengthen their environmental profile downstream. This will take a couple of years to accomplish, so the downstream effect cannot be dealt with in this analysis. Similarly, Danisco Paper has recently joined a major development work on methods of LifeCycle Analysis, in cooperation with the 32 biggest corrugated paper producers in Europe. The initiative came from their common

organisation, as a response to the mentioned environmental packaging debate, and the “environmental competition” between recyclable plastic containers and recycled corrugated boxes, a competition where LCA analysis is an important issue.

## **B) Stora Dalum**

Stora Dalum, or rather the previous owner DfP, decided in the end of 1980’s to shift from producing normal finer paper to producing recycled finer paper. This has involved a radical product innovation, Only a couple of firms existed which were doing this and DfP wanted to try a somewhat different technology and raw materials, aiming at producing a top-quality Rolls-Royce recycling paper. The incentive for this decision was severe economic problems, the small Danish paper machines not being able to compete with their more modern competitors. Green production within the finer paper section was seen as a new niche.

The idea actually arose at a cocktail party where it was discussed between the director of DfP and the director of the Danish Environmental Agency. DfP were promised policies (obligatory collection of waste paper) to guarantee their supply and given some financial support.

Production started up in 1990, but in 1991 the Swedish Stora corporation overtook the company, apparently to get into EU. Stora Dalum was now to concentrate only on recycling products, closing down the other lines. By 1995 the firm was entirely producing 100% recycled products.

Obviously, the customers of Stora Dalum had nothing to do with the decision. On the contrary they now had to learn to accept a somewhat different green product. Unfortunately, Stora Dalum only has a very weak accounting of who their customers really are and how they are changing. The reason for this is, that their sales are now run by the Stora corporation. Transparency is limited in the long downstream chain: Going through Stora sales companies, retailers and the varied group of professional users, such as small printers, envelop producers) and finally to the end users. They do know that their markets have shifted around quite a lot, indicating an exchange of customers. In Denmark, their market share have dropped from 56% to 15%, changing the myth of the environmentally advanced Danish society. Rising markets are Germany and the Benelux countries. Many of their customers are public institutions.

As already illustrated the information channels with their customers are very weak. The firm does, however, strongly pursue a green marketing policy, but this is mainly done in the form of written material, brochures with a clear green image. Furthermore they have improved their environmental reliability, investigating in environmental labels, (the Nordic Swan and the German Blue Angel) and are also introducing EMAS now. (But no LCA, the environmental manager considers them too complex and meaningless). Lately they have also worked out an environmental declaration on their products, as with Danisco Paper in response to growing number of inquiries.

The channels are also of a similar nature as Danisco Paper. Again, it is the long established technical customer service who are the main carriers of environmental information and also knowledge on the customers in general. Again the standardisation of the environmental information towards customers has meant a decrease in the reporting as the sales people have overtaken this job from the environmental manager. She is left with only the relatively few, but somewhat more numerous and growing as in the Danisco case, more demanding inquiries. The inquiries are mainly coming from Germany and the Benelux countries and to a less extent from Danish customers. The content of the inquiries is shifting somewhat from the content of the paper

(though it is a long time ago they stopped asking about heavy metals which is no longer considered necessary to inquire about) and the emissions towards softer issues such as whether they have environmental management systems and certifications. The inquiries towards Stora Dalum are thus quite considerable and advanced, and must be said to be an effective monitoring of the environmental performance of this firm. Going green obviously binds oneself.

The environmental manager of Stora Dalum is currently participating in the graphic industries attempt at developing a lifecycle analysis. The expectation of Stora Dalum from this quite detailed work (running for 2-3 years) is expected to be recommendations for paper purchasing. The investigations so far point to the fact that it is the paper production and not the ink that carries the heaviest environmental load in this chain, making the investigation of considerable importance to Stora Dalum. Again, when dialogues are undertaken with customers, it seems to be at the sector level rather than as an interfirm interactive learning processes.

Although the shaping of demands is normally presumed to be a downstream affair, there are also upstream feedback's, at least in the form of the (green) advanced producers providing easy green technological opportunities for their customers.

## **II. Coordination of systemic technological innovations. The case of paper recycling**

(Based on interviews with DP and SD as well as the glue producer Casco Nobel and the copymachine producer Xerox.)

### **The systemic nature of recycling**

Recycling represents a very special case of innovation, as it is extreme in its systemic nature. The coordination efforts of Danisco Paper and especially Stora Dalum in this context will be focused upon here.

