Innovation Networks,
Corporate Coherence and Environmental Capabilities

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Abstract

The rise of environmental issues and their diffusion through the selection environment lead to the necessity of firms to build environmental capabilities. Depending on the firms prevailing capability structures, they often pose a challenge to corporate coherence, since the firm has to develop and respond to - inherently - particularly different, originally bio-physically encoded kinds of knowledge. In order to deal with this coherential 'stretch', the establishment of cooperative relationships, to – environmentally more competent – firm-external actors is in many instances inevitable. From this perspective, peculiarities of 'innovation networks', in the sense of innovation systems as an 'extended' concept of Marshallian industrial districts (e.g. in terms of spatial proximity or involved actors), and the necessary organisational and institutional impacts are investigated, attempting to develop contributions of an environment-related analysis to the general understanding of the principal idea of networks and related phenomena.

Introduction

This paper attempts to shed a light on possible connections between two fields of interest, which have recently blossomed within economics as a discipline, namely between what might be encompassed by the term networks and related phenomena in the broadest sense and the 'economic analysis' of the ecological environment. The main fundament for the here made claim that the analysis of environmental issues is of particular benefit for the understanding and development of networks is represented by the diffusion process of environmental issues, mainly hazards, into the socio economic sphere. Thus first, the main traits of this process represent the starting point of the paper. The epistemological conditions of this process bear the central element of the encodation of knowledge as a shaping factor of the direction, shape and pace of this process. From the resulting specific challenges posed to the firm, second, some specifically derivable elements of what might be called 'environmental capabilities' can be developed. Among those, the ability to respond to the specific coherential tension caused by environmental issues, plays a pivotal role. Thus, third, it shall be focussed here on the hence eventually resulting need to include actors external to the firm into the learning processes of the firm and on the realization of the entailed organizational adjustments within the firm. Finally fourth, it shall be looked at how a so derived necessity of cooperation and networking 'fits' into, is related to and 'locates' itself within the existing forms, motivations, processes and outcomes of those networks, which have dominantly been discussed in the literature.

The Diffusion of Environmental Issues

For several decades now, in varying intensity and priority, environmental issues have been on the agenda of both, the ‘real-world economy’ and its actors such as policy makers, firms, etc.. as well as a field of research in economics, with the respective perceptions, rationalities and resulting activities being extremely heterogenous. In this part, however it shall be looked at elements and processes of this rise of environmental issues, which appear to be to a fairly broad extent generalizable and somewhat ‘inherent’ to them. They represent the context for the attempted widening of the understanding of networks between firms, triggered by the necessity of having to respond to ‘newly’ risen requirements concerning the environmental soundness of the firms activities and their results, i.e. its technologies in the broadest sense.

But how do environmental issues become a part of the firms selection environment? And how does the firm respond to these alterations? In order to investigate these questions, one could rephrase them and ask how actual or potential environmental hazards, which come into the perceptional range of the society, are transformed into ‘environmental knowledge’ and become eventually part of (and thus get ‘embedded’ into) the technological performance of firms. The catalyst converter, in this view, can be considered as a ‘response’ to the discovery of the hazardous impacts of Sulfurhydrogens. So it appears useful to depict a (yet highly stylized) ‘path’ of information (turning into knowledge) from an (analytically distinguished) ecological sphere into the soco-economic sphere, and within that in the technological performance resulting from the interplay of the actors within the latter.

Epistemological conditions: The fundamental role of encodation

In order to identify the main mechanisms underlying this process, some epistomological conditions, individual as well as collective, of these socio-cultural entities shall be outlined. Only some, which appear of particularly high importance for the perception of the ecological environment shall be mentioned here, while putting emphasis on the role of encodation in perception and transfer of knowledge and its simultaneous transformation, which turns out to play a pivotal role in this process.

For example, the way the view of nature is cognitively framed undergoes significant changes in time and social phenomena such as the projection of desires shape and distort the societal view on nature (all through history, nature has been for instance mystified, seen as the principal of a 'natural order' or 'reduced' merely to a pool of resources, etc.)[1]. Also, the nature of knowledge about the environment is controversial, ambigious and 'temporary'; consider for example early, mainly positive evaluations of what has been discovered already at the beginning of the 20th century as 'glasshouse effect', the antecedent of the greenhouse effect.[2] Finally, due to its fundamental importance to be elaborated in some greater length, encodation shall be introduced as an epistemological mechanism, considering the approaches by Luhmann[3] (mainly on the general level of society) and Arrow[4] (on the level of the individual firm). While the former emphasizes the functional differentiation of societal subsystems, which develop specific codes by which they communicate, Arrow - in anticipation of evolutionary concepts such as path-dependencies and routines - points towards the building of information channel structures within a firm in order to receive and internally transfer information from the rest of the world. The building of these channels is costly, so that the communication (and channel building) in similar codes is easier and thus leads to the emergence of rigidities in terms of the responsivesness to future changes.

In short, the principle possibility of drawing analogies between individual and organizational perception is stated, while the systemic interaction on the aggregated level of organizations lead to new emergent qualities. They can be described based on the concept of 'codes', which has been approached independent of each other, from sociology (Luhmann), strongly based on systems theory) and economics (Arrow), respectively.

Luhmann describes that in the course of socio-cultural evolution there has been a functional differentiation leading to the emergence of societal subsystems, necessarily going together with the setting of their boundaries and developing their own specific codes, by which the communication within the system and with its environment is ‚organized'. Examples are the legal system (different areas and procedures of

[1] See Hauser (1994), Pasche (1992), for a discussion of the (widely generalizable) underlying role of religious and cultural factors in the attitude of society towards nature see White (1962), (1967).
[2] See Martinez-Alier (1992), pp.45ff., Arrhenius (1903), Callendar (1938)
[3] See Luhmann (1986), also (1994)
[4] See Arrow (1974)

legislation), the political system (institutional structures and processes), the science system (various disciplines and research institutions), the educational system (various educational forms and depths of the imparting of knowledge), the economic system in the sense of business in providing goods and services (firms, customers, etc.), etc.

Codes are of fundamental importance since they – roughly spoken - decide about what is perceived of the systems environment and what is not. Most trivially, for instance, the subsystem ‚market' has developed the codes ‚price' or ‚monetary equivalent', scientific disciplines their own terminologies or theoretical frameworks, the legal system has developed the code ‚legal or illegal', etc.. This encodation provides some ‚manifestation' and via conditions for the adequacy of operations within the system that are set by the systems ‚programmes' the ‚concretization' to build on, that allows further differentiation and an increase of the systems complexity. However, and in our context somehow as the drawback of this phenomenon, by their described ‚encodation' the communication of the system with its surrounding systems is at the same time significantly *narrowed*, namely the systems perception is limited to information that is expressed in its code and by this to what lies within the scope of its ability to ‚recognize' developments beyond its boundaries. In consequence, environmental impacts of economic activity become problematic when the former does not lead to perturbations in the codes of the latter.

