Theory of the Firm and Environmental Issues: some empirical facts.

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Abstract
In this paper we analyse the core elements of the emerging evolutionary theory of the firm through the development of corporate environmental management systems. By stressing the importance of new knowledge creation at the individual and the organizational level for firms' environmental performance, we propose that effective environmental management capacities derive primarily from the adaptation of three constitutive mechanisms of firms: the incentive mechanisms, the coordination mechanisms and the cognitive mechanisms. The environmental management process mean a process by which organizations change their structures and cultures as a result of an interlinked effort of individual learning and organizational transformation. Moreover, an analysis of environmental management systems represents an interesting research field for the understanding of the organizational evolution in general.

Keywords: environmental management / incentive, cognitive and coordination mechanisms.

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Introduction

The purpose of this paper is to analyse the core elements of the emerging evolutionary theory of the firm through the development of corporate environmental management systems. We want also to attempt a better understanding of the integration of environmental problems in business activities and firm's behavior.

Even if the evolutionary theory of the firm does not really exist yet, we can note, following Cohendet and alii (1998), that there exist many propositions quite fruitful for the analysis of organization's evolution. The philosophy of this emerging theory could be summarised by the following quotation: "… the firm is an economic institution which performs multiple functions by implementing different mechanisms which interact in complex, sometimes conflicting and still largely unexplored ways. We maintain that a theory should abandon the uni-dimensional view of most current approaches and try to address specifically the interaction among such mechanisms, seeing the firm (and economic organization in general) as a delicate balance between such interacting processes"(Cohendet and alii, 1998, p.3). We propose to analyse these mechanisms and their evolution, through an important and new challenge for industrial firms; the perception and the management of ecological issues. Partly because of growing public concern over environmental problems and partly because of increasing pressures from the government, one can note some changes in organizational structures and management practices in order to assign responsibilities for environmental issues and to develop clean technologies. A variety of organizational alternatives emerge with variable effectiveness. Thus, an analysis of environmental management systems could be an interesting research field for the understanding of the organizational evolution in general.

Environmental economics and the firm.

Environmental economists who have been concerned for many decades with market failures, and more recently with regulation failures, still commonly assume that firms operate efficiently. The firm is usually modelled as an agent that maximises profit given prices or other constraints, which are set exogeneously by the market and by regulatory authorities. The traditional literature in environmental economics adopts a "black box" view of the firm. It is our attention that there is a third institution subject to failure with environmental implications. That institution is the firm. Many pollution problems and violations of environmental laws are not wilfully intended, but rather represent failed but sincere efforts to preserve the ecological environment. If the firm is considered as an organization of individuals who make decisions, the way in which the individuals create new knowledge and co-ordinate their actions is essential in the determination of organization's environmental performance.

According to Cohendet and alii (1998), this coordination task can be achieved by a set of different mechanisms, which are the following: the incentive mechanisms, the coordination mechanisms and the cognitive mechanisms.

Concerning coordination mechanisms, the emphasis is put on the role of hierarchy concerning the development and the diffusion of competencies and organizational routines, which guarantee an efficient coordination of the different departments of the firm. These mechanisms make it possible, through structural arrangements and rules, to bring together both individual actions to meet a defined set of objectives, and local and centralised learning processes to drive organizational change in a given direction. The establishment of environmental units in industrial firms is one of such organizational arrangements. Whereas they were mainly restricted to reaction to government regulations and limited to temporary tasks, they now become part of the decision-making structure and they currently influence the activities of the firm. We will interpret the creation of environmental units as a control and monitoring mechanism but also as a necessity for the firm to have a "robust" knowledge basis.

The cognitive mechanisms promote the development of a collective knowledge basis which is essential for the coordination of individual actions and groups. In fact, in order to conceptualise the integration of environmental issues in firms, the concept of "organizational learning" is useful. Solving environmental problems related to products and production processes often requires developing new skills and capabilities. For example, the integration of environmental issues in training programmes, together with other management subjects, reduces the sources of conflict in the mind of trained personnel and equips them for better decision making in their activities. We show that the integration of environmental issues in the firm will require a double-loop learning process. Changing the set of complex routines requires redefining what the organization stands for (i.e. its strategy), but also changing the nature of the work done by the organization and placing people in new roles that require new knowledge and new skills. Through "environmental learning processes" organizations should be able to change their structures and cultures as a result of an interlinked effort of individual learning and organizational transformation.

Finally, the incentive mechanisms provide a "payoff structure" in order to guide the firm's actions. They determine the structure of individual and group incentives in order to promote environmental quality. We show that environmental integration has several implications on the incentive policies of firms through the creation of cost and benefit units, the introduction of new evaluation criteria and the intensification of monitoring and auditing tasks with respect to environmental activities. In quantitative terms these incentive mechanisms reflect the evolution of benefits and costs associated with environmental actions. We show how firms adapt their incentive tools with respect to the environmental question in order to create a coherent framework to motivate change and to develop the necessary knowledge to ensure the involvement and co-operation of its members.

Our theoretical work is supported by empirical results which are based on twelve industrial case studies (realised by face-to-face interviews) in automobile industries, refinery industries, electric and electronics industries, mechanical and surface treatment industries and brewery

industries. The firms of our sample are localised in France (Alsace) but also in Germany (Bade-Würtenberg).

I. The role of Coordination Mechanisms

The environmental knowledge and innovations which are developed result partly from a combination, specific to each firm, of learning techniques (life cycle analysis, environmental audits, value analysis...) and learning structures. In this sense, although the adoption of these techniques passes through a phase of learning by doing, this does not mean that they are always implemented and exploited in appropriated structures.

The efforts made by standardization organisms at the national (AFNOR in France), European (CEN) and international levels to develop standard environmental management systems represent a support to decision making and learning. Their objective is to create a common language and to give firms a coherent procedural framework (Meyronneinc, 1994). Thus they constitute a coordination tool for firms adopting them. Nonetheless, these standards do not integrate the structural dimensions of firms. They essentially prescribe a standard action procedure, which in no way implies a standardization of organizational and strategic choices adopted by firms.

Our main purpose in this section is to outline some theoretical results relative to the coordination mechanisms and the organizational structures in firms in the context of environmental management. Very little research has been done in the economic field to analyze the way firms organize their environmental decisions and their impact on coordination, hierarchy and delegation (Gabel & Sinclair-Desgagné, 1992).

I.1. Theoretical foundations of coordination mechanisms and environmental management

Organizational structures and the trade-off between centralization and decentralization

A central question outlined by different theories of the firm is the trade-off between centralization and decentralization of decisions. The comparison by Aoki (1986, 1990) and Itoh (1987) of the A-firm (centralized structure) and the J-firm (decentralized structure) in models with bayesian uncertainty and incomplete information shows that the relative efficiency of these structures depends on the nature of uncertainty faced by firms. In extreme cases defined by stable or volatile environments for planning the hierarchical mode reveals to be superior. However when "*external environments are continually - but not too drastically changing, the J-mode is superior. In this case, the information value created by learning and horizontal coordination at the operational level may more than compensate for the loss of efficiency due to the sacrifice of operational specialization*" (Aoki, 1990, p. 9). Following this assertion, if we suppose that environmental policies, technologies and products do not follow abrupt and frequent changes but are modified by incremental adaptations through time and in a long term perspective, environmental management can profit from an enlargement of

competencies and enforcement of delegation at the operational level (rotation or effort allocation between environmental and production activities, horizontal interactions, integration of environmental responsibilities into job descriptions). As put down by Corbett and Van Wassenhove (1993) and Viardot (1997) an approach by analogy between environmental programs and existing concepts in management (reduction of hazardous inventories / JIT, zero waste / TQC, design for environment / design for manufacturability...) can allow firms to proceed in a participative way by referring to work procedures which are common knowledge and extending them to environmental management.