In principle anything that is added to paper at some stage in the chain of production as well as consumption may act as an "impurity" disrupting either the production process or the quality of the recycled final product.(Baumgarten 1987) Sometimes the additives are not impurities, but may serve as useful rawmaterials, i.e. the chalk content of a certain wastepaper may be wanted in the recycled product being produced. The waste paper based manufactures, especially those with a high content of waste paper usage, install varies cleaning and deinking facilities in order to remove the unwanted impurities. Equally, or more, important is their efforts in achieving an adequate composition of waste paper qualities through sorting (by hand) as well as advanced logistical methods.The recycling industry (= the firms responsible for wastepaper collection and sorting), knows what kind of waste producers and collecting schemes give rise to certain compositions of wastepaper and direct this to the suitable paper producers.(Andersen 1992) The paper industries try to adjust their recipes so they can buy the cheapest wastepaper, which is also the most impure/mixed qualities, which still suits their needs and are available in adequate amounts.

As recycled paper production has boomed the last 20 years, the technologies for cleaning and deinking waste paper have improved greatly. Still, however, there exists some "problematic impurities". These are the impurities that cannot be cleaned away by any means and cause

problems in the production of consumption of recycled paper. Examples of these are varies type of glues, some inks, carbon and wax.(Neumann 1987, Sudan 1987, Baumgarten 1987)

As the level of recycling rises, the problem of the impurities rise as well, only partly being countered by the technology development of the cleaning measures. There are two reasons for this: 1. The quality of waste paper decreases, as still more marginal, less pure qualities are being collected. The quality also decreases as a still greater share of the total paper consumption is being recycled, causing a shortening of the fibre length and strength.2. The quality demands on waste paper increases when waste paper is being introduced in the production of not only the robust board qualities, but also in finer paper production. (Baumgarten 1987)

Since 1986 it has been legally possible to take measures against productions that are hampering recycling. This paragraph has, however, never been taken into use. The issue has been left to the market mechanisms.

### **A. Danisco Paper**

The efforts of Danisco Paper on this theme will only be dealt with briefly, as they have done very little. Basically, they have not at any time been discussing the issue with the “trouble making” firms.

Instead they have invested heavily in cleaning devices building up an effective technological buffer. Also, they have put great effort into controlling the waste paper market (integrating into the recycling industry, negotiating the recycling regulations). Their product is fairly robust and the technologies mature, so they manage quite well. Occasionally, the impurities accumulate on the machines and they have to make costly halts in the production in order to clean them up, but this is now a routine procedure that is barely noticed.

To the technicians (production and development manager) these issues seem somewhat far away. They have never considered doing anything about it. As one of them says: “It is not our job to do a thing like that.” They only have limited knowledge about the technology development of the other, to them via the waste paper, influential industries. In general, it is not something they keep an eye on. As the development manager say. “We don’t live from being scared. When the problem arises, we will deal with it.” They mentioned that at some time, they believe there were some problems with the ink because of the development of new printing techniques. But the problem had solved itself without there interference.(compare the mentioned reduction in heavy metals mentioned in theme 2).

There cognitive limitations on the issue is also due to the fact that they do not monitor the content of their waste paper (as i.e. another Danish paper manufacturer Brødrene Hartmann does). The only way they know approximately what is in the waste paper is by measuring what is in their paper and their process water and through dialogues with the recycling industry. They are discussing to begin measuring the waste paper as a way of optimising the production process, but also as a way of improving their environmental auditing. As the environmental manager says: “The waste paper is a big black box. We have no idea what is in it. What we add ourselves to the production process is minimal compared to the effect of the waste paper contents”.

One conclusion from the above story is that innovations are not just either systemic or autonomous. The degree of “systemity” is manipulated by the firms, and they go to many efforts and high costs to keep the innovations autonomous. Their cognitive horizon is basically autonomous, at least in the case of Danisco Paper.