While Luhmanns approach comes from sociology, *Arrow*s starting point is from economics, yet eventually leading to a similar notion. In his very important, but – in my view – somewhat ‚forgotten' book ‚The Limits of Organization'[5], Arrow develops the notion of an ‚organizational agenda', based on the *information structure* of a firm, defined as the possibility to acquire relevant information in the future, departing from its role in the allocation of risk-bearing. The information structure is shaped by the existing *information channels*, which the firm posesses in order to receive signals from the rest of the world. Thus similar to Luhmanns point, he ends up analysing factors that lead to a narrowing of the perceptional scope of the organizational entity. Like each individual member, the organization has a ‚prior probability distribution over the space of possible signals'. The crucial factor that - in this view - determines the ‚trajectory' of this probability distribution – in other words its information channel structure – are *information costs*, which thus shape the organizations (varying) ‚sensitivity' towards (different kinds of) information. Unlike in statistical information theory, information is qualitative, and thus of differing value, benefits and costs. Without explicitly using the term, Arrow undoubtedly describes path-dependencies, by realizing the irreversible nature of the investment in information and that once a channel is developed, sticking to it is (or - more precise - appears) more beneficial and the reverse of the initial commitment becomes difficult. If signals shall be received the *respective codes* (i.e. channels), have to be learned (i.e. built). Hence, the costs are *not* uniform in different directions of their acquisition, the exploration of areas and the communicatin with others from areas with more *similar* codes becomes easier. Two fundamental conclusions are drawn for the organizations agenda: First, the channel structure of a firm heavily depends on random events, and second, the efficiency pursuit easily leads to rigidity and a decrease in responsiveness to future changes.

[5] See Arrow (1974)

Arrow uses the distinction of experiments (decisions of the collection of information) and terminal acts (concrete action) from statistical theory. He identifies *active* (an overweight of terminal acts based on earlier experiments), *monitored* (some experiments but yet not entailing further experiments or ‚new' terminal acts) and *passive* (no experiments) areas of the organizations attention, with the monitored areas as the ‚critical' ones, since those are the fields of its potenial changes. Monitoring can be stimulated by potential benefits or ‚coercive facts', i.e. crisis', and it entails the question for the efficiency of internal communication structures, since only a vast minority of the possible experiment based information is necessary for the efficiency of the terminal acts. By monitoring, the firm increases its sensitivity towards fluctuations from a particular area; but of course only to the degree the firm can intentionally define these areas of different behaviour. Despite his introduction of path-dependencies, it can be sensed in general that Arrow at least implicitly considers a higher degree of intentionality possible in the ‚choice' of a structure of information channels – based on cost-benefit considerations – than Luhmann does, who emphasizes the development of the respective codes in a more ‚self-organizing' manner.

Organizations can do more experiments (and more monitoring) than an individual can, but create at the same time higher coordination costs and the need for efficient internal communication structures. The latter point is particularly important since first only a vast minority of signals is eventually relevant for the terminal acts of the firm, and second, because organizations do describe heterogenous paths of internal specialization, thus leading to the emergence of various codes *within* the firm, which is also a higher degree of differentiation of this concept compared to Luhmann. This internal code variety is ambigious: 'externally' it increases the probability of (general) environmental changes to be within the firms 'perceptional range', internally it makes communication - and the transmission of stimuli to adapt to these changes - more difficult: in Arrows words, there is a 'greater ability to monitor, but a lesser abilty to change'.

Many elements of both approaches contain elements of what has been brought together in the seminal works of Nelson and Winter[6], but especially Arrows line of thought appear as an important (yet to my knowledge not at all sufficiently acknowledged) antecedent.

Main traits of the diffusion process

Based on these introduced concepts, some basic traits of the process how ecological issues become a part of the selection environment shall be outlined. Therefore, it now has to be looked at, which actors and which elements actually ‚guide' or at least ‚influence' the exploration of environmental impacts. Thus the emergence of the context, within which the development and implementation of technologies takes place, and thus within which firms act, shall be developed. In other words, although eventually carried out by firms (and thus subject to organizational processes and phenomena), for instance the production of a filter technology or of more fuel-efficient and less noisy jet-engines in the end they emerge because a much wider

[6] See Nelson/Winter (1977), (1982)

scope of societal groups and economic factors (e.g. research infrastructure, regulatory constraints, articulated complaints by residents subject to pollution, users, etc.) has included ecological criteria into their selection requirements.

The process might be basically described as follows. Environmental impacts only enter the socio-economic sphere if the related information (in systems theory vocabulary a 'fluctuation') is codified in a way, which is compatible with (at least) one societal subsystems code. Due to the diversity of codes by functional societal differentiation, the extent to which it becomes a part of the selection environment depends obviously on the degree to which it is actually transformed into the codes of the relevant actors. This happens via a deliberate or unintentional signalling to other societal systems in their respective codes and the so entailed diffusion.

Deliberate signalling of this kind could be for instance done by scientists, informing the public about health hazards of a pollutant (it would have entered the scientists system by confirming or not confirming a hypothesis, created phenomenologically or theoretically), for which it would make use in the most general sense some media (which in a sense and to a limited extent could be seen as serving as ‚code-translators' or at least as contributors to it), to describe them. It would *transform* e.g. equations of biocemical reactions into potential diseases. Depending on the codes, the same information may reach different societal groups in different ways. The societal group ‚family' would feel threatened in terms of their health, and would try to identify the origins of this threat and would start to raise pressures, which are by themselves again only perceived by those targeted groups if it is encoded appropriately. The societal group ‚insurance companies' would think of how it is affected financially by the consequences for the insurance benefits and premiums. Regulators would think of pressures for them as policy-makers (one code would be ‚keeping or being removed from their positions') and would integrate this into their decision-making process. Firms that cause the pollution would think of liabilities (code ‚degree of financial impact' or ‚image towards the public') towards employees, customers, local residents or regulators, etc.

In order to investigate this process of transformation and diffusion of ecological information further, the elements of the selection environment, which are involved in this process must be identified. Here, (out of numerous possibilities of such a structurization) three levels, which shall be labeled as *market actors*, *market constructs* and *market factors*, with an increasing degree of aggregation are distinguished, with one level in an emergent way building on the other. After having outlined above the principle mechanism, they will be only mentioned and not further elaborated here, in order to concentrate on the processes within the firm.

- Market actors are identified on a basic, ‚individual' level; main actors could be listed as follows:

- Actual and potential customers
- Regulators and governmental bodies
- Competing and cooperating firms
- Non-governmental institutions
- Academia
- Media

- Environmental stakeholders

- The interaction of these actors, i.e. the execution of their socio-economic roles, guided by their specifically developed bounded rationalities, gives rise to what shall be called here *market constructs*, with the use of this term stemming from the fact that those entities are ontologically much less clearly identifiable in their boundaries and determining factors compared to market actors:

- The legislative, regulatory and standard based framework
- Socio-cultural framework
- Prevailing scientific rationality
- Industrial networks, systems of innovation, economic infrastructure and externalities

- The overall institutional conditions set up by the interplay of these market constructs create some of the phenomena, called here in an admittedly arbitrary way *market factors*, which represent the highest degree of aggregation and e.g. determine the appropriability regimes, deciding about the share of the economic success which remains with the original innovator. Such factors influence the generative ability of firms (also in conjuntion with other actors) as well as the, so to say, general responsiveness and 'diffusability'; in a way the technological acceptance provided by the socio-economic environment:

- Appropriability factors
- Increasing returns of adoption
- ...