In a paper relevant to compliance with environmental regulations, Beckenstein & Gabel (1986) give a more precise conclusion about the way delegation and centralization are linked when firms' decisions are made with uncertainty as to their legality. In their model the decentralized decision structure is characterized by better top down information (legal aspects, audits) and monitoring which entail explicit costs. The centralized structure imposes standard operating procedures without supporting explicit costs. These structures have distinct effects on the decision errors made by the firm and are in certain conditions complementary. Decentralization reduces both the probability that legitimate and profitable actions would not be taken (type I error) and the probability that the firm unwittingly violates the law (type II error). Centralization reduces the probability of type II error while raising the probability of type I error. One of the models' relevant results for our purpose is that when the environmental risk associated to a project increases centralization is fostered. But the effect on top down information is not clear-cut. Decentralization increases only with centralization if the former reduces more the costs associated to type II errors than the costs associated to type I errors. Although adopting a static and strict informational approach the paper of Beckenstein and Gabel points to a crucial point in hierarchical structures by overcoming the dichotomical conception between centralization and decentralization. Furthermore, their model suggests that the degree of strictness of environmental regulation can play an important role on the organizational structure.

By stressing the role of coordination structures on learning processes and on the constitution of a common knowledge in firms from an evolutionary perspective Marengo (1993) has also outlined the close relation between these two structuring modes. His simulation models show that when flexibility and fine-tuning to the environment are required, local learning processes can be effective provided higher hierarchical levels have the capability of pulling them together. Effective decentralization seems therefore based on bottom-up knowledge and information flows more than on horizontal information flows. That is if learning is duly emphasized, the main issue of decentralization becomes the possibility that operational units can influence such a process, but this depends on the organizational use of ex post information flows coming from such units, that is vertical bottom-up information flows (Cohendet & alii, 1994).

Although decentralization constitutes a way to establish a participative structure and to motivate local learning processes, the models cited above do not distinguish it from a team-

based approach. When in fact, important organizational or technological changes are required, a team-like approach could be the structuring factor in the decision process and replace decentralisation. In the context of environmental management, where conflicting representations among different functions can impede change and create stickiness (conflict between productivity or quality and environmental protection) effective cross functional teams can be constituted to internalize the necessity for change and develop new ideas, strategies, products and technologies, as we will explain in the next section "Cognitive Mechanisms (Nonaka, 1991). This argument suggest also that a coherent learning process rests on a trade-off between team-like and hierarchical structures in terms of exploration vs. exploitation (March, 1991), dynamic vs. static routines (Dosi & alii, 1991), or double loop vs. single loop learning (Argyris and Schön, 1978). As outlined by Romme (1996) "*teams are the key learning units which can best absorb and produce novel information, whereas the hierarchy acts as a stabilizing factor by processing and storing important learning results (by transforming team information into relatively objectivated, confirmatory information*" (p. 414). The circular hypertext organization structure analyzed by Nonaka (1994) constitutes an efficient way to switch between different information contexts through different organizational modes. In this sense, by adopting a proactive environmental policy, teams are indispensable to generate new information and knowledge. On the other hand a switch to hierarchy is indispensable for diffusion, objectivation and institutionalization of the knowledge generated by teams[2].

Routines as coordination mechanisms

Using the concept of organizational routines can help us to give a more complete and precise view of the coordination mechanisms current in firms (Nelson & Winter, 1982). Coordinative routines can be defined as problem solving action patterns. They determine the organizational learning paths and crystallize the knowledge acquired collectively through time and experience by firms. They involve not only the explicit and codified mechanisms but include a tacit dimension which makes them difficult to replicate and contribute to the firms distinctive competencies and dynamic capabilities (Teece & alii, 1997). Furthermore, as firms have to adapt to environmental changes and find new ways of ensuring their viability, routines differ from mere rules. They have an incomplete and imperfect nature stemming from the limited and dispersed knowledge of firms' members in front of new problems. Coordination in this context rests rather on rules to be interpreted than on rules to be executed (Reynaud, 1994; Favereau, 1995). Such coordination based on 'open' rules is the source of collective learning processes. On the other hand, some routines have a rather robust character and play a generic role allowing firms to deploy them as a coordination basis in different situations. Such

[2] We think that it is important to precise further the role of hierarchy under both decentralisation of decisions and a team work approach. Vertically structured teams incorporate the hierarchical element directly in the decision process. In a decentralized structure or in horizontal teams, hierarchy plays an indirect role. Both structures should then have implications on how centralized decisions evolve in response to new information and new knowledge at the operational level.

routines being internalized by firms' members permit an economy of time and knowledge and reduce the costs to organize change. This set of routines is more akin to the notion of corporate culture in the sense that it constitutes a focal point, a coordination basis supporting subsequent changes. As shown by Pentland & Rueter (1994) coordination routines can, in this sense, be assimilated to "grammars of action".

In the context of environmental management the emergence of coordination routines can be evidenced in a twofold way. First, firms can develop their green strategy by shifting some of the successful management routines they have elaborated to environmental management. The procedural similarities between standard management systems such as ISO 9000 and ISO 14000 justify this approach. One important reason is the possibility to apply past experience in a new domain when this experience can be used as a coordination mechanism for creating an environmental learning process in the firm. Past successful organizational routines (i.e. quality procedures) can then serve as grammars of action or as a coordination basis to introduce environmental objectives. An incremental logic is at work in this particular case.

Second, the necessity to develop new environmental friendly products, processes and technologies need to be driven by environmental specific routines. These are in no way pre-existing in firms but must be elaborated through coordinated search procedures. The risk exists also that environmentally viable routines be incompatible or enter in conflict with other existing routines. It is then important to have a coherent policy taking into account the interdependencies existing among different management aspects. There is no doubt that a proactive strategy could require from firms a co-evolution of their whole set of procedures to guarantee such a coherence. Cross functional or cross departmental teams supported by hierarchical coordination will be in this context an organizational solution to confront different representations and trigger a double loop learning process.

To conclude the theoretical part of this section we would like to notice that although we limited our analysis to the internal organization of environmental management there is no doubt that the integration of the environmental dimension in the strategy of firms adds to the difficulty to define the frontiers of the firm (Dosi & alii, 1990). Environmental management appears then to be also an evolution factor for the interactions of firms with partners, other firms and institutions (Faucheux and Nicolaï, 1998).

I.2. The organization of environmental management: some empirical facts

The case studies show that firms form in a first stage punctual project groups or name expert persons in charge of specific environmental issues. In this phase environmental management procedures are practically inexistant and in most of the cases only top and mid management is involved in decision making. Only by the second stage, firms create a stable structure which evolves through time towards more decentralisation. The creation of such a formal structure

leads also to the emergence and development of modes of coordination based on rules and procedures which partially substitute or complement hierarchical coordination modes.

The structural aspects

We present the different structural configurations adopted by firms according to the integration of environmental and production activities they achieved at the time of the interviews.

A case of low integration is given by a firm belonging to the electronic sector where environmental policy is focused essentially on end-of-pipe technologies Although a separate environmental unity has been created in the General Service Department, the links with the production units are punctual and concern technical and legal matters. In such a case, delegation and coordination are minimized by the nature of the environmental strategy being pursued in the firm.

A second structural and coordination approach adopted by some firms relates to the close link established between quality and environmental management. The two small sized firms belonging to the surface processing sector have basically a similar organizational and coordination approach. Neither of them have a service nor a person dedicated specifically to environmental issues. The link between the production activities and the environmental activities is made essentially through the quality technicians.

Although two other firms belonging to the electronic sector have strongly integrated quality and environmental aspects, their size and the fact that they elaborated a separate environmental management system constitute a significant factor for explaining their specificity. In one of the cases, environmental management is directly delegated to the quality manager who elaborates and controls the environmental procedures. In the other case a person is specifically charged with environmental and safety issues. His function is to centralize the environmental requirements, to ensure the technological evolution and to search for improvement solutions in collaboration with the parent company. The coordination between the quality insurance and environmental units is taken in charge in a centralized way by the Total Quality Management Service through environmental management procedures developed in work groups to which attend the production services concerned by the projects discussed. The main role of this service is to organize the projects and to ensure the coherence between quality and environmental management. This coordination principle through multidisciplinary and vertical workteams is also adopted by the other firm but through a more simplified structure due to the absence of an environmental unity. A common feature to these firms is the absence of a decentralized environmental management organization at the level of production units. In other words the coordination structure and the work teams are essentially vertically organized.