## **B. Stora Dalum**

Stora Dalum's recycled finer paper is a very white paper where only a limited amount of dark spots (stemming from the impurities) are tolerated. Also there are high demands to the runnability of the product in the machines of the various users. Stora Dalum invested heavily in cleaning technology to achieve this. They used known technology, but they put together more steps than has been done before. The costs of this exceeded greatly any cleaning plant seen before. Also they use relatively costly, very white waste paper grades (office waste and waste from printer works). Since the production started in 1990, the process has been running fairly well, but with many problems. Considerable improvements in process and product development has taken place especially the first 2-3 years. They do, however, still have frequent halts of the production process due to problems with the impurities and spots on the paper, but these conditions have gradually been improved. In 1993 they started getting severe problems with users of their copying paper, one of their most important products. Xerox, one of the world leading firms of copiers, were receiving complaints from some of their customers. The problem was that "stickies", rests of certain gluetypes in the paper, was transferred to the copying machines, causing spots on the paper. There were also complaints about to high dust production during copying and printing. Half a year earlier the paper had been officially approved by Xerox. This means that the paper goes through some thorough tests and, if these are passed, the paper receives the official Xerox approval. Xerox then guarantees that it runs well in their machines. Also the paper may, if wished, be wrapped in Xerox paper and sold as such. Even though Xerox has no economic connections to the paper industry they are a considerable paper producer. Not just by sanctioning other firms paper, but also developing their own recipes - they have 5 R&D departments for paper development and monitoring in different parts of the world. 75% of Xerox's customers use their paper (though maybe not exclusively, and Xerox market share on copymachines is approximately 75-80% on the big machines and 30% on the small machines on a world basis. Xerox is consciously not integrating into the paper industry, as they believe they will retain greater flexibility and innovative capacity by staying out. It is also a firm with a strong environmental profile, known for their green design, including the recyclability of their newest machines.

Losing the Xerox approval was a serious setback. The development manager of Stora Dalum was in the subsequent months engaged in dialogues with the English Xerox R&D department working on solving the problem. Xerox's serious interest in the issue is illustrated by the fact that they called in a top researcher from their American department. Little came out of the efforts, and Stora Dalum still has not gained Xerox's approval. According to Xerox, they are continuously testing all copy paper qualities, as their customers use them all, and are therefore also keeping an eye on Stora Dalum's paper. It is, however, possible to make recycled paper that runs effortlessly in Xerox's machines. Xerox has their own recycled quality and also approved another recycled quality, the German Steinbeis paper, Stora Dalum's biggest competitor.

The development manager of Stora Dalum turned towards the central R&D department in Sweden, where a workgroup was created. They worked intensely on the problem the next couple of years. Stora Dalum also cooperated with another big Stora division, which have considerable experience with recycling technologies (but with different paper grades). Some improvements have taken place, especially of the dust but also the stickies problem. Recently they have started producing a new quality, a coated version (a glue toplayer) which has better runnability. But none the less, here in the beginning of 1996, they, on the suggestion of the

production manager, decided to put less effort into developing the copy paper, shifting their priorities towards the production of off set paper. They are, however, still selling the copy paper.

Recently Xerox has shown some interest in their new coated quality. This information has come through Stora's sales department in Sweden, and not through the contacts the development manager established with the Xerox researchers in UK. Communication is completely lacking between the Danish Xerox unit and Stora Dalum, as it was this unit which originally complained about Stora Dalum's paper. According to the sales manager of this Danish unit, they are now pursuing a policy of discouraging their customers from recycled paper (in general, not only the Stora Dalum paper), which they see as troublesome and no more environmentally friendly than other types of paper. They have just (summer 1996) introduced a price differentiation, making recycling paper slightly more expensive than other paper to pursue this goal. Whether this somewhat discrete policy (it was only mentioned by one of the employees I talked to) is pursued by the whole Xerox corporation or just the Danish unit, remains to be investigated. In many ways Xerox appears as a powerful actor on the paper market, not as much as direct voicers of their suppliers, but as unauthorised standard setters on paper quality, indirectly influencing the paper producers greatly.

Interestingly, Stora Dalum has not been in contact with any other copymachine producers. The development manager has wanted to get in contact with the firm Océ, believing that their paper would properly be able to run in their machines, as they are using a different technology. No initiative has been taken, however. Also, he has considered contacting the firm Canon, which has a technology similar to Xerox, to see if there is a better fit with their paper. Again nothing has happened. The outgoing initiatives that have been taken has been on the development managers own initiative, with no backing from the (powerful) Stora group who have focused their forces entirely inward.

The development manager states that one of the reasons he contacted Xerox was because the Stora corporation is a big supplier to Xerox, but little has this helped in the negotiations. Notice also that these coordination activities take place quite late in the innovation process, and only as a result of severe problems.

