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Conflict and consensus formation in knowledge communities

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Abstract

The evolutionary perspective of the "systems of innovation" approach meets with difficulties in accounting for new developments, such as the creation of new technological paths or technological convergence. The development of a new micro-approach to technological development and innovation is needed, which focuses on the governance of a multitude of communities involved in different arenas of the knowledge transformation process in innovation systems. Concepts such as "definition of the situation", "framing", and "image" underline the need of future innovation research to include a richer and more focused view on cognitive and collective aspects of technological governance.

1 Introduction

Concepts such as "transformative technologies" (Phillips 2007) or "converging technologies" (Roco and Bainbridge 2005) represent new challenges to the "systems of innovation" approach. The idea of a continuous, cumulative development of isolated technology strands, characteristic for this approach, does not capture the dynamics of current technological development. Instead, new aspects such as fundamental transformation, path creation, and, in particular, technological convergence, come into the foreground. The evolutionary perspective of the systems approach[1] clearly has difficulties in accounting for such new phenomena (Schienstock 2004).

Furthermore, the approach, although conceptualizing an innovation system as a social system, in which the relationships between actors have an important role to play, widely ignores conflict. This is the more astonishing, as social scientists have argued that conflict represents a key quality of social relationships (Giddens 1984, Foucault 1989, Coser 1956), can become inspiring, constructive and fruitful and can initiate technological change and systemic restructuring. But, although scholars have shown that conflict often stimulates creativity, inventiveness and innovation (Dahrendorf 1969), representatives of the systems of innovation approach have not analyzed this dimension of social relationships. Because of the fact that scholars, applying this approach are primarily interested in factors leading to successful innovations, we may characterize systems of innovation as a "consensus theory of innovation" (Boulding 1997).

Challenges of this kind make it necessary to develop a new micro-approach to innovation, which focuses on the coping of different communities with uncertainty and ambiguity within complex knowledge-transforming processes and which includes conflict as an important dimension of social relationships. Identifying efficient forms of knowledge governance then becomes a key target of innovation research. There is widespread agreement that, due to the specific character of knowledge, the governance of technological innovations cannot be based on contractual regulations and bureaucratic control; instead, future approaches in innovation need to broaden their scope to include a view on collective action and cognitive processes (Lampel 2001: 306). "Definition of the situation", "framing" and "image", developed, stabilized, and changed through communication and dialogue, represent key concepts in a new actor-centred, micro-oriented approach to innovation. These concepts can be used to overcome conflict and guiding knowledge and know-how production, to deal with sets of problems in various knowledge arenas. This article aims at contributing to the development of such a new micro-model of innovation.[2]

2 Systems of innovation as knowledge-transforming systems

Innovation, as scholars have often stressed, is not the result of a singular event or a punctual decision act, but must be understood to be a complex social process (Lundvall 1992b). In this process, a multitude of individual or collective actors is involved, who alone or together initiate, adopt, produce, or use something new. In particular, the innovation systems approach focusing on the institu-

[1] Key publications, using the system of innovation approach, are among others Lundvall (1992a), Edquist (1997), Fagerberg, Movery and Nelson (2005).

[2] We are, of course, aware of the fact that conflict has been a topic in the STS literature for quite a while (see for example Hard 1993). Here we are primarily interested in revealing conflict structures; we do not intent to analyze concrete conflict episodes, a particular focus of the STS literature.

tional embodiment of a general innovation capability of a national or regional economy underlines the importance of the interdependency between social actors and the accumulated relational capital. As no actor is self-contained, the linkages, exchange relationships, and forms of collaboration between different actors become crucial (Saviotti 1997: 180).

Many definitions of innovation focus on the development of new technical solutions and the creation, diffusion, und commercialization of new product- and process technologies (OECD 1992: 22). However, more recently, and in connection with the intensifying debate on the knowledge economy, scholars have paid "more attention to the knowledge behind or in technologies and the learning behind or in innovation" (Saviotti and Nooteboom 2000: 5). Lundvall's definition of a national innovation system demonstrates this, which, according to the author, "is constituted by elements and relationships which interact in the production, diffusion and use of new, and economically useful knowledge ..." (1992b: 2). Knowledge has not only become a core input factor to and a key output factor of innovation systems, it can also be seen as an important individual or collective resource accumulated in many innovation processes that is necessary to transform knowledge into new knowledge.

We can therefore characterize the innovation process as a knowledge-transformation process und the innovation system as a knowledge-transforming system. The basic idea of such a conceptualization is that, within innovation systems, knowledge input is transformed into knowledge output by applying internally accumulated knowledge capital. Different types of knowledge are included, such as abstract scientific knowledge, application-oriented technological knowledge, and action-oriented practical know-how and know-who. All these different types of knowledge are involved in innovation processes, but, depending on the type of innovation –, for example, whether it is an incremental or radical innovation –, one or the other type of knowledge dominates the innovation process, or at least, particular sub-processes.

3 The knowledge-transforming process and knowledge communities

In innovation research, a shift from structural to action parameters has taken place; research focuses less on technical facts, and more on technological action. Following this trend, we can characterize the innovation journey as a multi-focal process, including a multitude of knowledge-activity clusters (van Ven et al. 1999). Corresponding to this view, we can characterize the innovation system as a multi-functional system comprising a number of different knowledge fields. These fields can also be characterized as "problem domains" (Trist 1983), because each cluster of knowledge-transforming activities demands the continuous dealing with and solving of a set of interrelated problems.

In the literature, we can find different typologies of knowledge processes and functions (Rush et al. 2009); here, we differentiate between the following functions, each of them representing a problem domain within the innovation process:

- knowledge imagination and anticipation,
- knowledge creation,
- knowledge acquisition,
- knowledge diffusion,
- knowledge application,
- knowledge domestication or knowledge consumption,
- and knowledge assessment.

The knowledge transformation process is understood as a recursive process in which particular knowledge activities can be both: cause and effect, consequence and pre-

requisites (Asdonk et al. 1991). The process involves complicated feedback mechanisms and interactive relationships between the various knowledge activities and especially knowledge creation and knowledge application are inextricably intertwined (Edquist 1997: 1).