In summary, the underlying rationalities of the particular market actors are very complex conglomerates of a variety of underlying factors of preferences and situative factors, which can facilitate or impede the consideration and integration of environmental information. Thus the mentioned selectivity and distortions of ecological information are heavily shaped by the specific rationalities of the actors (aggregated and cumulated on the higehr levels in the sketched way) involved.

The process and the main elements involved are stylized in figure 1[7].

Challenges of Corporate Coherence from 'Environmental Capabilities'

Environmental capabilities and environmental routines

It shall be looked at now, how firms are affected by this process, since this determines the 'requirements' of how to build external relationships on environmental dimensions of the firms activities and performance as well as of the affection of the firms internal organization.

Capabilities might be described as the representation of the firms ability to perform functions, that are related to meet existing or potential requirements and demands posed by the selection environment. Capabilities represent the most visible part of the firms performance. The degree to which undertaking a flight is comfortable, safe or

[7] See Appendix for figures

environmentally sound for instance in terms of fuel effciency of the engines (note the intransparency for the consumers of many of the demanded criteria) is, although maybe only on average, tangible. Despite numerous other influencing factors that hinder the construction of simple causalities, this tangibility also leads, or at least contributes, to some sort of ultimate positive or negative sanctions in codes the firm understands (e.g. consumer complaints, drop or increase in ticket sales, etc.). What is much less visible, however, are the *underlying routines*. This invisibility not only holds for the perception by the customers, that pass as users through the various stages of the ‚performance', but also for the people who exercise them and also for the managment of the firm, that attempts to influence, design or redesign the routines. One could say, that capabilities represent the *traits* of the firms performance. They somehow show to which degree the intentions and efforts of the firm to achieve the establishment of a function have been realized and the degree to which those are actually reflected in the outcomes of the firms activities.

Here, it is suggested, that it contributes to the understanding of the hierarchical relationships and the diverse nature of routines, if one considers organisational capabilities as an emergent outcome of underlying routines on suborganizational levels, including the level of individual skills. Those underlying routines seem to show three basic intertwined dimensions. First, the type of routines can be described, which represents the execution of the corporate functions such as R&D, manufacturing, marketing, etc. (on one axis of a possible matrix) by organizational subunits (on the other axis). Those could be described as routines of performance *generation*. In the phone call case, an example would be marketing campaigning routines the type of media analysis, design of advertisement. A second type expresses the ‚results' of their interplay, i.e. those routines that *actually* represent the *performance*, i.e. routines that are phenotypically reflected in the capabilities; take as an example the organization and carrying out of service functions, billing, and maintenance services. A third type of routines could be then in this logic ‚*meta-routines*' in the sense it was put forward by Nelson and Winter[8], concerned with the strategic level, consisting of the development of the strategic set-up, e.g. decisions about alliances, choice of a new system of technology of data-transfer, compatibility decisions, etc.[9]

The nature of ecological information

The question has to be raised now, whether the building of resonance that is sensitive towards *ecological* changes of the environment is peculiar from others. There seem to

[8] See Nelson/Winter (1982)

[9] It shall be emphasized that routines can be behavioural *and* manifested in artefacts. The artefact is semantically embedded into the inherent potential behavioural context of its ergonomy. Furthering the logic behind this thought, routines and the degree manifestation of the knowledge which is stored within them, becomes somehow continuous. This ‚continuum' in this view spans varying degrees of ‚institutionalization' of routines, of which the weakest lies on the definitorial border to random behaviour and has the least degree of repetitiveness and of which the strongest has reached such a *high degree of repetitiveness* that the routines have been somehow ‚frozen' and embedded into artefacts.

be two main reasons entitled to justify such a thought, while the second builds on the first. The first lies in the peculiarities of ecological information *itself*. The second lies in the very specific way it qualitatively changes in the course of its societal diffusion, i.e. the characteristics of the information change substantially depending on the *stage* at which the information is perceived.

First, substantial difficulties stem from the particular *nature of environmental information*. As it might become clear from the briefly mentioned example for the case of the disputed and controversial effects of global warming (or even of the phenomenon of global warming itself), the above provided example of the pollutant is to a very high degree idealized. From the very beginning, environmental impacts have posed a challenge to the scientific community by their nature, since the statement of secured and reliable theories or regularities are *particularly* difficult. This is because they exceed conventional boundaries and understandings of

- time, here not only uncertainty concerning long-term effects but most fundamentally the limitations of curative approaches and thus implied *reversibility* of impacts of activities and technologies (e.g. long-term effects of biodiversity reduction, resource depletion, climate change, or geological time-scales concerning nuclear waste, etc.),
- environmental media (e.g. air pollutants are washed into the soil and groundwater)
- geography (e.g. global causality chains, problems of international externalities).
- scientific disciplines (e.g. blurring of the frontiers within and between natural and social sciences),

Undoubtedly, the overwhelming complexity, which is reflected in these issues adds to the already enormous complexity of ‚solely' socio-cultural developments a new dimension, raising new and high epistemological and cognitional (in terms of the bases for behavioural contingency) barriers to ecological issues, that are of fundamental socio-economic impact: These characteristics are basic reasons why the *codes of ecological information are particularly distant from socio-economic codes*. This is of fundamental consequence for the establishment of environmental capabilities.

Second, as we have seen, as one consequence of its nature, the ecological information changes its ‚shape', i.e. its encodation in the course of the described path. Thus the difference between the code of the firm varies during this path: it becomes less distant the more it is integrated into the socio-economic sphere, i.e. relevant environment of the firm. The information can enter the perceptional scope of the firm on basically any stage of the depicted path. As it will be further elaborated below, to a certain degree (and most importantly bounded to past experience and so determined present perceptional settings) the firm can ‚support' or actively seek or sensitivize itself for this information.

This second reason, the qualitative evolution of the ecological information – due to its peculiarities – will be the main building block of the line of thought in the further analysis of environmental capabilities. Since the perception of the ecological information can happen on different stages and is connected to specific risks and opportunities, what is introduced now as *‚possible stages of resonance focus'* represents at the same time a matter of strategic ‚choice', which is *particularly*

entailed by the emergence of environmental capabilities. It is at the same time a condition for the building of resonance ability.

If it is considered that the existience of a process describing the path of ecological information is at least in an idealized way known to the firm and became part of strategic considerations (which requires in a preceding step a resonance ability of its own), then it can focus on different stages of this path. It is claimed that the earlier the stage is at which the firm sets in, the more *difficult* it becomes to ‚perceive' *and* to ‚understand' the ecological information.