The development manager has taken one other initiative to solve the stickies problem. He had a couple of meetings with researchers of one of the big producers of the problematic glues. They quickly backed out, however. One of their technicians explains their position, stating that they do not see any immediate technological solutions, and that the market for recycling paper is so small that they do not expect market opportunities from engaging in such a development work. (He obviously has not looked into paper statistics lately, or more likely employs a very short time perspective).

These coordination efforts were initiated in quite a muddled way. The development manager had been talking to one of their customers, a Danish envelope producer, about the stickies problem, as it is the glue used for closing the envelopes that is one of the main sources of the stickies problem. (It reaches Stora Dalum through the office waste). He mentioned that he talked to this firm and not the other big envelope producer situated in Denmark because it is a Danish firm (the other one is Swedish), and a firm with which they have long and good trading relations. But it was not until this firm wanted Stora Dalum to buy their waste paper, thereby becoming the supplier of Stora Dalum, that they started discussion the technological problems connected to the

envelopes. The envelope firm then referred to their glue supplier. A further incentive to take contact to this firm was that it is a subsidiary company to the multinational chemical corporation Eka Nobel, one of Stora Dalum's main suppliers.

Again it was an initiative undertaken by a single person rather than the corporation, where the connection to the big Stora corporation seems to have had little influence on the bargaining power. The dialogue between the hitherto unconnected units, only took place because there were indirect trade relations to form some kind of connection. Long lasting trade relations, or the absence of it, seems to be a more important factor for bargaining power, than the sheer size of the corporation involved. The question is, of course, whether the glue producer experienced that he was negotiating with the small Stora Dalum or the big Stora group.

Another interesting point is that the technician from the glue producer believed part of the stickies problem had been solved, the one resulting from "hot-melt" glue (glue used on the back of books). A German paper research institute the "Papiertechnische Stiftung" has, according to this technician, set standards for this type of glue, so that the recycling-damaging glues are ruled out. He was not too certain about this issue, though. Apparently there are institutions working to coordinate these products, but the initiatives are little known (for example not to Stora Dalum) and little implemented. (It may be only a German initiative that has not spread further). At least it is still impossible to recycle glued books in Denmark, such as the huge amounts of telephone books that are turned into waste each year. It seems though now (December 1996) that initiatives will be undertaken by the telephone company to use another glue, partly influenced by the public (municipal) recycling industries.

A final remark is the lacking interest of Stora Dalum on the ink problems to paper recycling. These are not critical to the recycling, though causing high cleaning costs. They are therefore not paid much attention.

To conclude, coordination efforts on systemic technological change are only undertaken when there are severe coordination problems and interorganisational relations are favourable. Even then, the outcome is limited.

It seems that coordination needs based on systemic innovations are exaggerated in much of the resourcebased innovation theory (such as Teece 1986, 1996), not taking sufficient account of the limited cognitive horizon of firms, and the institutionalisation, or 'stickiness' of the learning channels and modes.

### **III. Knowledge access & exchange. Green process innovations in interaction with suppliers (and partly competitors)**

#### **The case of water closure in Danisco Paper**

(Interviews from DP as well as the chemical producers BASF and Eka Nobel)

In the middle of the 1980's Danisco Paper were facing a serious decision brought on by stricter environmental regulation. Either to invest in very expensive secondary treatment of their waste water, or introduce clearer technologies that would allow them to purify their water sufficiently. The latter was quite difficult and instead they took the drastic decision of closing the water circulation system completely (meaning that waste water emissions are down to 0). This was

something only 3-4 paper producers had done so far and nobody with a waste paper based production which gives special chemical conditions.

The water closure was suggested to them by one of their main machine suppliers, who had delivered machines to a similar system to a Dutch firm. They closed the system and visited shortly after the Dutch competitor for inspiration. Later they also visited two other closed mills. They received one crucial advice from the machine supplier: to reduce the amount of water used considerable. Several innovations remained. The chemical conditions of the production process changed considerable, turning from aerobic to anaerobic so new chemicals were wanted. The most important one is the ancillary agent called retention. It is a material that promotes the water drainage of the paperweb, crucial for the production speed of the papermachine. In order to get the right retention agent they exchanged their main chemical supplier, going from BASF to Eka Nobel in 1986, two of the leading multinational chemical corporations. Another important step was developed by Danisco Paper themselves through experimenting, going from gradual to chock dosing with some of the ancillary agents.

The system is running well, but there are still many problems. Fine tunings are continuously undergoing. One of the serious problems has been the negative effects on the working environment.