Knowledge fields represent ongoing patterns of relationships between a number of communities[3] occupied with developing and applying knowledge and know-how to solve emerging problems and to take advantage of new options.[4] Consequently, the term "community" refers to collectives that operate in particular problem domains. We can conclude that communities engaged in innovation activities are searching for better ways of anticipating, accumulating, applying, consuming, and assessing knowledge by striving to generate new knowledge and know-how in order to improve their contribution to the solution of field-related problems.

In the literature, different aspects are cited to characterize communities in innovation processes. For example, some scholars speak about communities of practice (Wenger 1998), others about knowledge communities (Foray 2004), and still others about communities of meaning (Yanow 2003). These are not different concepts; the various terms only highlight specific dimensions of communities. Here, we use the term "knowledge community" to grasp the emergence and expansion of new social forms, which are explicitly devoted to the production and reproduction of knowledge through decentralized and cooperative procedures to deal with an interrelated set of problems (Foray 2004: 37). Different factors can initiate the development of communities within a knowledge field, including vocational education, special expertise, methodological orientation, affiliation to "locations" within an organization, social class, or ideological orientation and world view (v. Looy et al. 201: 330).

Furthermore, the boundaries of communities are rather fuzzy; they do not always develop within a single organization; instead, they often cross boundaries and integrate members of different organizations. Particularly in the case of converging or path-breaking technologies, communities often overstep the boundaries of single organizations. For example, in the field of knowledge creation, we will probably find communities integrating scientists from different universities, private research institutes, and firms belonging to different disciplines and applying different methods. In the field of knowledge application, technologists, engineers, and production workers from different firms may form a community. On the other hand, a single community can be engaged in different knowledge fields. A scientific community, for example, can participate in know-

[3] In the literature sometimes a distinction is made between communities of practice within firms and occupational networks connecting members of different firms (Brown and Duguid 1992). The latter are less tightly linked than communities, but they still share a common knowledge reservoir and search practices, allowing some kind of dissemination of knowledge and know-how among their members. Here we will not use this distinction; instead, for us the occupation represents one factor among others that can initiate the formation of knowledge communities.

[4] In the systems of innovation literature, scholars refer to actors within an innovation system as organized entities such as universities, R&D departments, transfer institutions, or consumer associations (Lundvall 1992, Edquist 1997). But in general, whole organizations are not engaged in particular innovation processes. We therefore prefer to use the concept of communities to speak about actors in innovation systems. However, the concept of communities does not imply a particular number of members; a community can consist of a small and a large number of members and sometimes the boundaries of a community can correspond with the boundaries of formal organizations or parts of them such as departments.

ledge creation, knowledge diffusion, and even knowledge consumption activities, becoming a consultant for consumer organizations.

The various factors that underlie the formation of knowledge communities lead to the development of sets of values, beliefs, meanings, and norms that bind people together. Through a process of interaction, members of a community come to share their knowledge and search methods for using the same or similar language to talk about their ideas, thoughts, and planned actions, and to develop common practices for dealing with problems. Through group processes, these developments are reinforced, promoting internal cohesion as an identity-maker with respect to other communities. We can define a knowledge community as

> "a sustained, cohesive group of people with a common purpose, identity for members, and a common environment using shared knowledge, language, interactions, protocols, beliefs, and other factors not found in job descriptions, project documents or business processes" (Miller 1995, see also v. Looy et al. 2001: 334, Yanow 2003: 237).

The fact that communities develop their own sets of beliefs, practices, routines, and identities creates strong path dependency in various sub-processes of knowledge transformation, defining certain boundaries for knowledge development and indicating directions in which progress is possible and desirable (David 2007, Arthur 1994). Consequently, a community's basis of knowledge and know-how and related technological advantages lay the foundation for succeeding rounds of development (Foray 1997: 65).

Knowledge communities develop in knowledge fields, they cannot be established formally. Furthermore, the community concept represents a specific learning approach. A basic assumption of the community concept is that one cannot separate learning and innovation from practice; instead, learning occurs, and knowledge is created, mainly through conversations and interactions between people involved in the same knowledge-activity cluster (Brown and Duguid 1992, Easterby-Smith and Araujo 1999). Nevertheless, organizational structures and linkages, incentive systems, and skill requirements can support or hinder the development of communities. Furthermore, communities do not have a constant, formally acknowledged number of members; they constantly adapt and change membership. Through fluid membership, knowledge communities can become important sources of innovation (Brown and Duguid 1992).

Different communities confront one another in the identification of problems, the definition of questions, the development of new knowledge and know-how, and the creation of problem solutions in particular situations: "arenas". But arenas have no prior existence; they have to be enacted by members of various communities. The enactment of an arena means that conflict structures and bargaining relationships between communities become institutionalized. Here the development of knowledge and know-how takes place, which is needed to deal with a set of field-related problems. We define an "arena" as a place of continuous confrontation, cooperation, and collaboration between communities engaged in the same knowledge field. In arenas, as Strauss argues, "different subjects are debated, negotiated and the representatives of different worlds or sub-worlds confront one another ..." (1978: 124).

4 Uncertainty and ambiguity as sources of conflict in knowledge-transforming processes

Both uncertainty and ambiguity are present in innovation processes, as well as in individual knowledge arenas (Weick 1995, v. Looy et al.

2001).[5] Uncertainty is an inherent characteristic of innovation processes here, because we are dealing with expectations concerning future developments. The fundamental unknowability of the future implies that actors involved in knowledge activities have to deal with chronic information deficits.

For example, because of a lack of information, we cannot know whether research activities will result in new scientific knowledge that can trigger innovation processes. And even in the case of success, it remains uncertain whether complementary knowledge needed will be available, and can be acquired and integrated without problems. Furthermore, we do not know which technology path may yield fruit, unless plausible alternatives are explored (van de Ven et al. 1999). Generally, we can assume that the information deficit increases with the complexity of the knowledge-transforming process. We can conclude that, because of a lack of information, acting in knowledge arenas becomes a highly uncertain undertaking.