As done in figure 2[10], it is possible to outline a stylized increase in the penetration of the socio-economic sphere by an ecological issue in time, marked by a common sequence of observable stages during the rise of an ecological issue. After first incidents draw attention of some ‚early adopters' (e.g. directly affected groups or for instance intuitively anticipating – and thus pioneering – often earlier ‚condescendingly smiled at' environmentalists and scientists) to the underlying ecological processes, they are further scientifically investigated and diffuse through the scientific community by journals, conferences, etc.. Partly by the increase of a societal attention shift to these impacts, partly by their natural intensification in time the (perceived) scale of their hazardous effects become more major, bringing it to the interest, awareness (and concerns) of broader layers of society, reflected e.g. in mass media. By this it becomes part of the political agenda, especially since previous legislative or regulatory frameworks often turn out to consider the issue only insufficiently. In the long term consumer (and firm) behaviour is altered and regulatory actions follow.

In the light of the question of the conditions under which ecological information enters the firm, it becomes clear, that in the first case the relatively ‚pure' ecological information is encoded very ‚distantly' to the existing codes of the firm. It becomes less distant, if the firm focusses on the second and the third possibility, and within this option, the distance becomes smaller, the later the stage is, that is considered of the transfer process. This is due to the fact that this transfer, i.e. the diffusion of ecological information into the socio-economic sphere is at the same time the process of a ‚*translation*' of the ecological information. It entails a translation of scientific-ecological codes that are relatively distant, into the ones the firm is traditionally sensitive towards, i.e. into the socio-economic codes or into codes that are closer to them (buy or not buy, penalization by regulators, etc.).

Admittedly, this is a highly stylized pattern. The sequence might be different, and the time scale of the particular diffusion phases may be vastly different, depending on many factors, e.g. the tangibility of the hazards, the strength and fierceness of disasters, the estimated time scale of their manifestation, etc. Of course, their spatial location and the extremely complicated interaction with the specific *institutional context* they diffuse into is also a crucial factor that restricts attempts of a ‚generalization' of such patterns. For instance leaking oil pipelines are institutionally approached differently in Russia compared to Scandinavia. The extreme diversity of what an ecological issue is, serves also as a main obstacle for – ambitious – attempts to derive even ‚stylized facts' in such an analysis.

[10] See Appendix for figures

Possible stages of resonance focus

However, even if the shape of the diffusion curve varies, maybe even specifically for *each* issue related to ecological information, it seems justifiable to claim that in principle *three broad strategic options* exist of the stage of this diffusion process the firm can focus on for every ecological issue. This is untouched by the fact that not every issue becomes eventually institutionally established; some issues might fade away at any stage of the diffusion process.

- The *first* possibility for the firm would be to focus on developments directly within the ecological sphere, or on the direct ecological impacts, *before, during* or *early after* they have actually entered the socio-economic environment. In this case, the gradual exploration of inherent environmental impacts is no longer up only to the actors of the socio-economic environment, but would be carried forward also by the firm itself. For instance, the life-cycle analysis, which will be elaborated further below, is a tool to grasp the direct ecological impacts of corporate activities, or the participation or use of environmental information systems, such as monitoring or control networks, or substantial research links with academia and NGOs.

- A *second* option would be to focus on the ongoing process of transfer: The firm can try to sensitivize itself for indicators which are located already within the socio-economic sphere, but *before* the transfer into (entirely) economic codes has been ‚finished', for instance by the emergence of reports about ecological and/or health hazards of sulfur-oxydes in media. The firm can try to derive for instance empirically stylized patterns how this transfer takes its course in order to be able to predict more precisely.

- A *third* possibility would be to focus on the end of this process: The ecological information can also be considered only by the limitation of the attention to the outcomes of the transfer and thus on the actors of the selection environment, and the way they have transfered the information into selection-relevant institutions. For example on the articulation of changes in preferences by customers towards the desire for a decrease of this pollution, e.g. by prefering vehicles with lower emissions. An example involving the regulators would be the transfer of this pressure into regulations concerning emission limits or the compulsory use of a catalytic converter, or also for instance liability regulations concerning health or ecological hazards.

Thus, the 'understandability' of the information for the firm increases in the course of the process of the societal integration of environmental impacts. The more the information is integrated into the socio-economic selection environment, the more likely it is that the information enters the firm, or that it is perceived by the firm. In turn, the ‚earlier' the firm wants to apply its sensitivization, the more efforts it must undertake in order to make it understandable in its own codes. This points towards the notion, that not only the understandability increases, but also the transparency about *how the ecological information is likely to affect the firm economically*, thus about how the outcome of the translation process will look like. Thus the quality of the prediction how e.g. the emission of sulfur-oxyde will affect sales, technological standards, corporate image, the relationship to suppliers, the attitudes and strategies of

competitors etc, *increases* the *further* it has been integrated and, in turn, *decreases* the *earlier* the process is considered. With the uncertainty, of course, the costs rise significantly. Abstractly spoken, new modes for the translation of the codes have to be developed.

At the same time, however, earlier anticipation not only entails fundamental uncertainties and costs but also fundamental opportunities and potential cost-reductions. The technological and managerial shifts that are implied as necessary in response to the ecologically altered selection environment, such as compliance with technological standards, require time and involve significant costs as well. If the firm ‚waits' until the transfer process is finished, or in other words, if the knowledge ecological alteration of selection criteria enters the firm only at the *very* end of the societal integration process, then three main cosequences occur:

- *First*, the time span to react to the changes is smaller, leading to higher shifting costs and also e.g. to possible questions of principle technical feasibility.

- *Second*, the opportunities to influence the integration process are reduced. Information asymmetries between regulators and industry often enables to influence the specific shape of regulation concerning standards or the time limits of their achievement (or e.g. even prevent it by voluntary agreements), also the information policy of the firm can influence public attitudes and (e.g. buying) behaviour and reduce (or change) pressures on regulators.

- *Third*, among the competitors there will be heterogenity concerning the stage each company focusses on. Thus firms can lose discretionary action-space because of ‚earlier-focussing' competitors with e.g. ‚standard-determining' or ‚critical' market share gaining activites.

Thus the ‚beneficiancy' of the alternatives has to be specified from case to case and is not derivable theoretically. Thus the – in environmental application even more so – very complex question of such ‚first-mover advantages' or disadvantages in the here described sense can only be decided from case to case.[11] Examples may be found for the reasonableness of each strategy. Again, like at all steps of our line of thought, there is further need for specifications by empirical research in this area. Obviously, the potential ‚costs' of a late shift have to be balanced somehow with the costs of efforts for measures that are connected with an earlier focus, such as monitoring, eco-information systems, prediction, etc.

Remaining in the logic introduced of the path of ecological information, hence two main areas exist, where an *early* focus can set in.

First, the earliest alternative possible way of doing so is to try and seize ecological impacts of corporate activities right at the point and time of their emergence, i.e. at the physical boundary of the firm. Obviously, any attempt to identify even only nearly all influences is an impossible task. The basic question is whether the organizational

[11] See for one of the few good discussions of specific first-mover advantages Nehrt (1996)

attention in that respect overlaps with what is (or will eventually turn out later as) ‚relevant', i.e. in our sense later potentially economically relevant for the firm.