In all, Danisco Paper has very close cooperative relations with their two main chemical suppliers. The last two years they have had an official cooperative agreement with Eka Nobel, but cooperation with BASF is nearly as intensive though on an informal basis. They are continuously in dialogue and the suppliers. The suppliers are offering free testing and research facilities which Danisco Paper uses extensively as well as courses for their customers employees. On the other hand, on their frequent visits to Danisco Paper, at least monthly, they study the production process of the mill closely, doing tests here too.

Danisco Paper does not have any R&D facilities or development departments themselves. The people involved with development are few: The environmental manager (a chemical engineer with a background as works engineer, the last 2,5 years he has been head of the new "Environment and quality department", which is also where development work is controlled), a chemical technician, a very experienced machine engineer mainly dealing with technical customer service (25 years in the sector) and three laboratory workers. Also there is the earlier development manager, who is now employed as a kind of internal consultant seeking out new trends and technological ideas, often by visiting or working for competitors.

They state that they do not do any development themselves because of lacking capacity, only experimenting. The estimation of the environmental manager is that their technology development is based fifty-fifty on respectively internal experimenting and external inputs, mainly from the suppliers. As the environmental manager expresses it: "We are very dependent on external inputs. We cannot develop anything ourselves. It is not important, it is essential for us to cooperate with our suppliers, quite essential. We have to have the door open".

According to the environmental manager they are consciously seeking learning relations with what they believe are the technological leaders in the field, which apparently is also the biggest firms with extensive R&D facilities. They are actively seeking the cooperation of more, not many but a few, of what they see as suppliers with interesting competencies, not wanting to become too

dependent on only one supplier but also seeking a varied knowledge base. An illustration of this is the organisation of a recent big experiment carried out by Danisco Paper, testing on the water quality and the workings of the retention agent. They closed down the mill, emptied the water system, and started up with fresh water, doing measurements the next 14 days. They invited both Eka Noble and BASF to participate in the experiment, despite the fact that BASF is not a supplier of the retention agent to Danisco Paper. The environmental manager illustrates the cooperation this way : “They worked as madmen in our laboratory, because they are so interested in seeing what has happened. So they are completely open, they even talk together, perhaps not quite as much”.

From this it appears that Danisco Paper is actively promoting the competence accumulation of both competing suppliers. But Danisco Paper is also seeking new learning partners. Recently, they were contacted by another chemical firm, the American Nalco. Nalco, Eka Nobel and BASF are the three biggest paper-chemical firms in the world. Nalco also possesses the critical retention agent, and is therefore of great interest to Danisco Paper, both as a potential supplier and as a learning partner. It is still too early, however, to say what evolves from this.

On the other hand, what is also evident is the strong interest these leading chemical producers have in gaining access to Danisco Paper's competence and involving themselves in cooperative arrangements with the firm. Both BASF and Eka Nobel express, that they find Danisco Paper highly interesting because of a unique combination of three competencies: A closed water system, 100% recycling and a very fast production process. Actually, Danisco Paper has the second fastest papermachine in the world within this paper grade (and in tests they have reached world record). Speed is the main competitive factor in this bulk production. So top speed is a strong indicator of a high innovative capacity.

The admiration of the chemical suppliers, situated in countries flooded by paper supplying, -producing, and -converting industries as well as paper education and research institutions, towards the medium sized Danisco Paper situated in a country with a very small paper industry and no institutional back up, is considerable. They do not quite understand how they manage to be so good papermakers, but speak of the story of the bee that did not know it wasn't supposed to fly. Danisco Paper is using some unconventional techniques and praxis's, perhaps because they are not uniformly shaped by the paper-education and research environment. They mention themselves that one of their advantages is that they, in contrast to their competitors, have drawn in competencies from the finer paper production, which used to dominate paper production in Denmark.

Danisco Paper is very well aware that they are much-coveted. Where the development manager (a machine engineer) emphasises that they get many inquiries and visits because of their speed, the development manager (a chemical engineer) ascribes this to their closed water system. He says about BASF's interests: “It is fundamental that we have a good retention to run the machines. They can't solve this. They don't have a system that can work in a closed watersystem. They know this. But, believe me, it is just a question of time. They have to find this if they want to stay in paper production, because all mills are closing their watersystems. If they can solve our problems, they can solve many problems in future.”