"Portraying the innovation process as resulting from the involvement of different communities also means that ambiguity or asymmetries of interpretation enter the stage" (v. Looy et al. 2001: 334).

"Innovation, in fact, rests upon ambiguous, confused, not wholly defined situations" (Strauss 1969: 26).

While uncertainty results from chronic information deficits, ambiguity refers to the existence of multiple and conflicting interpretations of a situation (Weick 1975). Members of different communities in a particular knowledge arena may interpret the same situation differently; they may disagree about how to make sense of confusing information, and what implications a particular observation has on their way of acting. To summarize:

"Uncertainty relates to finding answers to well defined questions, equivocality or ambiguity implies that one is searching for the adequate questions" (v. Looy et al. 2001: 335).

Referring to these comments, we can characterize knowledge arenas within an innovation system as zones of uncertainty and ambiguity (Crozier and Friedberg 1993, Schienstock 1995, v. Looy et al. 2001).

Challenges arise from uncertainty and ambiguity, as Strauss argues (1969: 26). The situation within knowledge arenas is continuously monitored by members of the communities involved, causing them to reflect critically on themes discussed, questions asked, problems identified, and solutions found, and to question the adequacy of the knowledge and know-how reservoir, as well as the instruments, search methods, and procedures applied. Doubts may arise, whether the current constellation will foster optimal solutions for dealing with problems and whether it will allow taking advantage of emerging opportunities. Because of uncertainty and ambiguity, we can conclude, knowledge, know-how, practices, and procedures within knowledge arenas will be challenged by members of communities involved, and will therefore remain precarious. Members of different communities, developing sets of contradicting priorities, striving for conflicting goals, following different norms, and adhering to different beliefs, may have different views on how to remove the "irritation of doubt" (Laws and Rein 2003) in a knowledge arena, and may come up with different problem solutions.

One may argue that changes in the knowledge reservoir of an arena and in the set of search practices and problem-solving methods applied are caused by temporary events including occurrences determined by chance (David 1985: 332). Yet, we contend that such changes are pri-

[5] Weick and v. Looy et al. use the terms "equivocality" and "ambiguity" interchangeably.

marily the result of a continuous internal struggle and bargaining process between various communities. The concept of arenas makes it possible to analyze conflict and negotiations within particular knowledge fields, as well as the knowledge-transformation process as a whole. Striving for continuous improvement, actors can always challenge the knowledge reservoir that can be found in a particular knowledge arena, as well as the search procedures and problem-solving strategies, with the implication that practices in knowledge arenas remain problematic, and are open for continuous revision and for the integration of new and even contradicting knowledge elements; at the same time, this process is accompanied by the elimination of parts of the existing knowledge stock and search procedures. We can conclude that, within knowledge arenas, a process of continuous reproduction, challenging, and renewal of knowledge and know-how takes place.

Analyzing social relationships within knowledge arenas as sites of the articulation of conflict and differences, and as a place of social and cultural competition, we cannot focus on struggle over the optimal way of dealing with problems and taking advantage of new opportunities only. Conflict cannot be characterized exclusively as a knowledge-creating and problem-solving debate; it is also about the disposal over resources necessary to develop new knowledge for the solving of problems (Bourdieu 1977). Uncertainty and indetermination open up opportunities of reshaping the distribution of tangible and intangible resources among various communities, including for example financial or human resources. By amending their resource portfolio communities can make more significantly contributions to the knowledge transforming process.

Demands for material and immaterial resources can be understood as a concrete expression of interests. While striving for accumulating additional resources communities also aim at realizing specific interests such as increasing their esteem, prestige and status within a knowledge arena or the knowledge transformation process as a whole. This suggests focusing conflict analysis within or between knowledge arenas not only on the aspect of resources distribution, but also on the struggle over specific interests, communities aim at realizing, which are often antagonistic in their character. The interest frame can be seen as an attempt at getting away from haggling over knowledge capabilities and the distribution of scare resources (Fisher and Ury 1981: 42). Most important is that a change in the disposition over resources within a knowledge arena also effects the power relationships between involved communities. Communities are interested in amending their resource endowment, because this enables them to make credible threats and promises, which improves their chance to get their knowledge and know-how accepted as common knowledge capital and to push their envisioned solutions through. We can argue that members of the different communities aim at occupying, dominating, and exploiting knowledge arenas to increase their power and influence in further rounds of struggle and bargaining. This means that knowledge arenas are in a perpetual state of unresolved conflict (Boulding 1997: 103).

In addition, social actors have a specific identity, and they aim at acting in accordance with it. It is often the case that actors who feel their identity to be threatened defend the norms and values on which their identity is based, and forge their own sense of self in opposition to others. This means that we have to take a third type of conflict into account, the conflict over identity-forming norms and values. The issues at stake are the actors' general purposes, their mental models, and

Table 1: Examples of different types of conflict in knowledge arenas

	Type of conflict		
knowledge arena	Resource conflict	Interest conflict	Identity conflict
Knowledge creation arena	State research budget, distribution of public research finance among industries and technologies	Prioritizing of research fields, application orientation of university research, superiority of theoretical approaches	Ethical restrictions of scientific research (steam cell research)
Knowledge acquisition arena	Research expenses of different partners in supplier networks	Exploitation rights to knowledge created in cooperation	Acquisition of knowledge through offering bribes
Knowledge distribution arena	Privatization of services offered exclusively by public KIBS	Violation of patent rights	Passing of highly sensitive knowledge to foreign countries (nuclear technology)
Knowledge application arena	State direct support of product development in single firms	Fixing of environmental standards by industry (self-control)	Animal experiments to test cosmetics or new drugs
Knowledge consumption arena	Price setting for new products (overpricing)	Comprehensive labelling of products, restriction of advertising	Selling of new products with dangerous side effects
Knowledge anticipation/ assessment arena	State support of knowledge anticipation/ assessment activities	Superiority of methods and approaches in the field	role of experts, expert status of consumers

sense-making processes, their self-understanding, and self-definition. Summing up, we can distinguish between three major frames of conflict, which can be characterized as "resource conflict", "interest conflict", and "identity conflict" (Rothman and Fischer 2000: 584).[6] All three types of conflict are present in knowledge arenas. In reality, however, it is hardly possible to distinguish between them; in general, a conflict within a knowledge arena has several dimensions. The following tables gives some examples of different types of conflict in the various arenas of the knowledge transforming process.