The *second* possibility of early focus lies in the cooperation with other actors, which are involved at earlier stages of the translation process. Research cooperations with academic labs, other firms, may they be competitors, non-competitively horizontally or vertically related or (very important) consultancies as well as with NGO's appear in our context as means of anticipation and exploration of the path of ecological information. The entire networking approach, the growing interest and research in cooperative behaviour, (and wider of industrial networks and innovation systems) is relevant here, gaining new analytical dimensions through the cooperation of institutions from the viewpoint of their (varying) positions in the translation process. Like the choice of the ‚right' fields of what impacts shall be ‚searched for' in the LCA, the decisions about environment-related cooperation and such cooperative behaviour itself and independent of the exact stage on which the firms resonance comes into effect, it is important to state that these abilities require *specific*, i.e. *environmental* capabilities, which are themselves *routine-based* and subject to every characteristic that comes with this (such as path-dependence, etc.).

The challenges to corporate coherence

In the context of this paper, all these strategies eventually seek an appropriate alteration of the firms capability structure towrds higher environmental soundness. Thus they are a mean in order to get new, 'greener' routines and capabilities established.

Due to the tenacity of routines, not only in their functional performance, but bounded to this fact *also* in the acqusition and interpretation of external information and knowledge as a fundament for learning and capability building, there is a twofold coherential challenge appearing: not only the actual capability as it is 'established', but also the required 'unhabited' and overcritically 'context-varying' focus of attention and learning. They lead to a twofold motivation and trigger the building of external relationships and networks not only with other firms, but with literally all other actors of the socio-economic environment.

The above depicted line of thought should illustrate that considering the code-discussion, there might be 'specifically' environment-grounded motives for this behaviour. Even more so, because firms scope in terms of the range of their capabilities turns out to be not unlimitedly expandable; rather, one can observe a quite high degree of 'coherence' within a firm. The overall set of routines – or, on the phenotypical trait level, of capabilities – of a firm shows phenomenologically a variety, which is always limited in the range of functional performance they produce with a certain degree of *similarity* in their substance. This leads to the important concept of corporate *coherence*, which is also underlying the equally important question of the ‚boundaries of the firm'.[12] There are hardly single product firms, but the observable diversification is only within a certain range, thus shows relatively high

[12] For a seminal discussion see Teece et al. (1994)

coherence, while as Teece et al. put it[13], coherence means the relatedness of lines of business in the sense that there are certain technological and market characteristics common to them. The authors carry out a main distinction between organizational-administrative and technological-productive capabilities. Also they outline a sort of taxonomy of firms, based on criteria such as learning patterns, selection, path-dependencies, opportunities and inherited complementary assets, distinguishing so-called special firms, vertically integrated firms, coherent diversifiers, conglomerates, network firms and hollow firms. The last one for instance has 'externalised' almost all of its capabilities, and can only survive if it develops certain 'glueing' capabilities. This extreme case at the 'end of the spectrum' sheds a light to potential problems, when firms which traditionally have domains and core competences in other areas are confronted with environmental requirements.

Generally, the introduction of environmental capabilities represents an interesting case in this respect. Irrespective of their specificity, the need to develop them exists cross- and intrasectorally, so that firms with partly extremely differing diverse set-ups and locations of ‚traditional' capabilities are confronted with these requirements and challenges, which puts them in a more or less suitable ‚disposition' to incorporate them. At the same time, one has to ask now, to which degree and in which way the *existing* or prevailing coherence is endangered and challenged by the necessity to develop greener capabilities, i.e. in which cases does the ‚span' of capabilities become too broad in that respect? When does the ‚stretch' become to ‚wide'? And what consequences are derivable for cooperation and integration and thus for the 'boundaries' of the firm? These questions are highly relevant, because for instance in the case of environmental regulation, a pattern of a ‚required capability structure' is very likely to arise, which as an imperative implies the ‚complementation' of the prevailing routine structure (may it lead eventually to a total replacement of the existing routines or not) by relatively distant routines, one set representing the traditional functional and one set the new, environmentally more sound routines, so that both sets have to ‚coexist' at the same time, creating coherential tensions.

One could distinguish now on several dimensions characteristics of such new routines and capabilities, such as first, their actual environmental efficiency in terms of reduced impact, second, where it is located within the processes and products of the firm (i.e. to what degree it is integrated technologically) or third, the degree of their technological maturity. The first two do not seem to be suitable to serve as criteria to understand the coherential challenge and thus the need to get externally engaged.

Concerning the first, obviously, different kinds of new 'greener' routines are likely to affect the firms coherence to varying extents. Their categorization yet is difficult, due to the numerous ways and vast differences in the possible degrees to improve environmental performance. Yet, what can be stated safely is that the actual improvement or impact-reduction, so to speak the environmental 'step-length', does not allow any generalizations or indication concerning the coherential effects.[14]

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[13] ibid, p.2

[14] It should be said, that it would be a fallacy to believe that the degree of actual scientific environmental improvement, i.e. the environmental efficiency, would *necessarily* correlate (positively) with the affection, i.e. a challenge of corporate coherence. In other words, there might be a lot of imaginable cases, where only relatively small alterations of the previous

The second point is concerned with the question of how early the environmentally hazardous impacts are either prevented or reduced in the process of their emergence during the execution of technological performance. This relates to the in the literature common distinction of between so-called ‚end of the pipe' solutions (‚cleaning up technologies')[15] on the one side and more (technologically) ‚integrated' or DFE (Design for Environment) solutions (or ‚cleaner technologies')[16] on the other. In the former, environmentally hazardous impacts of technological processes that have *already* emerged are ‚cleaned up', or more precisely, are prevented from leaving the boundaries of the (involved) firm(s), while in the latter, their *emergence* is (to which degree ever) prevented.

Because of some confusion about these terms, the technological integratedness deserves some further important elaboration. Three points seem most critical. *First*, this distinction spans more a *continuum* between two ‚extremes' rather than representing two discrete cases. Many intermediate solutions are imaginable. *Second*, and maybe most importantly, new environmental technologies – as a result of the execution of environmental capabilities – can have such differing degrees of technological integratedness on *any* stage of the generation of produts and services; in other words at *any* of the life cycle phases. There can be end-of the pipe *or* integrated solutions on the stage of raw material extraction, as well as of manufacturing or of usage or disposal. Thus, the integratedness of a technology does *not* increase with ‚going back along the life cycle phases'. An environmental routine where impact is prevented on the process stage is not necessarily more integrated than a routine, which does so at the stage of consumption. The *third* concern here is the discomfort with the often put forward, more or less explicit, normative categorization of ‚good' for integrated and ‚bad' for end-of-the-pipe solutions. Although there are undoubtedly several factors that often make the former more desirable, such as for example the irreversible (or only partly reversible) nature of environmental impacts (see above) and the resulting sheer impossibility of ‚repairing' the hazard or the often observable sole shift of environmental impacts (e.g. to the filters) rather than their ‚cleaning', cases are nevertheless imaginable where eop-solutions are economically ‚superior', and may have some important inducing effects for further improvements.