For the other cases studied an important point observed is the presence of a decentralized organization structure for environmental concerns. The differences between these firms stem

essentially from the localization of the environmental unity at the management level and the way horizontal and vertical work groups are constituted. In two cases (automobile sector) the environmental unity belongs to the General Service Departments which also include for example the water and energy supply services, the water and waste treatment services. In both cases, we observe a specialization by domain (water, soil, air, waste and fluids) and the creation of an environmental observatory to centralize all the information relative to the impacts of the production activities. In an another case (brewery sector) the environmental unit is integrated to the Technical and Investment Department. In all tree firms, these Departments are directly linked to the productions units. At each production unit, a person is charged for organizing the environmental management and is in relation with the environmental service. This structure emerged in these firms through the desire to decentralize the environmental decisions at the production level but also to intensify the horizontal coordination procedures. In this context the main functions of the environmental department is to advice, to coordinate and to control the production units with respect to their environmental impacts and decisions. In one of the firms the objective is even to evolve towards a delegation structure where the environmental service has in charge only the legislative aspects.

Two other firms (automobile and electronic sector) distinguish themselves by the central role they give to environmental decisions at the production level but also in the R&D and conception of new procedures. The environmental unity is integrated in both cases to the industrial engineering department and the intra and inter team coordination aspects constitute a crucial point. The environmental unity has mainly a coordination and advising role and intervenes in strategic and investment decisions. More specifically, in the case of the firm belonging to the automobile sector, inter-functional commissions for each specific domain are set up at the production level. Each commission is presided over by the environmental manager and reunites the production managers of units having a significant environmental impact for the domain considered. Insofar as the maintenance and the conception units constitute the most critical action phase for controlling the environmental impacts, they both intervene in all the domains.

In our case studies the firm belonging to the refinery sector is according to the importance of its environmental activities and products a specific figure. It is the only firm where strategic and environmental aspects are directly integrated at the top management level. Because of the technical characteristics of the production process a central role is reserved to the production control center which has to work out the operational innovations and monitor in a centralized way all the equipment. The decision circuits are shortened in order to guarantee a quick coordination in case of anomalies at the production level. A participative approach with the Technology department and the operational units is adopted to integrate the different competencies in the conception of new techniques.

Environmental procedures as coordination rules

The hierarchical and horizontal interaction structures established by firms allow them to evolve towards a set of coordination rules based on environmental procedures established in a collective manner. An important feature of these rules is that they integrate the knowledge and experience acquired through time by the actors. They result in this sense from an environmental and organizational learning process. A feature of these coordination rules is that they permit an economy of communication among members and a diffusion of environmental practices which become common knowledge. The cases we observed allow us to distinguish three modes of coordination by rules. This distinction is mainly based upon the specialized or general nature of these rules and their formal and tacit character.

We consider the adoption of standard environmental systems such as ISO 14001, Eco-audit or EMAS as a formal and specialized approach. These standards have been adopted in our sample by seven firms and are considered as a way to rationalize and institutionalize the environmental procedures elaborated. In most of the cases the development of these standards passes through a top down and a bottom up approach. The purpose of horizontal work teams at the operation level is to solve day to day problems and develop local environmental initiatives and programs specific to each service, by identifying critical activities and improving the efficiency of environmental actions. This delegation process helps to explicit more precisely the local needs and environmental targets. Which constitute for the employees a reference point guiding their actions. These local objectives are part of the coordination mechanisms that ensure the coherence of the local management systems.

The function of the bottom up approach is to work out and adapt the environmental procedures and methodologies. The setting up of these coordination tools requires a global vision of the different processes and leads firms to organize vertical work groups. Their role is to centralize the critical information in order to integrate them into the procedures and then to diffuse them to the operational services. Vertical work groups, by developing rules which codify in an adaptive way the environmental management system reduce by the way also the frequency of hierarchical coordination and enforce decentralisation of local decisions.

In other cases environmental coordination rules although having a codified nature are developed in the specific context of quality management. These firms consider generally environmental management as quality management. In our sample, the two small firms studied verify this approach. Having developed a formal quality management system, they assess their environmental performance through the impacts of quality improvement. They explicitly underline the positive effects of quality management rules on environmental aspects.

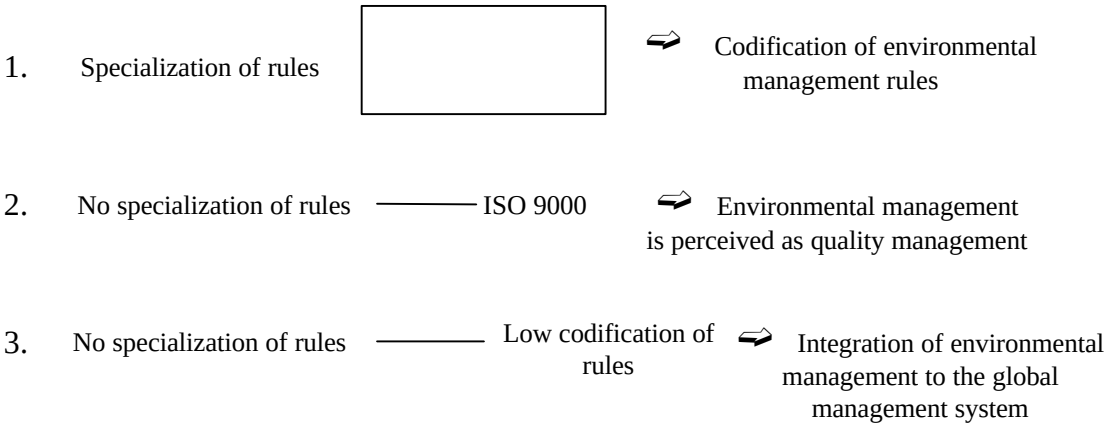
Finally a third approach based more on tacit coordination rules prevails in firms having integrated environmental protection issues into a more global management system. These firms make no clear-cut distinction between environmental coordination mechanisms and other coordination mechanisms which are elaborated in a systemic way. The environmental policy does not lead to an additional management system but favors the evolution of the existing one through its adaptation to environmental criteria. The two firms in this category

(refinery and electronic sector) are those for which environmental protection actions constitute a particularly critical dimension of their activities.

Our case studies show that the use of procedures and rules, by implying a decentralisation of environmental decisions induces also an intensification of monitoring measures. The development of environmental management rules is accompanied in most of the firms by periodical internal audits to control the application and relevance of procedures through efficiency indicators and quantified objectives assessed by the environmental departments.

It is important to precise also that these three modes are not exclusive. For example, nearly all the firms having obtained the ISO 14001 certification have previously adopted the ISO 9000 norm and benefited from the procedures developed by the quality approach. In other words, pre-existing coordination rules have guided the actions of these firms to develop their environmental management system. Moreover, we observe in all the firms, a tendency to more or less codification of environmental management rules. In the refinery case for example, the tacit management rules are supported by short decision circuits connected to a central monitoring unity which intervenes in case of anomalies to coordinate quickly the actions.

Coordination by rules



II. The role of Cognitive Mechanisms

Cognitive mechanisms promote the development of a collective knowledge basis which is essential for the coordination of individual actions and groups (Crémer, 1990). Indeed, in the evolutionary theory, the firm is viewed as an organization bringing together the individuals who make decisions. In this view, decision making - i.e. choosing an 'appropriate' action in response to a new problem posed by a changing environment - is a core element determining the firms' performance. The question is then to find how the firm acquired competencies and knowledge, i.e. "core competencies" according to Teece (1988), over time. Therefore, environmental management must be analyzed as a problem of perception and decision-making about the ecological effects of the activities of the firm. The success of the integration of environmental issues in industrial organizations depends on their capabilities to create new knowledge and to change organizational routines through learning processes.

II.1. Theoretical foundations of cognitive mechanisms and environmental management

Representations (or "models of the world") and routines (or "operational knowledge") in environmental management.