5 Boundary-spanning as a key aspect of knowledge governance

Long-term arguing out conflicts within knowledge arenas can become dysfunctional for the performance of an innovation system; but it can also bring about disadvantages for the communities involved, and for their members. This is because communities, by pursuing their goals and interests, depend upon each other's competencies and knowledge capabilities. In particular, in the case of complex innovations merging different scientific and technology fields, single communities are not self-sufficient; instead, the knowledge as well as other tangible and

[6] There are of course other typologies of conflict, as for example those suggested by Dahrendorf (1969) or Coser (1956). Because we understand knowledge as a resource, we have not added an additional type of conflict. The more recently discussed risk conflict can partly be interpreted as identity conflict; but here more conceptual work is needed.

intangible resources needed to develop new solutions, to be able to deal with problems, and to take advantage of new opportunities, are distributed among a number of different communities. In the case of converging technologies, for example, knowledge from communities specialized in fields such as biotechnology, nanotechnology, ICT, and cognitive science is integrated to achieve scientific progress (Roco and Bainbridge 2002a, Phillips 2007).

In the literature, the main problem of developing solutions for sets of problems in a particular knowledge arena is described as enabling communication and information exchange among communities. However, cooperation between communities is "first and foremost contributing to the joint production, rather than 'exchange' …" (Lindenberg 2003: 50). Of course, information and knowledge exchange is important for the coproduction of problem solutions and related knowledge and know-how. But, if information exchange is focused exclusively improving the knowledge capabilities of a single community by broadening its knowledge base moves into the centre. Joint production of problem solutions, however, demands more: the integration and fusion of the knowledge capital and know-how of different communities into one common knowledge reservoir.

This, of course, is a very difficult undertaking. In particular, in the case of converging technologies, the risks of network-inconsistencies and network failures are high, which can hinder or even interrupt innovation processes and thus reinforcing possible breaks and ruptures between the involved communities (Ott and Papilloud 2007). "Boundary-spanning", as v. Looy et al. argue, has been a precondition for many successful knowledge-based innovations (2001). This means that successful knowledge transformation demands the spanning of boundaries within and between knowledge arenas. However, the wide distribution of knowledge, know-how, skills, and competencies among a number of different communities creates barriers for communication and collaboration, and hampers an open and constructive exchange of ideas. At the same time, specialized knowledge capabilities and competencies are used by communities to cut themselves off from interaction and cooperation with other communities, in order to pursue their own goals and interests more efficiently.

On the other hand, the interdependency between communities within knowledge arenas suggests that all parties involved aim at finding a common ground for reconciling incompatible demands and diverging interests, in order to be able to explore ways in which their concerns can be redefined in mutual terms, and integrative solutions can be forged (Rothman and Fischer 2000: 588). On the one hand, the spanning of boundaries across communities within various knowledge arenas is necessary. On the other hand, communities create significant impedance of effect that prevents and imperils boundary-spanning activities. This demonstrates the contradictoriness of this integrative undertaking (v. Looy et al. 2001: 330-331).

For the success of knowledge-transforming processes the spanning of boundaries between communities operating in different knowledge arenas may be even more important than boundary-spanning within an individual knowledge arena. For example, boundary-spanning between communities operating in the knowledge-creation arena and those operating in the knowledge-application arena becomes increasingly important. On the one hand, innovation activities can draw from technological opportunities stemming from scientific advances, while, on the other hand, technology "shapes science in the most powerful way: it plays a major role in determining the research agenda of science" (Rosen-

berg 1994: 16). In addition, linking knowledge-consumption communities with those operating in the knowledge-application arena has the advantage of securing consumer-oriented technology development. And integrating knowledge-assessment communities with knowledge-consumption communities can foster socially and ecologically beneficial technologies. Of course, spanning boundaries between communities operating in different knowledge arenas makes overcoming differences and contradicting orientations, belief systems, and values even more difficult.

Boundary-spanning can be seen as being at the heart of trans-community technology governance (Aichholzer et al. 2010). Of course, governance is a very vacuous term that is used confusingly to the extreme by scholars from different disciplines. While traditionally research on technological governance focuses on the system level, we apply the concept to the level of intra- and inter-organizational group relationships. Strongly influenced by transaction cost theory, the governance concept is, on this level, usually applied to contractual relations (Lindenberg 2003). The definition by Lynn et al. suggests a more inclusive concept. According to these authors

"… governance generally refers to the means of achieving direction, control and coordination of wholly or partially autonomous individuals or organizations on behalf of interests to which they jointly contribute" (2000: 234, see also Grant 1996: 362).

This definition counts contractual regulation as just one form of governing. We therefore define governance in innovation systems as including all kinds of structural forms and processes of collaboration in the knowledge-transforming process, and of directing knowledge flows between actors, in order to enable the coproduction of knowledge.

Difficulties in homogenizing the knowledge of various communities result especially from the fact that knowledge is neither true nor false, and is also never complete; instead, the generation of knowledge and know-how to develop new problem solutions is associated with the discovery of areas of the unknown, producing further uncertainty (Stehr 1994). On the basis of the principle of truth it cannot be decided, which knowledge to integrate into a common knowledge pool within an arena. Instead, members of different communities agree on what kind of knowledge and know-how they will fuse into an arena-wide knowledge base. This suggests not to conceptualize knowledge fusion as a zero-sum conflict (Rothman and Friedman 2001: 588), where communities haggle over the value of their own particular knowledge and know-how for the arena as a whole, as well as over scarce resources, such as prestige, influence, and power.

Of course, the fusion of knowledge and know-how owned by different communities cannot be based on a formal contract, in which regulations are specified how to proceed in the generation and reproduction of a common knowledge base which is needed for finding joint problem solutions. Under conditions of uncertainty and ambiguity

"… the view that coordination sets out the interlinking tasks and governance sees to it that people do what is expected fails when tasks cannot be well specified" (Lindenberg 2003: 50).