Thus both characteristics of new greener routines coherential impacts are only to a limited degree derivable. Yet the third point appears to give more reliable guidance. Those new ‚pieces' of knowledge, developed by the disturbance caused in the course of the ecological information in the broadest sense, are not only developed at different stages of the translation process but exist in shapes that vary in terms of the *concreteness* of the derivable new solutions, so that new ‚greener' options exist at various degrees of scientific and technological maturity which are perceived by the firm. There might be for example only relatively vague imaginations about possible (maybe competing) technological configurations how to decrease its amount or new solutions that are already existing in a mature and experience-bearing shape. New

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behavioural patterns, already achieving the (for instance by regulation or consumer pressure) required increase in environmental soundness. But in those cases, where distant solutions have to be established, the coherential tension is high.

[15] For an overview see Skea (1995)

[16] See for example Billatos/Basaly (1997), Kirwood/Longley (1995)

technologies and routines might be already developed for instance in research labs or implemented by other firms. The degrees of maturity of this new routine in terms of its previous manifestation, however, can vary significantly:

- A high degree of maturity would exist in the identification of a new capability, represented for instance in a new technology or, for instance standard based modifications of existing ones with relatively clear specifications, for example filter technologies, CFC-substitutes, catalytic converters and the modified technologies for their use, etc.

- A lower degree of maturity would be the case if only the ‚direction of change' in the shape of certain environmental criteria or requirements are given and no specific routines or capabilities could be yet identified; for instance in cases of knowledge that has been developed in academic research, but that has not yet been technologically implemented, or only so in premature prototypes or small scales.

Put another way, the problem of maturity reflects the question to which degree the new knowledge has been already ‚transformed' to actual, operationalised procedures in terms of capabilities, or an a lower level of emergent aggregation, which are an emergent result of the interaction of new ‚greener' routines in the above introduced sense.

There is an important parallel to the discussion of the maturity of technologies and its relation to the question of whether a firm should acquire technologies externally or build the respective capability itself put forward by Teece[17]. In a very simplified way one could say that he claims that in House development is more favourable, the less mature (or also in a way preparadigmatic) a technology is. Yet, as said, if this new technology is distant in its required technological and managerial capabilites, coherential tensions are widely inevitable.

The Network Dimension of 'Environmental Capabilities' in the Light of Industrial Districts

Which could be potential ways, in which these foundations might enrich the recently remerged discussion of industrial districts[18] and the manifold 'extensions' and variations this concept has been subject to, beyond the already hinted ways? In the broadest sense, maybe one could formulate that the above derived needs for cooperation fall into the category of 'positive externalities'. But this appears although true much too broad, since more elaborated and deeper conclusions appear possible. Yet, there should be no doubt about the fact, that the bulk of literature and numerous workshops on the concept of industrial districts should not divert from the fact that severe and most basic ontological problems have not been resolved yet. Thus the applications of this apparently not very thoroughly understood underlying overall concept should always also serve as a possible source to overcome these lacunae.

[17] See Teece (1996)
[18] See for a very precise and thorough discussion Loasby (1998)

Industrial Districts and Innovation Systems

Natural settings, the former 'patronage of a court', the emergence of a large pool of skilled labour force, partly related to this the settlement of immigrants and also a good deal of chance combined with agglomeration effects belong to the initial causes of the emergence of Marshallian industrial districts.[19] The viability of the district is mainly determined by factors such as spatial proximity, and stemming from this (not necessarily but sufficiently) mutual knowledge and trust, which itself generates the famous 'industrial atmosphere'[20] and also by the existence of economics of the division of labour, while the latter are thus 'extended' beyond one firms legal boundaries up to these regional clusters. In regional clusters of many small firms, ideas and a mutual cooperative spirit is 'in the air'[21], in the exchange of highly skilled members thoughts are taken up and carried forward by others leading to innovative progress[22], while some sort of feeling of commitment towards the district by its members (sometimes even more than to its own firm) is developed. What makes this concept so phenomenologically unique and original (and so contemporary) appears to be above all the fact that what is exchanged and what is flowing between the participants is knowledge, which is so different from 'unidimensional' units such as prices in traditional economic models. The theoretical investigation of this phenomenon show somewhat a 'gap' in intensity after Marshall, with only a few scholars, such as Weber[23] (location theory), Christaller[24], Lösch[25] (the latter two developing the famous concept of hexagonal honeycombs) and Perroux[26] (developing the idea of 'growth poles') keeping interest in the subject, until the emergence of the discussion of the the Silicon Valley and Route 128 areas, which yet have some specifics, such as the lack of manufacturing tradition and of at least some state-guaranteed security, but mainly of the so-called and quite unique 'Third Italy'-districts[27], to which the above made differences not apply and which thus maybe come closest to the original districts of Sheffield and Solingen given by Marshall[28], (yet having like Silicon Valley the existence of venture capital providing institutions as an important difference).

Yet, despite the striking similarity of for example the Third Italy districts at the Emilia Romagna, an extension of this traditional concept is – obviously at the age of transnational corporations and microelectronic revolution – inevitable. There are myriads of networks of most various kinds, with widest forms of cooperation (and configurations of firms external organizations). The empirical observations of firms behavior in this respect have shifted the phenomena related to the relationships between firms – as Richardson[29] puts it – which lie somewhere between integration

[19] See Marshall (1961), pp.268ff.
[20] See ibid., p.205, also among the huge bulk of literature for example Bellandi (1990), p.143
[21] Marshall (1961), p.281
[22] See ibid.
[23] See Weber (1909)
[24] See Christaller (1933)
[25] See Lösch (1954)
[26] See Perroux (1948)
[27] See for instance Piore/Sabel (1984), Brusco (1992), Maillat (1998), Brusco (1982) (for Emilia Romagna), Amin (1994) (for the Veneto)
[28] See Marshall (1927), pp.285ff.
[29] See Richardson (1972)

and market transaction into the center of attention. Still, it seems that industrial districts and the entailed phenomena lie still at the core of these considerations. They lie even at the very core concerning the by far observable failure of cost arguments in explaining exhaustively cooperations, in their motivation, the emerging processes as well as phenomenological and organizational outcomes. Hence, the question should be more, to which degree industrial districts bear generalizable, 'universal' traits and how they are related to other, 'extended' forms.

Here it shall be focussed especially on the integration of an a little more recently developed another line of research, which has developed towards what can be subsumed under 'systems of innovation', most prominently looking at the innovative performance of overall socio-economic systems on the national geographical scale[30], but also regional (into which industrial districts could very well fit) as well as supranational are distinguished.[31]

To approach industrial districts in the context of this paper, it is of interest how national systems of innovation relate to the original concept of industrial districts.

- The before mentioned scholars and districts observed all bear the characteristic of spatial proximity. Obviously a distinction in regional, national and supranational is also spatial, but no longer in the sense of the original concept. Thus the spatial dimension is extended, the analytical integration of a larger number institutions involved necessarily carries the influencing factors of the firms behaviour becoming ‚spatially unbounded' as knowledge flows generally are. In consequence this ‚de-spatialization' has accelerated with information and communication technologies and the generally higher ‚common availability' of knowledge (note that this takes nothing from the importance and characteristics of tacit elements of knowledge). Beyond regional agglomeration and its economic traits such as described by Marshall, the direct geographical accordance of the impact range of legislative frameworks with national borders and the resulting incentive structure has brought the geographical ‚aggregation level' of the nation into the focus of attention of innovation systems research. Yet, it seems important to emphasize that although the national level has and will sustain specific importance, that what is meant and what is seeked explanation is often not limited to (politically defined) nations. In the heart of the approach lies more the interplay of actors and institutions and patterns of its development that is more generally applicable, so that the national level of spatial aggregation seems sometimes even arbitrary and does not necessarily overlap neatly with the boundaries of innovation systems.