According to Kim (1993) and Nonaka (1994), a good way to understand individual knowledge is to distinguish two main elements in tacit knowledge. The first one is the concept of "mental models" which represent a person's view of the world. These representations provide the context in which new material is viewed and interpreted and they determine how stored information is relevant to a given situation. They include schemata, paradigms viewpoints that provide representations helping individuals to perceive and define their world. By contrast, operational knowledge (or "routine") represents skill or know-how which implies the physical ability to produce some action. These two elements, which constitute the tacit knowledge of Man, are the core capacities of individuals to take effective actions.

But competencies and knowledge do not reside only in the minds of managers. The organization's knowledge is also a complex set of "shared mental models" and routines: "Routines are the skills of an organization. The performance of an organizational routine involves the effective integration of a number of component subroutines (themselves further reducible), and is ordinarily accomplished without "conscious awareness" - that is, without requiring the attention of top management (Nelson & Winter, 1982, pp.124-125). These routines are executable capabilities to generate actions or to guide action sequences in a context that has been learned by the organization in response to selective pressures (Cohen et alii, 1995). This complex of routines not only determines what the organization can do well but also conditions how it will interpret messages, that is how information from the environment will alter the repertoire of existing routines. In fact, this complex of routines determines what the organization recognizes as meaningful in the environment and thus it strongly influences how the organization learns and how it perceives opportunities.

Concerning representations, individual mental models become embedded in the organization's "Weltanschauung»: the organization's view of the world slowly evolves to encompass the current thinking of the individuals within (Kim, 1993).

In such a theoretical context, the integration of environmental issues in the firm's activities demands not only the "cleaning" of existing technologies, but also requires capabilities to turn environmental constraints into new and viable business opportunities. This depends on whether the firm is able to create the required new knowledge and capabilities. In fact, the environmental management requires a redefinition of norms and representations.

The environmental representation (or vision) of a firm defines the worldview that its managers and members share. It encompasses their beliefs, assumptions and values regarding the relationship of the firm to its natural environment. The understanding of this relationship will have a decisive impact on the environmental strategy of the firm (Ulhøi, 1995). For example, the relationship between organizations' activities and the environment is subject to important questions of scale. Indeed, environmental issues arise at the global, regional and local level. But no firm, however large or small, can avoid this range of relationship. Particular global concerns can have a critical impact on small companies, such as small independent manufacturers and users of paint who are under pressure to reduce the volatile organic solvent because of their impact on the global climate change (Roome, 1994)[3]. In fact, the visions and the responses of firms to environmental issues have varied to a large degree in the past and are likely to vary in the future. We have established elsewhere that reactions of firms can be ranked in three categories, according to the implication of the firm in the environmental problems and capacities to handle opportunities deriving from such environmental issues. These reactions are: offensive strategy, characterized by "anticipating and proactive" innovation behavior, defensive strategy, charaterized by "resisting" innovation behavior and adaptive strategy, characterized by "imitating" innovation behavior (Héraud & Llerena, 1992).

But environmental management must also become a core norm which determines the decision-making processes of the firm and the theory-in-use of the members. Because the natural environment has not achieved its proper place in management practices, decision-makers are too often faced with seemingly insoluble conflicts between environmental protection and economic success. They do not ignore environmental issues, but they have difficulties to revise management thinking. A recent study provides empirical information on the problems experienced by engineers developing innovative products and processes for environmental protection (Caird & alii, 1994). The results show that the most frequent problems are those concerned with securing financial backing and establishing the technical

[3] The vision of the organization is also influenced by the considerable scientific uncertainty about nature and the importance of environmental problems. Scientific research produces continuously information about the effect of human actions on the environment. But ecological systems are intrinsically unpredictable. The evolution of the composite natural systems has been influenced by a kind of selection pressure which favors not only different sorts of efficiency but also evolvability, i.e. the ability to adapt to environmental change (Bernstein, 1981). Moreover, the evolution of scientific knowledge occurs within the context of continuous social and political changes. Thus, a large number of firms are confronted with unpredictable changes about environmental issues.

viability of the new product or process. In fact, the use of polluting technologies is the result of decision processes that are led by existing activities and established routines. These existing rules satisfy the firm's aspiration level because their assessment does not include environmental issues: the firm is not induced to engage in search behavior in order to integrate the harmful effects of its activities. Even when companies have introduced environmental protection measures, the possibilities for further improvements might be missed because of ignorance: "… most companies still have no idea of the amounts of pollution and waste they are producing and thus are unable to undertake elementary assessments to minimize waste and save raw materials" (Robins & Trisoglio, 1992, p.177). In fact, end-of-pipe treatments are only the result of minor modifications of existing routines. The organization restricts itself to an adjustment of existing routines, where environmental issues appear only at the end of the development of new products or processes. In many products, environmentally compatible solutions are only found for the end of the product's life. The solution often consists of a procedure for sending a useless product to a recycling company for disposal. By contrast, the technology of waste reduction (that is, in-plant processes that reduce, avoid and eliminate the generation of waste) does not have a widely accepted scientific basis (Friedlander, 1989, p.175), since firms tend to adopt steady routines because they try to reduce the uncertainty of innovative search. Such behaviors appear also because improving knowledge within frequently used rules increases the frequency with which these rules result in successful outcomes, and thereby increase their use. In fact, innovation opportunities for companies to innovate are limited by path dependencies, organizational routines and acquired knowledge. These core capabilities may act as core rigidities.

Thus, one can note that changing the basic assumptions and vision of an organization is a very difficult task because those elements form the foundation for the organization's routines. In fact, the integration of environmental issues in the firm will require a "double-loop learning process" which connects the failures of the theory-in-use "not only to strategies and assumptions for effective performance but to the very norms which define effective performance"(Argyris & Schön, 1978, p.22). Changing the set of complex routines requires redefining what the organization stands for (i.e. its strategy), but also changing the nature of the work done by the organization and placing people in new roles that require new knowledge and new skills. This "environmental learning process" needs a process by which organizations change their cultures as a result of an interlinked effort of individual learning and organizational transformation. Environmental management requires then completely new values and norms: ecological efficiency is not achieved by technological change alone, it is also achieved by profound changes in the goals and assumptions that drive organizational activities. This means a break with business-as-usual mentalities and conventional wisdom that sidelines environmental concerns. The integration of environmental issues is not a compromise strategy - that is earning a profit while doing as little damage as possible to the ecosystem. Rather, it is an integrative strategy which provides competitive advantages to

organizations by simultaneously enhancing the quality of the environment and the long-term survival of the firm (Porter and Van der Linde, 1995).

Individual competencies and environmental training

The complex nature of competencies and knowledge leads to numerous definitions that sometimes are in contradiction. The typology of knowledge which is the most familiar in the litterature is the one suggested by Lundvall & Johnston (1994). These authors distinguish the following forms of knowledge: "know-why", i.e. referring to scientific knowledge principles, "know-what", i.e. referring to the knowledge about facts, "know-who" referring to specific and selective social relations, and "know-how, i.e. referring to automatic knowledge and skills. Any transformation of knowledge implies a learning process: training and education, but also direct experience or learning from others. In fact, to create knowledge requires some learning to take place from others (teacher or colleague), frequently through laborious and intensive interactions among members of the organization.

The acquisition of new individual competencies and knowledge through training is a key factor in developing human resources for the environment. One can distinguish three elements to environmental training and education (North, 1992). The first is a need for knowledge of the environment, of actions taken and the consequences of these actions on environmental quality. This element concerns, for instance, the monitoring and analysis of waste streams, the assessment of the environmental impact of the plant, but also biological and chemical knowledge (the "know-why" part of knowledge). The second concerns the attitude towards environmental issues: the major challenge for personnel managers lies in providing environmental education which will bring about a change in attitude and behavior among managers, staff and workers. Indeed, according to Petts & alii (1998), if individuals are concerned about the environment (with a well understanding of environmental issues), attitudes, beliefs and "representations" do not predetermine behavior in general. Thus it seems that, for employees and managers, there is a need for an appreciation of the relevance of attitudes in actual work tasks: the environment is important but does not seem to be related directly to their work activities (the "know-what" and "know-who" parts of knowledge). The last purpose of environmental training is the acquisition of the relevant competencies, i.e. general environmental management competencies as well as special competencies. These competencies concern environmental legislations, new technical solutions and environmental technologies, but also Environmental Auditing and Life Cycle Assessment tools (as the "know-how" part of knowledge).