Knowledge production does not result from separating tasks in the workflow of knowledge operations and from establishing rules of behaviour (Pawlowsky 2001); instead, the integration of knowledge must take place in joint practices. Common experience makes it possible to identify other communities' models and to react accordingly. Because a common knowledge pool emerges out of collaboration in problem-solving processes, we have to identify those mechanisms that can explain how the knowledge and know-how

of single communities becomes homogenized, and develops into the knowledge of the arena as a whole. We need to explain why different communities within a knowledge arena are motivated and prepared to act jointly and show solidarity within knowledge arenas (Lindenberg 2003: 51).

"Definition of the situation" (Thomas and Znaniecki 1927, Thomas 1969), the "image" (Boulding 1997), and "framing" (Goffman 1974) represent cognitive concepts that can be used to explain the readiness and motivation of members of communities to act collectively and to show solidarity within knowledge processes. By using these concepts, attention is drawn to the cognitive dimension of governance. The concepts can become the basis of a micro-approach to innovation drawing attention to communication, interaction, and collaboration between communities (Kesting 2008).

6 Definition of the situation, image, and framing as concepts of a micro-approach to knowledge transformation

Individual as well as collective actions depend, as Thomas (1969) argues, on the definition of the situation. Whether members of a community are prepared to collaborate with members of other communities in a particular knowledge arena depends on their subjective interpretation of elements and relationships that constitute a situation. The cognitive structuring of a situation is highly selective though; actors take only those parts of a situation into account which they interpret as relevant, based on their goals, interests, and normative orientations, while they ignore other factors as irrelevant.

In general, members of different communities are prepared to collaborate only in a crisis situation. If the perception of relevant problems evokes a consciousness of crisis, members of different communities may join together to formulate the relevant problems, identify adequate solutions, and promote them in the wider environment, including the organizations they are part of. However, it is difficult to formulate a homogeneous definition of the situation, which oversteps the boundaries of single communities, particularly when it is complex and highly dynamic. Communities therefore often aim at agreeing on very general definitions, which include a number of sub-definitions, and relate only to a single or a few aspects of the situation. They may also agree on a sequential problem-solving procedure, which means that they will continuously reflect on the situation, and will, depending on progress, revise their definition of the situation from time to time.

The concept of framing assumes that actors involved in a knowledge arena are placed in relation to a frame. Additionally, their way to act is influenced by the framing of a problem. We can define framing

> "as a particular way of representing knowledge, and as the reliance on (and development of) interpretative schemas that bound and order a chaotic situation, facilitate interpretation and provide a guide for doing and acting" (Laws and Rein 2003: 173).

Frames can be interpreted as systems of beliefs that intertwine with identity and social action (ibid.: 174).

In general, a knowledge arena includes a number of different frames that, at least to some extent, oppose one another, and can therefore paralyze a knowledge arena. However, being interested in the preconditions for the preparedness and motivation to collaborate in knowledge production, we have to shift attention from contest among conflicting frames to the integration of different beliefs, world views, and identities within a common frame, to make sense of an uncertain and ambiguous situation, which enables the coordination of

actions and the coproduction of problem solutions (ibid.).

Developing a common frame is one way by which different demands within a knowledge arena can be synthesized. As long as each of the communities involved in a knowledge arena orients itself on a different frame, we cannot expect that communities adapt their behaviour, and take concerted actions. This is likely only if the different belief systems fuse, and a collective identity unifying all communities develops. Consequently, the main function of an overarching frame is to serve as a basis for discussion and joint action. The development of a common frame in each of the knowledge arenas, as, for example, a common knowledge-accumulation frame or knowledge-application frame, makes it possible to bring together and integrate the stocks of knowledge and know-how of different communities into one common knowledge reservoir. Then members of various communities can mobilize this common frame "which enables them to perceive and to understand the phenomenon they witness and to organize own action" (Flichy 2007: 81). A common frame implies that members of all communities are motivated to use their intelligent effort adaptively to advance the joint problem-solving and knowledge-creating process (Lindenberg 2003: 50). However, under no circumstances do frames determine procedures, activities, or practices. They rather provide a point of anchorage, a set of constraints which make particular activities possible, but actors can still choose freely how to act within a particular frame (Flichy 2007: 85).

Boulding's interactive theory of innovation is based on the concept of the "image" (1997). All behaviour, according to the author, can be explained not as reaction to stimuli, but to an image. Without the concept of image we cannot explain any kind of behaviour. Here, we will use Samuels' definition of an image.

> "The fundamental role of the image is to define the world. The image is the basic, final, fundamental, controlling element in all perception and thought. It largely governs our definition of reality, substantively and normatively, in part as to what is actual and what is possible." (1997: 311, quoted in Kesting 2008: 15).

It contains preferences, perceptions, as well as value judgements.

An image exists on both the individual and the collective level; we can define the image of a community as its "public image". Due to the fact that a knowledge arena consists of a multitude of communities, it will incorporate several images; in the knowledge arena, there exist in fact as many images as communities. Coproduction of knowledge within a particular arena therefore depends on the mutual modification of the images of all communities involved, and on the development of a common public image. The advantage of an image-based theory of innovation is, according to Kesting (2008: 16), that it allows for collective knowledge development through social learning.

The concepts discussed above emphasize that the development of a common view and the taking of concerted action within a knowledge arena very much depend on the establishment of a collective sense-making process which is needed to mobilize knowledge and know-how and to develop a joint problem solution. This can be achieved if communities give up their critical attitude towards problem solutions developed by others, and accept contributions of other communities to the problem-solving process as valuable, instead of stressing their limitations and risks. In addition, the creation of a climate of trust and collaboration through "attitudinal structuring"[7] makes it easier for communities to commit to the solution-seeking and

[7] The concept of "attitudinal structuring" is used by Walton and McKersie (1965) to describe a sub-process of wage-bargaining processes.

knowledge-creating process and to the outcome arrived at.