- Also the range of the elements ‚themselves' that are considered as relevant is broadened, from the almost equally sized horizontally linked firm to vertical inter-firm cooperation, up to 'districts with very unequally sized firms, such as in so called hub-and-spoke-districts[32], where for instance like in the german federal state of Baden-Württemberg one large firm as the hub (DaimlerChrysler) has attracted a large number

[30] Within the rapidly grown literature see for instance Nelson (1988), (1993), Lundvall (1988), (1992), Freeman (1988), (1995), Freeman/Soete (1997), Porter (1990), Patel and Pavitt (1994)
[31] see for example Archibugi/Michie (1997a), (1997b), Cantwell (1997)
[32] For an illustrating example from Brazil see Meyer-Stahmer (1998)

of small supplying firms around it. Also, most importantly, the relationships to other actors than firms have shifted into the focus of attention, mainly the inclusion of governmental and non governmental bodies and academia. The latter is symbolized with the rapidly intensifying ties first via the connection of the development of R&D departments in firms[33] and the crucial question of the responsiveness of academia for the needs of the industry and second its principally doublefold role as ‚leader' *and* ‚follower' of technological trajectories[34], illustrating the co-evolutionary and thus non-linear nature of the processes within National Innovation Systems.

How can the environmental discussion of the previous parts be related to the so extended and 'updated', and here necessarily only very shortly outlined concepts? From the firm-based viewpoint taken here, the mutual *complementary* relevance of the outlined process of the diffusion of environmental knowledge through the selection environment and the firms response for the (classic as well as extended) district concept appears on several stages.

1. In those cases where a timely perception of environmental issues would be required (note the discussion about benefits and risks from early anticipation above, especially the argument of influencing processes of standard setting and gaining of critical market shares), the 'sensorical narrowing' through the technological inertia, basically because of the traits of the underlying routines and the cumulativeness and path-dependency of capabilities, hinder the perception of distantly, bio-physically encoded information, especially at early stages of the in figure 1 described diffusion process. New greener routines usually require the *particularly* strong shift of at least one of the routinal perception scopes, either managerial, organisational or technological. Thus the firm is confronted with the need to develop a *particularly* high, scope based flexibility. In order to fulfil the perceptional precondition for innovating in the environmental field, so to speak in order to create terminal acts in the Arrow sense, the corporate information system must undergo a ‚greening': the fields of monitoring and in consequence information channels have to be shifted towards environmentally relevant alterations of the selection environments. Dimensions normally out of the perceptional scope of the firm have to pave their way on the organizational agenda. The collaboration with other actors thus represent an essential part of environmental capabilities, they exist when the firm is able to establish the cooperation and network building with market actors of *particularly* distant and fundamentally different areas (in which their capabilities reside) in order to make up for this perceptional deficit, entailing the need for *different* modes of exchanging *knowledge* as well as goods and services. These can for example be a cooperation with environmental agencies or academic institutions, which are asked to investigate possible hazardous impacts, such as in areas which previously have been considered as not problematic, of new and existing products and process, or as another instance supporting institutions in monitoring efforts concerning the public discussion about societal affection for example by pollutants involved in the technological performance. This goes beyond the traditional concept of districts, since here not the classic argument of established economics of specialization (within a firms traditional scope of capabilities) drive the beneficiancy of being in a district. Rather, it is a broadening of managerial,

[33] See Freeman/Soete (1997)
[34] See Nelson (1993)

organizational and technological scope of perception, ideally leading to a move of the firms codes, i.e. of its routines on different levels of aggregation.

2. If it is then now considered, that indeed issues have come to the attention of the firm, again especially at early stages, the uncertainty about how this will economically affect the firm leads again to a necessity to build and to align external relationships with other market actors, what can be basically subsumed under the term of 'collective learning'.[35] In case the potentially required technologies are at an immature stage, then as mentioned above, an in-house development, so to say a 'build not buy' of these capabilities is to a certain degree an imperative.[36] Yet, as said, doing this with environmental capabilities is likely to add a further, maybe overcritical, coherential tension to the firms prevailing structure, i.e. it might be outside the firms scope, so it has to be externalized, for instance to consultancies. This constellation, however, which shows a basically code-distance caused location of capability building processes external to the firm where they actually should be rather be located inside the firm leads to specific learning dilemmas. This is because an inclusion of actors *external* to the firm bears fundamental problems of *appropriating the generated knowledge* for a firm, especially in those cases where this cooperation is of the type of contracting and contracted firms, such as for example a firm contracting another firm with specific environmental expertise and capabilities (e.g. an environmental consultancy) for carrying out an eco-balance. Obviously, a good deal of the gained knowledge and experience is allocated to the contracted firm. In the case of tangible and easily transferable knowledge, which can be interpreted as relevant (here the operationalized impacts in the shape of the 'balance sheet' itself), this is unproblematic. The decisive point lies rather in significant problems with first, the gained knowledge, which is tangible, but would disclose its value only in the context of the 'contracting' firm and thus appears ‚useless' to the external 'contracted' firm and seeps away and second, the often intangible and hardly transferable spill-overs in knowledge and experience emerging *during the process of its preparation*, which would represent a major source for innovation stimuli.

The overall ‚information-pool' – and thus an essential source for capability building - that emerges in the course of environmental management activities thus *remains at the external* (specialized) e.g. consultant or governmental body. However, some measures seem imaginable to reduce these drawbacks of externalization and internalize and enable ‚environmental learning' to happen inside the company, such as, first, measures of participation (of the deciding firm), like critical accompanying, joint objective- motivation- and evaluation-workshops or 'milestone-presentations', or, second, an internalization of parts of the balancing after external screening and instrumental (external support) or sector-oriented pre-balancing with modular (and thus partly internalizable) structure. Yet, the 'externalization dilemma' in this sense appears – beside the problem of scientific information validity and the different nature of ecological information – as a fundamental problem not only of the implementation of for example eco-balances, but also of the concept of collaboration of the 'contractor-kind' in general; this holds for relatively immature goods and services in general provided by other firms or the (rapidly growing) sepcialised sector of suppliers

[35] See also Aggieri (1999)
[36] See Teece (1996)

of environmental goods and services.[37] Despite the emphasis on the learning and appropriation aspects, it has to be also considered that those contracted services often represent an enormous cost factor; e.g. only very few firms can afford company-wide eco balances.