According to Gilbert (1993), the establishment of this environmental training program is essential in order to remove the suspicions about environmental management among personnel. Moreover, it is important that training takes place at all levels of the organization in order to introduce environmental issues into the different decision-making processes. But the training program must also be an ongoing process and not just a one off exercise: the program should continually reassert the importance of environmental issues and affirm the

responsibilities of each member to environmental management within the organization. In fact, the benefits of integrating environmental training with other management subjects are important: this integration reduces the source of conflict in the mind of trained personnel and equips them better for decision-making in their day-to-day activities.

Organizational learning through "team work" and ...

Organizational learning, as individual learning, is "the way in which firms build, supplement and organize knowledge and routines around their activities and within their cultures, and adapt and develop organizational efficiency by improving the use of the broad skills of their workforces" (Dodgson, 1993, p.377). But organizational learning is more than the sum of the parts of individual learning (Argyris & Schön, 1978; Fiol & Lyles, 1985). An individual is never isolated from social interaction when he perceives things, so that the individual and collective levels of learning are not independent from each other, but interact with each other iteratively and continously through "social conversion" (Nonaka & Takeuchi, 1995). Indeed, very often, learning in an organization takes place by members sharing experiences and work practices. Thus, greater sharing or distribution of experience leads to greater organizational learning. According to Kim (1993), the intangible and often invisible assets of an organization reside in individual mental models that collectively contribute to the shared mental models. Such social constructions of knowledge are supported by social networks of members sharing their experiences, and these networks support feedback and review mechanisms among people.

The cross-functional nature of environmental issues represents an important challenge for organizational changes. Indeed, it requires the application of a more holistic, systemic thinking about environmental problems and the elaboration of solutions. To maintain progress and to attain systematic and comprehensive environmental management, it is necessary to have detailed information to assess the pollution reduction opportunities. The problem is to discover exactly where to focus efforts and which available technologies and products to use. After the strategy has been devised by the top-management, it has to be implemented by a variety of teams and people from different departments. Shared employee involvement and participation can facilitate the cross-functional links necessary for a holistic approach to environmental management (Roome, 1992). As is the case when organizing a project, specific tasks and responsibilities have to be defined.

The use of both cross-functional and departmental teams provides access to issues and data that relate to the entire plant, and focuses on specialized issues and processes associated with individual departments. Although many of the environmental opportunities appear to be departmental - or process-specific - the evaluation of these opportunities and their implementation require interdepartmental involvement. Indeed, “teamwork within the company guarantees that all relevant divisions take part in the project, pool their knowledge, apply their individual know-how to other areas, develop creativity and together support the solutions” (Fresner, 1994, p.44).

The integration of personnel from various departments into cross-functional teams will help the company in understanding its needs. Moreover, people on the shopfloor have a key role to play because they are close to the activities and incidents which may cause environmental impacts, and, if they are trained and motivated, they should be able to recognize and respond to needs for environmental performance improvement. Cross-functional teams that combine purchasing, marketing, engineering, accounting and production personnel can provide the data needed to assess current conditions and identify methods for improvement. For example, production scheduling conflicts that may limit the ability to effectively control purchasing and process operations may require assistance from purchasing, marketing and production personnel. Also, these cross-functional teams play an essential role in developing baseline data and accurately quantifying the true cost of waste generation in the company which are elements of the collective knowledge.

Cross-functional teams and departmental teams are essential to successfully perform the assessment, evaluation, implementation and monitoring activities associated with the environmental strategy of the company. Environmental leaders have experienced such organizational arrangements since many years. Firms, like Dow Chemical and 3M, elaborate pollution prevention programs where any employee or group of employees can propose a project. A co-ordinating committee reviews each project. This committee consists of members from engineering, manufacturing and R&D departments. Since 15 years, 3M completed over 2500 pollution prevention projects which have reduced the pollution of the firm in half and saved $500 million in costs (Shrivastava, 1995). In order to manage their environmental strategies, other firms, like Electricité de France (EdF), create teams or task groups with a limited lifetime where managers of different departments deal with specific environmental issues. Other firms, like ICI, elaborate “matrix management” around environmental innovation where an individual has simultaneous responsibilities for a functional department and for a specific project (Robins, 1992). In these sub-organizations, which are completely devoted to creating new ideas, it is possible to maximize learning processes and to benefit from localized knowledge.

... the role of the Environmental Unit.

Therefore, if localized learning processes in team groups become particularly relevant in the environmental management, we must focus our attention on the tension between the necessity of “keeping together” the organization and the one of allowing a diversity of experiences. As we explain in the section "Coordination Mechanisms", the modification of the knowledge basis is fed by the decentralized learning processes but has to be centralized, in order to cope with a changing environment. If the correct emphasis is placed on knowledge and learning, higher degrees of decentralized learning are not necessarily conducive to higher degrees of organizational learning, but only to the extent to which they can be pulled together and made coherent with the overall organizational learning process (Marengo, 1993). The firm needs a stable set of routines. Such a set can concern for example the global evaluation of ecological

impacts or the elaboration of the targets which must be reached. Moreover, the environmental situation requires not only to discover and exploit the “robust” set of routines, but also to ensure a strong coordination in order to make the entire organization implement coherently such a set and therefore emphasize the coordination around a unique central body of environmental knowledge. In fact, the emphasis is put on the role of hierarchy concerning the development and the diffusion of competencies and organizational routines, which guarantee an efficient coordination of the different departments of the firm. The establishment of environmental units in industrial firms is one of such organization arrangements (Groenewegen & Vergragt, 1991). We can interpret the creation of such units as a necessity for the firm to have a “robust” knowledge basis. Because the ecological environment of the firm is continuously unpredictable, the centralization of information learning in an environmental unit allows the constitution of stable and global representations of ecological problems. One example of such common knowledge is the conception of some Environmental Plan or Audit which presents the quantification of the environmental effects of firms' activities.

II.2. Cognitive mechanisms in case studies: some empirical facts.

The "representations" of environmental issues:

In our sample of case studies, we can found different categories of environmental strategies, which represent in fact different representations of environmental issues. First, in all German firms of the sample we observe that the protection of environment is a core element of the organizational culture. For the firm in the brewery sector, "environmental protection represents one of the action's guide", and the management is based on the vision that the firm must contribute to the preservation of environment. For two other firms (electronic and surface treatment sectors), the integration of environmental issues is analyzed and implemented in a systemic way, that is all parts of the organization are involved in the environmental strategy. The main objective of this systemic approach is to generate synergies between traditional activities and environmental protection. Finally, for the German automobile producer, environmental protection is directly linked to its products: ecological impacts are integrated in the R&D processes in order to preserve the high quality of products and production (according the environmental manager an ecological problem could decrease the sales around 10%).

A second group is composed of French firms owned by foreign companies (German, American or Japanese). In these production units, the environmental representations are based on the strategies of the head office. Note that in the Japanese case, the different decisions are guided by the German regulation which is evaluated as the most constraining. For all these production plants, the environmental policy and philosophy of the head office are the "references". Thus, environmental management practices are determined at the head office and diffused in a "top down" manner throughout the production units. In our sample, it seems

that for these units environmental protection is an important part of the "hierarchical" organization culture. But we can also integrate in this group French companies (refinery and brewery) where the production process is particularly harmful for the environment (with high environmental standards) or dependent on the quality of natural inputs (groundwater).
The last group of firms could be characterized by an adaptive approach concerning environmental issues and their management. This group concerns three French firms (automobile producer, electric manufacturer and surface treatment). Until recently, the environmental dimension played a minor role in these companies strategies. Only regulation pressures and citizen associations have pushed these firms to integrate environmental issues in their business practices. Moreover, for one of the electric manufacturer such integration has been constrained by the very nature of the production technologies used. This approach induced principally "end-of-pipe" investments.