Both parts also mention that they need the basic competencies of the other, i.e. that the chemical researchers with their understanding of the materials involved, need the dialogue with the “papermakers” with their largely tacit knowledge on the running of the production process, and vice versa.

Even though the material flow between the chemical industry and Danisco paper is unilateral, the learning relation is very much bilateral, characterised as it is by the presence of cospecialized competencies. The interactive learning is therefore intense and communication, as the environmental manager puts it, is “completely open.” It seems as if Danisco Paper is especially open and extrovert in their orientation, forced by the need to accumulate competencies exclusively through interactive learning. As the sales technician from BASF expresses it: “All the Danish mills are very interesting, and very open, but Danisco Paper is especially open”. I won't go further into the discussion on openness and appropriability conditions, just mention two findings: It seems that they are less protective (this goes both for Danisco Paper and Stora Dalum) of their green competencies than other competencies; i.e. green altruism leads to greater openness.

Another point is that incentives for knowledge exchange exist not only at the organisational level, but also at the individual level. According to an interview with a leading paper-technical researcher, Professor Baumgarten, earlier the director of the German research institution PTS, a very strong incentive for knowledge exchange is the personal competition between the paper engineers. They compete continuously on presenting new findings at conferences and seminars, for prestige reasons and to profile themselves to advance to better jobs. Baumgarten says he can point out the 3-5 people within each paper section who take the lead in this in Germany, and spent a great part of their time on this game. The importance of this phenomenon for my focal industries is hard to say, as I haven't been attentive towards the issue. The behaviour of the development manager of Danisco Paper does show some indications of this: He has been publishing a few articles and made many presentations on their process techniques (so the tacit knowledge is partly becoming codified) as well as he, as already mentioned, is having dialogues with competing firms. All this happens with the blessing of the top management, under the expectation that he brings home at least as much as he gives out in the long run.

A final factor, or rather two factors, influencing on the structuring of the learning channels, is geographical and cultural distance. (Lundvall 1986) It is noticeable that all the main suppliers of Danisco Paper are European, or to be more specific, German and Scandinavian. According to the development manager of Danisco Paper, one of the reasons they are able to keep up with, and sometimes ahead of, technology development is the short distance and therefore close relations to what they see as the technologically leading suppliers. These multinational corporations normally have sales divisions in Scandinavia, or, more seldom in Denmark. But relatively speaking, compared to US, Canada and Japan - the other areas with much paper production, this is close. Danisco Paper has gained a better relation to BASF after their contacts was shifted from the German to the Scandinavian BASF department, with more frequent visits from them as a consequence.

An analysis by Bonifant (1994) confirms the estimation of Danisco Paper, of the advantageous position of the European paper suppliers. He argues that they as well as the paper manufacturers themselves have a leading edge on integrated technologies (cleaner technologies) compared to their North American or Japanese competitors. The reason for this should be that environmental regulation on emissions originally (in the beginning of the 1970's) were higher in the US than in Europe, forcing the US paper mills to invest in secondary treatment. Regulation was more lenient in Europe, where the mills could reach these demands with the development of various integrated technologies. These initiatives did sometimes lead to cost savings due to reductions in chemicals and energy usage, so resource efficiency became an issue here, but not in the US where firms were locked in because of the high investments in the installation of secondary treatment. When regulations became stricter and secondary treatment no longer could suffice, the European,

notably the Scandinavian, paper manufacturers and their suppliers had developed appropriate competencies and were well prepared.

Cultural distance is, however, at least equally important for the character of the interactive learning process. These are associated with national differences, compare the (vague) preference for Scandinavian/Danish partners, but mainly professional roles. Several respondents mention the communication gap between papermakers and other professions, notably researchers, and the other way around, the intimate communication between papermakers. Notice, however also the earlier mentioned awareness of both parts of the importance of learning from each other.

The papermakers also play a crucial role for contactmaking, that is the establishing of new learning relations. The persons of papermakers in the firms of the cooperative partners of the papermanufacturers is fundamental for the interfirm communication. This can be illustrated by the experiences of the environmental manager of Danisco Paper. He states that although he deals with a range of people in the suppliers they are cooperating with, there are 2-3 personal contacts directing the daily communication. "The persons who make the contacts, they are people who have worked in paper mills, and they are the ones - I'm quite sure of this - who have created the contact and made it effective. This is because they have worked in paper mills and know something about the same problems as we have - there is foreexample one person in BASF. They create the contact and then they find out who we shall use in their organisation." He goes on to tell about two examples where the suppliers have given them contacts to other firms tussling with similar problems as their own, and continues own: "They are good at this the suppliers, and I believe this is because they are papermakers like us. It is not the researchers; we only draw on them for some knowledge."