Here emerges an important reference to the question of spatial proximity. It lies in the notion that despite all globalization tendencies and the rise of information and communication technologies with the entailed possibilities of knowledge transfer, in cases like the described learning dilemma, spatial proximity can *very well* crucially matter, since it turns out to be a required condition to implement these smoothening factors in order to reduce this dilemma and to achieve a higher appropriation of learning effects. However, it seems reasonable to argue that due to the enormous complexity of the potentially relevant impacts and of the diffusion paths of environmental knowledge, even with a higher degree appropriation the need for this kind of building of districts is not very probable to disappear. A formal acquistion and inclusion into the formal legal structure of the firm is unlikely to take away much of the problem, since the code diversity would be still given.[38] In contrary, since the formerly independent institution would be affected by the firms competence structure, its objectivity would suffer and thus the span of which distance can be overcome terms of codes would be significanltly reduced.[39]

3. This leads to another, concluding point of relevance, where it shall be turned to how the observable 'pathologies' of industrial districts relate to the so outlined environmental collaboration. Concerning the former, it can be observed, that with the emergence of a district, conformity concerning the way the exchange of knowledge is arranged develops and the increasing specialization leaves less and less room for newcomers and substantial rearrangements. One could maybe formulate that a kind of an increasingly strong 'institutional paradigm' is established (in the sense of 'which questions are asked'), which entails this 'sklerosis' and makes the district extremely vulnerable towards changes in the external conditions. Despite (and not contradicting) strong empirical evidence that indeed success bears almost inevitably the nucleus of failure inside, still it shouldn't be overseen, that this effect not only is weakened by the by definition generally very well working lines of communication and intellectual exchange and agility as well as the 'open-mindedness' in approaching ideas as a *rule*, which in its application does not have to be limited to the prevailing range of capabilities. The pathological 'disposition' also crucially depends on the *nature* of the district, especially on the *participating firms and other actors*, and this is the point, where the relevance of an environmental analysis comes into consideration. In the first point of this part above the case of a 'code-enrichment' within a district through the presence of entities with 'more bio-physical codes', might overcome such a sklerosis, at least concerning changes of this respective ecological dimension of the selection environment. It is seen though, that their 'introduction' might be just the

[37] See for an overview OECD (1996)

[38] Note the similarity to often problematic co-existence of very different 'cultures' for instance between departments within firms. Take the example of the R&D lab of Xerox and the executive management, which were spatially far (California and East Coast, respectively), where the latter refused to pursue and capitalize on the Graphical User Interface, when presented to them by the former (and which was later taken up by Apple)

[39] Also consider the argument of hazardous effects on productivitiy by an integration of 'too different' production processes brought forward by Richardson (1972)

tricky part and obstacled by these very pathologies. Still, however, those entities, such as environmental supplier firms, consultants, agencies or NGOs might broaden the corridor of responsiveness towards changes in external requirements and somewhat open up.

In taking up this thought, it was considered in 2., that under some appropriation conditions, such as moderation, which requires some intimate long-term collaboration and thus proximity, firms realize environmental improvements, tackling the inherent coherential challenges.

It is now interesting to realize that even such a shift in the firms capability structure towards higher environmental soundness might lead to another specific pathology in its own right, i.e. one can now think about to which degree this process is 'sustainable' (using the term here not in an ecological sense). Inertia and the resulting unequality in the probability distribution in the range of the future realizable options are constitutive properties of routines. By the ‚choice' – or, less intentional realization – of one technological solution, one degree of reduction of environmental impacts is ‚prefered' – or, less intentional, realized – to another higher or lower degree connected with the *not* and *in the future less likely to be realized* options. Also, the considered constellation leaves the concerned firms relatively much discretionary action space, also about the degree to which it indeed follows and implements the paths of learning potentially opened by the actors with more distant codes.

These facts become especially interesting as soon as the (common, but not necessary) case is considered, at which a long terms constant increase of the requirements form the selection environment concerning the environmental soundness of the firms performance is assumed, and options of the kind exist, where a *lower decrease* in environmental impact (thus the one that is likely to become inadequate in terms of selection requirements earlier) represents the one that is relatively *closer* to the existing routine scopes. In this case, this long term *in*adequate option is more likely to be realized. It may emerge a kind of ‚subsidy effect' observable at ‚over-matured industries' that prolongue their existence and impede structural change. Many of the efficiency increasing measures, i.e. in the sense of the increase of the efficiency of the *existing* routines, which appear *prima facie* as reasonable, belong to the category of options with the relatively lower decrease of environmental impacts. An example is the voluntary agreement of some German car companies to develop cars with a reduced fuel consumption of three liters in average. There *is* a reduction of environmental impacts, but not as much as it would be e.g. at fuel-cell based electrically powered cars, which would represent one of the options more far away from existing routines and that becomes more unlikely in realization. The option of the voluntary agreement realizes those new routines that lie close to the previous ones. By this, two effects are entailed: The realized greening turns out to be insufficient in matching the requirements relatively early (in the car example, the lowered consumption of single vehicles will be offset by a larger number of vehicles, leading even to the continuation of an absolute increase in emissions) *and* the probability of the distant option(s) to be realized is considerably lowered. This point is not only of fundamental managerial but also of policy importance.

Above all, it illustrates the importance of 'governing' institutions, in both, may it be governmental bodies as participating actors or legislative activities, i.e. regulation, where the strict regulations of California serve as the counterexample to the described German institutional setting.[40] But of course, remembering the diffusion path of ecological information, but especially the very nature of learning processes which are uncertain and unpredictable prevents jumping on the conclusion that regulatory activities can set neatly the pace and the steplength of the outcomes of the districts activities and thus overcome this pathology. It shows rather that the participation of such institutions has to be very well balanced and integral part of the collective learning process.

Through their different encodation, both might - yet under all the at least hinted constraints, limitations and conditions - complement those, often by their nature 'leading' firms, which take the reflective and 'philosophical' role in districts, which are so vital for their survival[41], and might open new ways to strengthen the viability of the district.

Conclusion

The main claim of this paper is twofold. First, in the light of the depicted diffusion path of environmental knowledge and the entailed challenges for the firm in terms of both, an early anticipation (which is 'desired' under certain conditions) and integration of environmental knowledge as well as of coherential tensions, industrial districts may serve as condensed platforms of a faciliated code-translation for firms, so that it can bridge the ‘distances’ in encodation between prevailing capability structures and actual or potential (sets of) new routines and capabilities, while enabling it to cope with otherwise reinforced problems concerning the setting of its boundaries. Second, it appears resonable to say that distantly encoded participants and so framing institutions might well affect and contribute to the viability of industrial districts, while the concept being significantly extended from the originial Marshallian concept along several dimensions, in terms of the spatial boundedness and most importantly of the participating actors.

At many points raised, the discussion only could stir up some points, partly because relative to the dimension of this paper, already a very broad scope of points had to be integrated to attempt an illustration of the line of thought. Partly also, because the line of argument, which was brought forward can be and only intends to be hinting towards a research agenda, which essentially requires empirical application, regionally as well as sectorally (What makes for instance Sweden the leader in low-energy housing?). These inherent constraints shall of course not serve as an 'excuse', but at least as some explanation for the lack of elegance and ‘analytical homogenity’ in dealing with these widely unchartered waters of the previously almost completely neglected evolutionary approaches to firm and policy level environmental economics.

[40] See for instance Wallace (1995), especially pp.125ff.
[41] See Loasby (1998), pp.81ff.

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