Individual competencies and training:

It is important to note that, except in one case, we don't observe specific and long-term recruitment (like an environmental manager). In two firms, students or temporary employees have been appointed in order to implement specific environmental tools. A rotation of managers among parent firms is also observed in some cases. For instance, in the French brewery, the manager in charge of the introduction of ISO 14001 certification was transferred to other production units of the company. A similar procedure was also observed in the German brewery.
In fact, we observe that the responsibility for environmental management is entrusted to senior managers which have strong scientific competencies (chemist, biologist) or management competencies (quality manager). This fact suggests that the firms manage environmental issues on the basis of existing human capital and competencies. Moreover, it seems that an effective integration of the environment needs experience in traditional activities. Many company believe that whoever is assigned this task should have technical background but also should have actual experience in operating the plant. The reason for this is that the environmental manager will be dealing primarily with the operations managers and will need such a background in order to deal with them effectively.
If the recruitment of environmental manager is still rare, all the firms of our sample have introduced training programs for their managers and employees. In fact the main objective of this training is to introduce environmental issues into the mainstream of decision-making by creating attitudes and teaching skills which will enable managers to recognize and fully consider the environmental consequences of their actions. For environmental managers, the new competencies concern technical and legal aspects in order to appreciate and understand environmental legislation but also to determine optimal solutions that ensure conformity with the new standards.

Organizational learning through "team work"

A great part of the interviewed firms (4 French and 3 German firms) have organized cross-functional and departmental teams in order to manage environmental problems. If the structure of these teams is very variable, they have the same objective: to establish links between the different hierarchical levels and between the different important units of the plants. Such organizational arrangements are essential for a good and effective transmission of information and data, but also for the transmission and exchange of experiences and knowledge inside the firm (as in the case of the German electronic producer). Moreover, in some firms (French automobile producer and electric manufacturer), these teams play an important role in the management of potential conflicting representations between units or managers. Indeed, it was underlined that the integration of environmental issues in investment and planification decisions modified the decision-making process itself, and led to conflicting interests. Firstly, taking into account environmental criteria in investment decisions is often perceived as inconsistent with economic profitability and technical effectiveness. Secondly, abrupt changes could be perceived negatively if important productivity or quality improvements are not induced by such changes. Such conflicts can perturb the influence of the environmental manager in the different parts of the organization, as it was the case for the German automobile producer where in case of conflicts with product quality demands the position of environmental manager is rather weak. For these reasons, team working is established in order to ensure that the environmental policy is implemented and that the individual responsibilities are defined for all employees and managers who are involved with the activities identified as having environmental implications.

But teamwork induces also mutual control between the members of the team. Indeed, for some firms, operational control is considered as an important factor for the success of environmental management. The collective elaboration of relevant targets and measurement and verification that all environmental activities are carried out clarify the responsibilities of each member, not only through the hierarchical structure but also inside the team.

The Environmental Unit's role

The way the environmental function, and its unit, is organized in a firm depends principally upon the size of the firm. But, in all the firms of our sample, we observe that the major role played by such a function is the coordination of environmental actions and the development of rules, procedures and documents that centralize new competencies and knowledge. It appears that the work of environmental managers is focused on the "socialization" of technical solutions and environmental representations. One can also observe that an effective and systemic environmental management induces that the manager in charge of this function must be localized in the core of the organization. For instance, in two of the firms interviewed, the environmental unit is integrated inside the industrial engineering unit, that is between the R&D department and the production unit. For these firms, the target is to

"capitalize" the knowledge emerging from interactions between traditional (process and productivity optimization) and environmental criteria in the process of new products development. For other firms, as the French refinery plants, the maintenance unit is entrusted to the environmental mission because environmentally responsible operation depends principally upon the plant being in good condition, which in turn depends upon good maintenance.

III. The role of Incentive Mechanisms

By incentive mechanisms we understand the structure of payments in financial or material terms which guide and co-ordinate the actions within the firm. This includes also controlling and monitoring mechanisms which directly check on actions and their results. Incentive mechanisms can be envisaged on two principal levels: as an element of the firm's interaction with its environment and as mechanisms within the firm, on the level of departments, units or the staff.

It should be pointed out that non of the constituting mechanisms of a firm can be ascribed to one exclusive category (Cohendet & alii, 1998). Thus, the payoff structures observed will not exclusively represent incentive mechanisms but also fall into the categories of cognitive and coordination mechanisms. For the theoretical foundations of these latter mechanisms the reader is referred to the corresponding sections of the paper.

III.1. Theoretical foundations of incentive mechanisms and environmental management

Among the theoretical approaches that strongly emphasise incentive mechanisms as constitutive element of a firm's internal organization are the recent developments of the neo-classical theory of the firm, especially those of principal-agent character. These approaches basically perceive the firm as a bundle of bilateral contracts designed to achieve coordination by imposing the appropriate incentive scheme. The analytical focus lies primarily on the optimal allocation of efforts among tasks, the phenomenon of co-operation being largely foreign to this concept. The need for incentives results from the presence of diverging interests and self-interested and opportunistic behavior with the possibility of hidden action and hidden information. In this context, incentives serve to direct individual action toward a common goal.

An environmental incentive scheme needs to comprise (environmental) evaluation criteria, on which the remuneration of the agents can be based. Consequently, quantification, monitoring and auditing schemes for non-financial objectives such as the environmental objective are put in place, even if - as Gabel and Sinclair (1992, 1997) point out - environmental performance can be measured only imperfectly. They conclude that when an agent's effort constraint is not binding, it is optimal to use an incentive wage to reward performance.

A similar perception of the firm as a nexus of bilateral contracts is also apparent in Williamson's interpretation of the transaction costs approach (Williamson 1975, 1985, 1993). According to his view the nexus of contracts is aimed at keeping opportunism under control. Seen from this angle incentives schemes represent governance structures which are designed as to minimise transaction costs which are interpreted mainly as cost of access to information, for example on prices. This theoretical approach may serve to explain the set-up which determines internal pricing schemes and corrects them to take into account environmental

costs. What is at stake is the possibility to know the internal prices of environmental goods but also to incite those who know these prices to reveal them.

Other interpretations of Coase's ideas, however, point out that coordination is another important aspect the theory is concerned with. Thus, questions of the coherence between coordination and incentive mechanisms (Aoki 1986) as well as qualitative coordination under uncertainty (Langlois & Foss 1996) are also treated.

In the evolutionary approach the analysis of incentives is still very much at the beginning. Contrary to the principal-agent approach, in this perspective the divergence of preferences is not considered as a danger which requires appropriate incentive schemes to cope with. But rather such a divergence is considered as a chance to enhance performance. If one takes the view of (organizational) learning, which is one of the key concepts in the evolutionary economics paradigm, diverging preferences may also imply constructive diversity which fosters learning and creation of novelties. In a disturbed environment these processes represent important factors of success. In this perspective diverging preferences call for coordination mechanisms, which allow to exploit their cross-fertilization potential.

While incentive mechanisms in the evolutionary context are not necessarily aimed at controlling and managing conflicting interests they do play a role in directing organizational learning and in allowing the organization to respond flexibly and satisfactorily to a turbulent environment. We note that incentive schemes appropriate for fostering learning not necessarily coincide with effective incentives for resource allocation.

The demands made on incentive schemes in an organizational learning perspective are first to stimulate local learning and diversity. This comprises on the one side the provision of criteria for an evaluation of the performance of trial-and-error experimentation. On the other side, the incentive scheme has an impact on the intensity and direction of organizational search for alternative routines – another element of learning. Secondly, it also has to be ensured that the incentive scheme fosters coordination among actions and processes. While incentives are seen as factors that drive learning, on the other hand, they are subject to learning and adaptation themselves (see Coriat & Dosi 1995 for this line of enquiry).

Complementary to incentive mechanisms inside the firm there are inter-organizational incentives which act on the level of the firm and are implemented by (quasi-) market mechanisms. A first possibility to approach this phenomenon is via a simplistic traditional neo-classical view. Here the firm is seen as unit maximising profit. Following this logic, the introduction of any additional constraint necessarily leads to a deterioration of results (higher costs, reduced revenues etc.). In the context of our analysis the challenge to integrate environmental concerns into the firm represents such and additional constraint. Neo-classical theory would thus predict negative consequences for the firm, if it engages in environmental management practices.