Such a commitment can be attained through a change of perspectives. Joint solutions become credible when they are evaluated from the perspective of future promises, rather than present reality.[8] By building up positive expectations concerning the joint problem-solving process and likely outcomes, it is possible to influence members of various communities in such a way that, using their predictions as a lens, they will confirm these predictions (Weick 1995). By applying such a dynamic perspective of collective sense-making, concepts such as definition of the situation, frames, and image can gain explanatory power.

7 Languaging and discursive coordination of knowledge

All concepts we have mentioned above assume that collaboration in problem-solving, knowledge creation, and know-how development is dependent on communicative action, and that new ideas emerge in dialogues and debates. Scholars either stress "the dialogical mode of communication where the exchange of arguments fulfils the creative purpose of combining knowledge to arrive at new ideas and solutions for problems" or they "highlight the more strategic use of speech acts to convince and persuade others of discoveries and initiate and push for change" (Kesting 2008: 32). The collective level of the creation of innovations is attained by a "process of the mutual modification of images, both relational and evaluational, in the course of mutual communication, discussion and discourse" (Boulding 1997: 103). Von Krough et al. argue that the production of collective knowledge is based on speech action; languaging is one of the missing links that connects knowledge bases and enables learning (1995: 95). The locus of collective learning in knowledge arenas lies in the communication among members of different communities. They have to communicate with each other about distinctions in their observations to ascribe meaning to observations, and to develop common knowledge (v. Krough et al. 1994). Communication can be seen as the means of producing and reproducing meaning over time.

Taking up the idea of the centrality of languaging for the development of collectively shared knowledge, we suggest taking "discursive coordination" as a key characteristic of the process of fusing knowledge and know-how and concerting actions (Schienstock 2004). The term makes clear that the integration of different sources of knowledge and know-how cannot be achieved without an intensive discourse about the rationale, meaning, and impact of different knowledge elements. Discursive coordination allows reconciling unorthodox or even oppositional knowledge in a novel formation, and concerting even contradicting actions.

But the aim of discursive coordination is not only to reach an understanding which may then result in the development of a common knowledge base and further collaboration in problem-solving processes. Discourse also involves a "positioning" of the participants. In such discourses, boundaries between the communities are likely to shift, or be traversed (Easterby-Smith and Araujo 1999). Learning can concern the manner of negotiating current relationships, as it can concern changing relationships. Extending the discourse over a longer period of time may result in the development of a "situated discursive identity", which enables members with different backgrounds to compare the per-

[8] This argument is borrowed from Lampel (2001). However, the author is primarily interested in relations between innovators and users, financiers, or other stakeholders, and not in relations between knowledge-developing communities.

spectives and action strategies of all communities involved. Such a discursive identity can become the basis for the fusion of single communities into a new formation spanning various boundaries.

In this respect, concepts such as "integrative power" (Boulding 1990) or "conditional power" (Galbraith 1983) become highly relevant. They describe a language-based power, which is of particular importance in the knowledge-transforming process.

> "Integrative power depends very much on the power of language and communication, especially on the power of persuasion" (Boulding 1990: 221).

> "Integrative power often rests on the ability to create images of the future and to persuade other people that these are valid." (ibid. 122)

The two concepts are closely linked to Habermas' theory of communicative action (1995); we can therefore argue that communities do not only make use of these types of power in a selfish way to achieve individual goals and to realize specific interests, but also to establish a dialogue, to reach an understanding among the participants, and to develop a common identity.

Habermas calls a dialogue "reflexive", if participants learn to understand each other's motives, underlying norms, and opinions (1995). Self-reflexivity can be defined as "the possibility for groups of actors ... to shape the course of economic evolution" (Storper 1997: 28). It means that actors do not blindly pursue the passion that moves them at the moment, or merely execute social routines. Instead, self-reflexivity characterizes the capability of actors to use their imagination, to act on different strategies (Sabel 1997), and to create new action programmes, if the external circumstances requires them to do so. Reflexivity therefore implies more than anticipating new developments, and considering them in the development of new strategies; self-reflexivity includes monitoring of the environment, critically dissociating oneself from the traditional functioning of reality, and developing alternative ways of acting (Sabel 1997).

"Reflexive discourse" means the exchange of rational arguments to deliberate about ends and means, while, at the same time in this process, the one's and the other 's preferences, goals, and interests may be changed, and a new common identity may emerge. Habermas (1995) argues that communicative rationality sets in, so that, inevitably, participants of a discourse reach an understanding. In such a reflexive discourse, participants will learn from each other and change their attitudes towards problems arising in such a way that they can develop a common solution and concert actions.

Habermas' assumption that a certain communicative rationality of speech acts which will lead to the development of creative solutions of conflicts, has often been criticized. We cannot assume that integrative power will always be consensus-oriented or inclusive (Kesting 2008: 20). Members of various communities may realize that their views, beliefs, and interpretations remain isolated, juxtaposed, non-communicating, and even conflicting. Coming to nothing has, of course, serious consequences for the knowledge-transforming process; it may lead to the breakdown of a knowledge arena and of the established patterns of arguing, negotiating and collaboration. Furthermore, language and persuasive power can also be used to manipulate others (Boulding 1990: 119), and to push solutions through, which are beneficial only to a few powerful people. Consequently, a new path developed within the knowledge transformation process will not necessarily lead to optimal solutions.

We also have to take into account that, in general, not all members of the communities involved will participate in the process of knowledge-

and know-how fusion, and in concerting actions. In this process, participants are differently legitimated to act in the name of their fellows, and they may have a different standing in their community. But they all face the problem of intra-community bargaining; without the approval of the members of the communities involved, it will not be possible to create a common knowledge pool and to agree on search processes and procedures of problem-solving. This includes the preparedness of community members to undertake adaptation processes in the creation and use of knowledge, in order to stabilize inter-community relationships within a knowledge field. But it is by no means sure, whether such an approval will result from intra-community bargaining.

In the literature, trust is often mentioned as a decisive precondition for the coproduction of knowledge and for collaboration in problem-solving processes. Cumulative learning processes, to be effective, have to be embedded in social capital – the ability to work with and trust others (Lundvall 2002: 43).