From the analysis so far, it is clear that Danisco Paper is engaged extensively in interactive learning with their chemical suppliers, which has led to consolidated learning channels.

Through the codification process associated with this, an underlying shared (specific) green agenda seems to have emerged.

As a chemical engineer from Eka Nobel says: "Everything is green. You cannot do product development without doing it green. This is what the market is about". Or the environmental manager from Danisco Paper: "It is all very much about cleaner technologies these days". The underlying agenda, the technological trajectory, for the ungoing dialogue is more or less green, so consolidated it seems nearly imperceptible. "Greening is in the air", which expresses itself in multiple, though largely incremental innovation processes. The respondents cannot point to certain events or factors or dates which has caused the greening, nor can they say which part has influenced the other one. The dialogue seems to be so close that the parts co-evolve.

One of the reasons for this apparent symmetry is that both the paper industry and the chemical industry are "sensitive" industries in an environmental sense. Both sectors have experienced severe legitimacy problems due to environmental crisis; i.e. the bleaching chlorine and dioxin scandal for the paper industry, the Bhopal dioxin catastrophe just to mention one for the chemical industry. A recent large survey in Italy on sectoral characteristics of environmental innovation, concludes that the chemical industry is the most environmentally sensitive industrial sector. One fifth of all the registered environmentally friendly innovations in Italy came from this industry and a third of the cleaner products. The strategies of the chemical firms were also found the most proactive with regard to environmental regulation as well as technology development when it comes to the big

firms, whereas the smaller chemical firms are more defensive and are adopters of technologies rather than developers.(Malaman 1996) Unfortunately, no similar figures exist for the paper industry.

### **A few preliminary conclusions on IL**

\* IL is taking place in a considerable amount; (for one of the firms it is a crucial way to gain competitive advantage, where as the other firm is more introvert, relying on internal R&D)

\* Whereas DP is more active on green technological IL, then DS is more active on IL as a consequence of environmental management. With firm is most influencing and influenced by their surrounding firms is quite difficult to tell.

\* The nature of IL is more cooperative (knowledge access) than conflictual (coordination need). Generally voicing is very limited, although the environmental management systems are now beginning to influence this.

\* Major cognitive limitations. Systemic effects of the innovations are seldom perceived and therefore not reacted to. The systemic nature of innovations can and are to a considerable extent created/manipulated by firms; i.e. they try to make them autonomous by establishing buffers.

\* Greening is beginning to influence the above factor. The “waste full” technological trajectory of the firms is greening, i.e. there is qualitative change and major cognitive shifts. This means that the greening process is strongly cumulative. Legitimacy therefor plays a diminishing role.

\* Competence “stickiness”. Firms stick to their competence to a very large degree and do very unwillingly integrate further out in the chain of production, despite major incentives and coordination problems caused by undertaken product innovations.

\* The specification of learning channels . Firms are embedded in their learning channels and seldom seek new sources, despite apparent incentives to do so. Within these channels, however, a lot of interactive learning is taking place. On greening issues this is rapidly increasing and interorganisational relations are changing considerably because of this.

\* The nature and position of the gate keepers is very important. Cultural (rather than geographical) distance is significant. The greening of industry is an extremely complex process. It is a muddled, segregated affair where multiple actors and factors are significant. Especially the technology gates are very open, so much greening emerges bottom-up. Gaps between the gatekeepers and the (environmental) management process hinders IL contribution to greening. A hypothesis from this could be that the technologically innovative firms are also the ones greening first.

\* Systemic change takes place partly co-evolutionary and partly interactive. The greening of business seems to be very much a case of simultaneous change of chains of production as well as branches, accordingly with limited direct coordination need between firms. I.e. a lot of the change happens co-evolutionary, because of changes in overall perceived rules as well as (indirect) actions of overall institutions. This may partly be explained by the significant role of IL. The interfirm dialogue is so intensive, that belief systems gradually become shared. "Greening is in the air".

\* The production system as a whole functions and innovates far from optimally. The system seems to be able to function quite well despite various unfulfilled coordination needs.

The theoretical discussion:

\* The need to integrate the concept of routines and bounded rationality further into the resource based approach and strengthen the emphasis on legitimacy as an important change factor.

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