Another aspect regarding incentives on the level of the firm is that these will necessarily have repercussions on their internal incentive mechanisms, structure and behavior. As is pointed out by Sinclair-Desgagné (1994) the nature of sanctions by the government imposed on firms

for non-respect of environmental norms will directly influence their internal decision structure and incentive policy. Thus, the necessity for firms to check on their environmental impact leads to the implementation of intensified environmental controlling procedures and according implications for inciting and remunerating the actors involved.

III.2. Incentive mechanisms and environmental management: some empirical facts

Empirical evidence on environmental incentive mechanisms on the level of the enterprise

Our empirical analysis has revealed four principal dimensions on the level of the firm, which can be interpreted as elements of the incentive mechanism to engage in environmental management: changes in costs, revenues, productivity and market shares. We will discuss each of the dimensions in turn.

Some of the evidence on cost changes related to the pursue of an environmental objective seems to support the neo-classical statement, that this will raise the level of costs. Thus, in the case of the German brewery, the refrigeration machine which complied with environmental regulation implied higher investment expenditures than a less "clean technology". The French brewery shows that apart from investment expenditures, increases in costs for operation and maintenance can also be observed due to higher prices for environmentally more benign inputs. In the specific case a change in the type of fuel form heavy fuel to a fuel with lower sulphur content was effected.

However, contrary to what neo-classical theories of the firm would predict, cost reductions have also been observed. These were mostly linked to environmental measures which work via a reduction in resource use. The following cases illustrate this:

- In the French automobile enterprise one environmental measure consisted in reducing emissions from solvents. By reducing the emissions the loss of solvents and thus of production resources has also diminished.
- The German enterprise in the sector of surface treatment states a reduction of costs of 10-15 % as a consequence of having integrated environmental objectives in its quality management. The cost reductions have several sources, for example:
  - Water consumption in the rinsing units has been reduced;
  - The procedure for removing lubricants from parts before further treatment has been simplified by a switch in lubricants, which allows to largely skip the environmentally quite harmful step of cleaning the parts with solvents. The effect is a reduction in solvent use and disposal costs.

Positive incentives for the firm to engage in environmental protection are not limited to opportunities of cost reductions. Several examples exist were originally environmental activities have contributed to increases in revenue and/or productivity. Thus the French enterprise in the sector of surface treatment has managed to change its rinsing procedure such

that the rinsings need to be exchanged considerable less frequently than before: once per year instead of every two weeks.

The fourth dimension that we found to be positively influenced by enhancing environmental performance are market shares. This is in fact a consequence of changing markets where clients begin asking for environmental quality in production or in the product. Thus for two firms part of the risk of an environmental accident consists in the likely loss of customers that would follow. This risk acts as a disincentive for neglecting environmental protection.

Empirical evidence on environmental incentive mechanisms within the enterprise

This part focuses on the internal "payoff structure" of the firm and its relation to the firm's environmental impacts. More precisely those interactions within the firm will be analysed that are related to the allocation of financial resources between different departments and investment projects and as well to internal pricing schemes and to the remuneration of staff. Part of the analysis aims at explaining the observed mechanisms on theoretical grounds. Another aim is to investigate how the various shapes and directions of environmental incentives from the "outside world" - which were presented in the previous section – are linked to the schemes set up inside the firm.

a) ***Budgeting procedures***

The procedures to establish the volume of the budget which will be assigned to investments serving environmental goals are closely linked to the organizational structure set up to realise such projects – as is the nature of the projects realised. A budget exclusively dedicated to environmental purposes is mostly linked to a strong division of tasks within the firm. In the case of the French firm producing switchboards, for example, the environmental manager is the only person responsible to implement environmental projects. Thus, the budget which he can dispose of represents reasonably well the budget that is invested into environmental efforts. The top management determines its volume by referring to the demands the environmental manager formulates. These demands need to be justified. One possible justification is compliance with legislation, others will be discussed in the next section on investment appraisal criteria. The case of the French switchboard producer is interesting in two respects. First, the budgeting procedure can be interpreted as imposing an incentive to reveal the objective reasons for an envisaged environmental investment and hence to assure the rationality of the decision. Secondly, it also may be interpreted as a cognitive mechanisms which serves to centralise local knowledge on capital needs.

More often, however, the environmental budget cannot be equated with the budget of one single unit. In those cases, where environmental activities are integrated into the general activities of the firm, the budget assigned to the environmental unit represents only a limited part of the total budget assigned to environmental activities. The latter may even be entirely integrated into other services within the firm and hence into other budgets, for example the general budgets of productive units. This reflects the fact that many projects do not

exclusively serve environmental goals, which makes it practically impossible to precisely ascribe the budget spent on "green" objectives.

The procedures to establish the general budgets are mostly also based on the demands made by the heads of unit. A range of possible justifications have been stated as permissible, including for example the need to enlarge productive capacity, to renew or modernise certain plants or to reduce costs and also environmental justifications. This procedure can be interpreted in the same terms as the procedure described above for a purely environmental budget. In addition it shows a further more evolutionary dimension of incentives: if the production units are obliged to choose a plant which not only satisfies productive demands but also environmental performance specifications and if they have to pay possible extra costs for environmentally benign features from their same own budget, this will orient their search for investment possibilities and incited them to search for synergies between environmental and productive demands on the plant.

In the German automobile firm this approach is pushed to the extreme. Here the environmental unit has completely abandoned its own investment budget to the advantage of the production unit, yet it is entitled to participate in the decision on the kind of investments made (see below). The production units are thus deprived of any possibility to shift on possible additional costs accruing for environmental features to the environmental unit. This procedure avoids the necessity to split investment expenditure and ascribe certain shares to certain objectives – a thing impossible to do without arbitrariness. At the same time this set-up enhances the pressure to make ends meet and hence to look for synergies.

b) Investment appraisal

In this section we present and explain the criteria which according to our case studies are important in determining investment priorities. Even though such assessment criteria cannot be separated from cognitive mechanisms it seem to us worthwhile to discuss them also in the perspective of incentive mechanisms. Several categories of investments may be distinguished with varying appraisal criteria. First, firms tend to identify "normative" investments, i.e. investments which they are obliged to undertake by environmental law. If there is such a norm and if there is only one technical choice to comply with it the investment is realised without further evaluation. This means, that compliance acts as a very strong incentive.

If there are several possibilities to reach compliance or if the investment decision concerns voluntary measures a mix of environmental and economic criteria comes in. In a principal-agent-perspective the economic criteria may in a first step be interpreted as the reflection of the incentives present on the firm level. Agents are urged (in a management-by-objectives approach rather than by direct incentives, see below) to evaluate investment opportunities according to the proposed criteria in order to maximise profits.

Economic criteria include investment costs, changes in operation costs and revenues, and pay back time. It is worth noting that we found a surprisingly decisive impact of the investment costs alone. This can be explained in the context of an "artificial" quantitative capital

constraint, which the budget represents, once it has been fixed. Possibilities to raise additional funds to invest in projects that were not calculated in the budget planning before seem to be very limited, even if the projects are highly profitable.

In addition, we found another interesting feature of the appraisal procedure which is linked to the importance of the payback time. In fact, it serves not only to evaluate profitability and risk. Often, certain threshold values are defined. If the payback lies above the this threshold, an investment is considered as strategic and hence requires the participation of the top management. In this perspective the criterion does form part not only of an incentive scheme but also of a coordination mechanism, which allows a division of tasks concerning investment decisions between (purely) technical experts (for "standard" investments) and the strategic management (for more complex investment decisions).

Concerning the environmental evaluation of individual projects different approaches can be observed. Not all firms make an own evaluation but base their environmental assessment on generalised classifications which regroup "clean" and "less clean" technologies. Such an approach is often linked to an only weak integration of environmental criteria in entrepreneurial decision making. The reason is, that it limits the possibilities to assess the difference in environmental quality and the true impact of investing into cleaner technologies on the environmental performance of the firm.