> "Trust is a tacit agreement in which rather than systematically seeking out the best opportunities at every instant each agent takes a longer perspective to the transactions; as long as his traditional partner does not go beyond some mutually accepted norm." (Zuscovitch 1998 quoted in Cohendet and Joly 2001: 77)

The success of communities in building trust among each other can be explained by a high frequency and intensity of interaction leading to a strong communication culture (Cohendet and Diani 2006).

Interdependency is a key precondition for the development of trust; it prepares the ground for the development of trust between members of different communities. Of course, trusting somebody is a risky undertaking, because trust involves the willingness to entrust oneself to another person and to become vulnerable to his/her action (Sabel 1997: 162). However, continuous cooperation between various communities within a knowledge arena can transform the exchange of information and mutual adaptation into a social norm. Through reliance on a "norm of reciprocity" (Gouldner 1960), practices can be developed that create expectations which turn exchange into some kind of "collective logic". Apart from economic self-interest, strong expectations of trust and abstention from opportunism develop. Social capital contributes to the compliance of all partners to the reciprocity norm. However, the reciprocity norm is very ambivalent, as it entails the problem of balancing the obligation of exchange with the self-interest of the actors. Furthermore, some scholars have argued that trust can also have major disadvantages as it may lead to an early closure of innovation processes, which can result in ignoring promising opportunities (Oppen 2009).

8 Converging institutions: Mediating roles, creative spaces, and boundary objects

Boundary spanning activities and discursive coordination are important means to enable complex innovations. But, to open up more long-term innovation perspectives, these activities have to become institutionally embedded. Ott and Papilloud (2007) use the term „converging institutions" to point to the need of overcoming the multiple risks of networking inconsistencies and network failures in innovation processes. According to the authors, converging institutions are not only responsible for the development and application of knowledge, just as any other actor involved in innovation processes, but they also have to take up a bridging function. They have to develop into a translation instance, which enables exchange and collaboration between various actors involved in complex innovation processes. This includes relationships

between communities of different technological strands as well as relationships between actors involved in different functional arenas of the knowledge transforming process.

Converging institutions not only act as stimulators of new linkages and networks, they also have to take an active role in the process of conflict resolution between communities involved in the knowledge transforming process, because these often have difficulties in integrating their diverging definitions of the situation and to develop a common frame. In doing so they can legitimize the process of homogenization and concertation and they can organize this process in a peaceful way. In the literature different forms of institutionalizing the conflict resolution process have been mentioned: the introduction of the role of the „gatekeeper“,[9] providing a „creative space“ and the establishment of a „boundary object“. The process of institutionalization includes both forms: the evolvement out of continuous interaction between communities over time as well as the formal set up from outside. Of course, these concepts are closely linked, and they will have maximum effects, when applied jointly.

The establishment of a boundary-spanning role is often mentioned as a possible measure for dealing with conflicts within or between knowledge arenas, because it facilitates information flows (v. Looy et al. 2001). Particularly the importance of the role of the gatekeeper (Pettigrew 1973) or information broker (Burt 2004) in the innovation process has been stressed by many scholars. Tushman and Katz (1980), for example, argue that gatekeepers are able to reduce cognitive distance and mitigate the confrontation of paradigms, world views, and value systems at the intersection between scientific communities and the more practically-oriented engineering communities that prevails in the firms' daily business. But the role of the gatekeeper can also be placed at the intersection between other knowledge arenas; the holders of the role can, for example, mediate between knowledge applicants and knowledge consumers or between knowledge applicants and knowledge assessing communities. And information brokers can be placed at the boundaries between different communities within a particular knowledge arena as is the case, when different scientific communities participate in the creation of converging scientific knowledge.

Gatekeepers can be characterized as translators.

> "They must be fluent in more than one 'language', at home in more than one world, adept at playing by more than one set of 'rules'. " (Flichy 2007: 47 quoting Aitken 1976)

These translators end up in creating a new language that will be used by a multitude of communities within one or several knowledge arenas. According to Burt, the role of the broker is critical to learning and creativity because brokers translate a belief or practice to draw analogies and to synthesize, because they see new beliefs or behaviors (2004: 354).

The Nordic Innovation Centre recommends the creation of an information point for converging technologies, where the business advisors have knowledge about converging technology activities within the main regional sectors. This may serve as a key element of a regional policy. The Functional Food Science Center in Skone is given as an example in the food sector (Larson, Ahlquist and Friorikssson 2007: 36).

Here we will present the German Steinbeis Stiftung as an example for an institutional solution of the role of a gatekeeper or an information bro-

[9] The role of the gatekeeper is often associated with particular individuals; here we associate the role with collective actors.

ker.[10] The foundation is placed at the boundaries between knowledge-creating and knowledge-applying communities and functions as translator between them. Its main task is helping to overcome the different beliefs, goals, orientations, methods and practices of communities to enable an effective and efficient co-operation between the two areas, while applying the rules of the market. The foundation has access to a network of experts from different, primarily technological fields, who can accompany problem solving processes from research and development to consulting and further training of the employees. These experts are placed at the disposal for firms in case they ask for support. The leaders of the centres, themselves mostly members of academic institutions, running them as transfer, consulting or research institutions, have great autonomy, but they have to act within centrally fixed general conditions.

An important boundary-spanning strategy is the establishment of "creative spaces" "discursive platforms" or temporal "zones of proximal development", which enable the interaction and communication between various communities, support the exchange of ideas and allow for collective problem-solving (Lowndes 2005, Vygotsky 1986). Such creative spaces can become spaces for common experimentation and learning. Their advantage is that different kinds of knowledge and a multitude of perspectives and experiences, from the different professional, social, and cultural backgrounds of the communities involved can be drawn together.

Creative spaces can fulfill their integrative function only, if each community involved accepts that no view is authoritative or true, and if none of them has a claim to a privileged position. In a creative space, trust relationships can develop, which make it more likely that members move from entrenched positions, and make concessions to concert actions. However, at the outset, such spaces are only weakly structured. Rules, methods, and functions must first be negotiated and newly agreed upon, which, at the same time, opens up a chance for improvisation and for challenging traditional models (Oppen 2009).

The establishment of discursive platforms or creative spaces within the knowledge transforming process is often seen as a core element of national and regional policy programmes in the area of converging technologies (Larson, Ahlquist and Fridriksson 2007). These platforms can be placed at boundaries of different knowledge communities within and between knowledge arenas, but they can also cover the whole knowledge transformation process.

> "… a regional converging technology platform could act as an umbrella-type of common denominator for regional exercises and create linkages between local research projects on the topic" (ibid. 35).

Furthermore, such regional platforms can initiate and enable a broad societal discourse about the benefits and risks of converging technologies, in which organized societal groups as well as the general public should take part. It could give some kind of guidance in the process of forming an opinion and accumulating knowledge and know-how. The platform could be looked after by a mediating organization, but "it should be supported by regional authorities or other public funding so that it is implemented in a sustainable manner …" (ibid 33). In addition, such a platform should closely be connected with regional foresight activities, which aim at identifying perspectives of developing converging technologies based on regional strongholds. Those foresight activities, which should identify both opportunities

[10] The focus of the Steinbeis Stiftung is not particularly on converging technologies, but the area of this technologies can be part of the foundation's activities.

and risks of converging technologies, could become an important input to the societal discourse (ibid. 31).

Other scholars have introduced the notion of boundary object to make communities cooperate and collaborate in and between knowledge arenas. According to Star and Griesemer cooperation between communities can only take place if they agree on a common boundary object.

> These "are objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity" (1989: 393).

The main problem is that the establishment of a boundary object should support the development of a single communities overarching identity without destroying their cohesion, which would also endanger the overall approach. The intention of establishing a boundary objects is to support communication and cooperation between communities without merging their practices. In the literature installing information artefacts such as an information system is primarily discussed in this context.

The Communicator, a "mobile systems designed to enhance group communication and overcome barriers that currently prevent people from cooperating effectively" is discussed as a collective vision of a powerful boundary object (Roco and Bainbridge 2002b: 276).

> "At the heart of The Communicator will be nano/info technologies that let individuals carry with them information about themselves and their work that can be easily shared in group situations. Thus, each individual participant will have the option to add information to the common pool of knowledge, across all domains of human experience - from practical facts about a joint task, to personal feelings about the issues faced by the group, to the goal that motivate the individual's participation." (ibid. 276)

The Communicator, having the ability to tailor its personal appearance, presentation style and activities to group and individual needs, will facilitate communication between various communities.

Boundary object should enable and support communication and cooperation between different communities. However, making a technical artifact available, does not guarantee that this aim will be achieved; instead technical coordination must be accompanied by social integration. We therefore suggest the establishment of a common frame as a completion to the instalment of a boundary object. Such an overarching frame, as we have discussed above, does not just represent a compromise, but it emerges out of continuous interaction. It enables communities to set the problems, they are dealing with, in a wider context and to develop a more comprehensive understanding of them. It can provide a useful lingua franca between members of various communities and can lead to the re-evaluation and renegotiation of the knowledge, beliefs and practices of various communities. It can even result in a synthesis around a new boundary-spanning community. Within such a community, it becomes possible to find a common ground for reconciling incompatible demands and diverging interests, and to forge integrative solutions from fundamental conflicts of interests.

Here regional initiatives in different countries, which use the concept of "learning region" as boundary object, can be presented as an example.[11] Such a frame is particularly suited to be applied to the converging technology area. The concept of a learning region is a public frame of all communities involved in knowledge transformation. The aim of this concept is to initiate a process of building a collective learning capacity in a bottom up and interactive fashion. In most cases such a boundary concept is initiated by a group of interested

[11] The article by Lagendijk und Conford (2000) mentions a number of regions that use the notion of learning region as a common frame.

people who often belong to different institutions within the knowledge transformation processes that are mostly positioned in fields of technology with a high learning and innovation potential. Organizing meetings, and conferences the initiating group aims at establishing the concept of learning region as a vision of regional development.

When an initiative has reached a critical mass, more calculated measures can be taken. But again, a bottom up approach is favourable; because of intensive communication and information exchange some members of thematically connected communities may develop pilot activities, which are expected to develop in more long-term projects. Financial support from the regional state is decisive for these pilot projects , at least for start-up activities. The integrative power of the boundary concept of learning region very much depends on whether these pilot projects lead to the formation of innovation networks attracting communities from different functional arenas and technological areas and whether these networks develop into more long-term forms of cooperation and collaboration within the regional knowledge transformation process.

9 Conclusion: A community-based micro-foundation of innovation

Knowledge moves into the centre of the analysis of innovation processes. Innovation systems thus can be characterized as knowledge-transforming systems. In connection with this, a newly developed micro-approach to innovation focuses on the reduction of uncertainty and on dealing with ambiguity within knowledge arenas, which involve a multitude of communities. Uncertainty and ambiguity can give rise to a constant struggle over the optimal way of dealing with problems and taking advantage of new opportunities, in order to realize own goals, norms, and values. However, uncertainty and indetermination also open up opportunities for reshaping the distribution of influence and power, as well as of tangible and intangible resources among various communities.

Together with the growing importance of radical path-breaking innovations, the knowledge-transformation process demands the integration of different kinds of knowledge. This points to the mutual dependency of knowledge communities. Boundary-spanning therefore becomes a key dimension of innovation governance. In the case of knowledge transformation, the traditional governance forms of contractual regulation and bureaucratic steering become inadequate; instead, cognitive aspects of governance come into the foreground, and languaging and discursive coordination become key elements of knowledge governance. In particular, concepts such as definition of the situation, framing, and image represent key dimensions of cognitive governance. The role of the gatekeeper, creative spaces, and boundary objects can be seen as efficient institutional forms of cognitive governance.

To conclude, dealing with uncertainty, discontinuity, and ambiguity and related conflicts within knowledge-transforming processes will become one of the core themes in innovation research. Additionally, research will have to focus on efficient forms of knowledge governance, including cognitive aspects. So far, this is a very much under-researched area, but because of a growing importance of technological convergence and new paths to creating technologies, this gap needs to be closed. In future, innovation research must include a richer and more focused view on various forms of conflict within the knowledge transforming process as well as cognitive and collective aspects of technology governance.

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