Firms using a more integrated approach – and also primarily larger firms – use different forms of environmental impact analysis and life cycle analysis. The advantage is that conflicts and incompatibilities in different environmental objectives are revealed and can be treated explicitly. In the case of the German firm for surface treatment, for example, the aim to reduce waste water and water consumption was found to be partly inconsistent with the aim to reduce energy consumption. An arbitrage between the two goals was found to be necessary. The more detailed environmental assessment allows this arbitrage to take place overtly.

The case studies also show that a more detailed assessment of the environmental impacts also facilitates the integration of the economic and environmental evaluation dimensions. Such an integration allows to assess possible trade-offs between the environmental and economic objectives in case the two dimensions yield opposing investment priorities. In the context of an integrated evaluation several enterprises referred themselves less to "economic profitability" but to the notion of "economic acceptability" of a project.

A particularly interesting scheme to manage trade-offs between environmental and other objectives of the firm was observed in the German automobile firm. Here, a committee composed of the environmental manager, the quality manager, the head of the production unit concerned, the (technical) planning department and financial planners, decides jointly on the acceptance of an investment project. Each participant represents one specific interest. While all the interests taken together are important for the performance of the firm, some of them may be conflicting at times. Thus quality demands often raise packaging needs, and hence resource use. The investment committee scheme allows to make the interests explicit and to

engage into a negotiation process which reveals their relative importance and yields a compromise with a fair equilibration of all interests.

Some of the aspects assessed in the investment appraisal procedures reflect incentives present on the firm level. For example, the impact of an investment on the risk of an environmental accident is assessed, where an environmental accident could result in a serious loss of clients. Thus the appraisal criteria form part of an incentive scheme, but more with a view to the firm level. They are significantly less linked to incentive schemes inside the firm. For example, they do not or not directly serve to determine the remuneration of the decision makers (see below). On the intra-firm level the investment criteria may be better understood first as an element of a cognitive mechanism, since they allow to improve the quality of decentralised decision making. Secondly, as the example of the investment committee shows, the appraisal criteria and the processes of determining and aggregating them serve to co-ordinate diverging interests within the firm. This rather evolutionary interpretation differs from the principal-agent-perspective, which would call for an incentive mechanism rather than a coordination mechanism in order to cope with diverging interests inside the firm.

c) Cost centres and internal pricing and accounting schemes

This section discusses incentives on the level of departments. Here, the environmental incentive mechanism is based on a distribution of (environmental) costs among departments or units according to the "polluter pays" principle. This approach is primarily chosen by large enterprises. The following two examples are both from the automobile industry:

- In the French automobile firm departments which recycle or resell their wastes are entitled to the revenues generated by this activity.
- In the German automobile firm departments are charged for the disposal of their hazardous waste. The "polluter pays" principle is now also extended to resource use in the domain of energy. Thus, units profit the reduction in energy use they achieve.

In both cases the remuneration scheme for the units incites them to manage their wastes as to maximise the revenues from valorisation and to minimise disposal costs. This logic is in line with what transaction cost theory and principal agent approaches would predict on the design of incentive schemes.

However, there is still another dimension to the observed mechanisms. The idea in both cases is that those decision makers should be entitled to additional revenues from environmental activities or charged with the costs who possess the best knowledge on possibilities and costs to valorise or reduce wastes. Thus, the mechanism shows also a cognitive dimension.

The case of the German automobile firm is also interesting in how the "polluter pays" incentive scheme has developed over time. In a first step the indicators used to attribute the hazardous waste disposal costs were based on historic average values of waste amounts which are adjusted periodically rather than on actual waste amounts or actual energy consumption. The problem with this formula is a certain inertia. Production units profit from a reduction of

their wastes only if they can at the same time convince the controlling department to adjust the indicator. For energy consumption there is now a project to reduce inertia by turning to actual measured consumption rather than using historic energy consumption in the ration formula. This shows that incentive schemes as drivers for cognitive mechanisms are themselves subject to learning and adaptation.

d) Incentives on the level of the personnel

Other than principal-agent approaches may suggest financial incentives on the individual level are found to play only a minor role in the environmental management systems we analysed. Only in one case there is a profit sharing scheme for personnel on the condition that environmental targets have been obtained. This concerns a large enterprise with quite heavy environmental impacts.

General systems of bonuses do exist in some of the investigated enterprises. However, they do not specifically reflect environmental criteria. It has to be pointed out, though, that some criteria refer efficient resource use and, hence, are closely linked to environmental issues. For example, the head of the paint workshop of the German automobile producer receives royalties if he fulfils certain performance indicators, among which there is also the specific use of paint per vehicle. In several cases the general schemes which gather the personnel's suggestions for improvements accommodate also suggestions on improvements of environmental performance. However, it was mentioned in one case that these schemes carry the risk of disappointing the staff if their suggestions are not put into practice.

Even though remuneration seem to be generally independent of environmental performance, the environmental evaluation criteria as a part of the incentive schemes only play a role in the context of an approach of "management by objectives" in assessing the performance of individual workers in the firm. These criteria allow for self control and also hierarchical control but were not found to be linked to short term financial repercussions for the actors.

Conclusion.

Our aim in this paper was to analyse environmental management by using the evolutionary framework and defining the firm through three generic mechanisms. The central idea consisted in pointing to the changes in the co-ordination, cognitive and incentive mechanisms of firms involved in environmental protection. We focused our analysis on the role and evolution of organizational competencies that firms develop through individual and organizational learning processes. Our results show that all three mechanisms play in the context of environmental management a crucial function in guiding the learning processes and co-evolve through acquired new knowledge.

The co-ordination of environmental activities can be taken as a first indicator of how firms integrate them in the decision process. In the firms we studied, the position of the environmental department and his role in the organisational chart can only be precisely explicited in relation with its interactions with other organizational units. It is essentially in this respect that environmental decision structures differ from one firm to another. The importance of vertical and horizontal work teams in some case studies is explicitly related to the necessity for firms to create new and specific procedures that integrate environmental, quality and productivity criteria. Furthermore, routines and rules serve as co-ordination tools in two respects. They formalise and codify new information and knowledge in a coherent framework and facilitate their diffusion. They also constitute a common knowledge base on which actors base their actions. Several firms, as an important co-ordination mechanism, have for example mentioned the use of quality management routines to develop new environmental procedures.

Concerning cognitive mechanisms, the evolution of competencies plays a central role in the environmental integration process. These mechanisms rely in most of the firms on existing processes such as quality management or security. Successful integration depends on one hand on the coherence between pre-existing competencies and on the other hand on the new ones developed in the context of environmental management. The technological and competence specifities explain also why most of the firms do not recruit environmental specialists but choose to widen the responsibilities of their managers. A great importance is therefor given to training programs.

Two elements – teamwork and the environmental unit – play a crucial role in the management of cognitive aspects. A team like organization is adopted in several firms for the elaboration of new environmental procedures and environmentally friendly products and processes.

Teams constitute structural units where local learning processes and locally generated knowledge are confronted, discussed and evaluated. They are in this sense sytems where new information is produced and understood. The environmental unit plays in this context a complementary role by co-ordinating the different local learning processes and represents a focal point codifying and confirming procedures and centralised information.

Last but not least, our work shows that a complete and a systemic characterisation of incentive mechanisms concerning environmental management calls for a multi-level analysis: on the firm level, on the departmental level and on the individual level. Depending on the incentive firms have to engage in more or less profound changes in their environmental activities, their internal policies are characterised by strong or low incentives at the departmental and individual level. Particularly in the case of big firms we observe through time an evolution towards specific environmental incentives such as the creation of cost units and the introduction of environmental criteria in investment decisions.

It seems important to notice that the three mechanisms we studied are strongly interdependent. The process that led some firms for example to the creation of cost units resulted both from structural dispositions and from a more accurate representation of each unit’s environmental impact. It is also the necessary coherence between these mechanisms that seems to explain why environmental integration is mostly realised through less radical but more incremental organizational innovations.

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