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THE CONTRARY FORCES OF INNOVATION
A conceptual model for studying networked innovation processes

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Keywords: innovation, process studies, friction, confrontation, IMP, actor-network theory

Abstract
In this paper, we argue that industrial innovation processes can productively be analyzed as consisting of two sub-processes that over time create and mobilize contrary forces within both internal and external interactions of the innovation project. One of these forces emerges from the process of mobilizing resources, activities, and actors in ensuring commitments to the project over time. The other is the process of explorative learning, which continues to create revised or even new propositions about the realities of the project and its opportunities. We argue that this analytical distinction permits us to expand our understanding of how friction forces develop over time in business networks (Håkansson & Waluszewski, 2001ab), the patterns of divergence and convergence in innovation processes as identified by Van de Ven et al. (1999) and the processes of "path creation through mindful deviation" as argued by Garud and Karnøe (2001).

1. Introduction

Innovation processes represent a particular challenge to IMP theory, since it has emerged from a greater focus on understanding why businesses tend to be much more intertwined in relatively stable collaborative networks. Given the dominance of interrelatedness, interdependency and stability across many business landscapes, observed radical changes and innovations must also be properly accounted for. To do this, a particular concept of 'friction' has been introduced by Håkansson and Waluszewski (2001b), which identifies tension between the forces of the elements that have been put in place and the forces of any movements, changes and efforts that interact with such an established order (Håkansson & Waluszewski, 2001b). In this paper, we aim to further investigate what some of these controversies are made of. In order to accomplish this, we have applied Actor-Network Theory (ANT) as an analytical approach for dealing with and explaining 'emerging phenomena', such as innovations. In particular we utilize ANT's attention to controversy and alliance-building; the assumption that networks emerge out of the more or less conflictual processes of overcoming resistance, and the semiotic principle of entities being entirely a result of their relations. ANT has also been used by other IMP researchers, with the aim of combining the two approaches in order to better explain change and innovation in business networks (Mattsson, 2003; Araujo, 2007; Brekke, 2009; Hoholm, 2011).

This paper is based on a detailed case study of a fairly complex food-product innovation project called 'Salma', which was jointly created by the Norwegian dairy company Tine SA, and the seafood company Bremnes Seashore AS, from 2005 through 2008. Based on this study, we suggest that the most crucial frictions and confrontations that we observe throughout the innovation process can be productively analyzed as a dynamic and controversial interplay between two kinds of processes. One of these processes has to do with the efforts to *mobilize resources, activities and actors* by means of including them into particular framings which represent visions about rewarding future states, and through arguments that are meant to convince others to commit to the project. The other process is the *process of learning*, referred to here as 'knowledge exploration', by those working toward the project's materialization. Learning evolves through a combination of discoveries, positive and negative feedback, and creation of additional creative propositions about the true state of the innovation and what represents the most promising routes by which the project might advance. New framings are created, different actors and resources interact, and new arguments are being generated to pull the innovation project in alternative directions. Over time, these two processes typically evolve into different paths, where they later confront each other in new battles for resources and activities. They also vie over the commitment of the existing participants to the future process. The outcome of such controversies depends on the ability of each of the alternatives to mobilize support, practical solutions and arguments in favour of some alternative as well as on their ability to undermine the existing or other rival alternatives. In particular, turning around a previously established framing – with committed resources, activities and actors – typically involves deliberate efforts to undermine it. This is often done through rejecting or deconstructing some of its core elements or propositions, by mobilizing findings extracted from new learning processes.

We argue that structuring the analysis into this kind of bipolar process model leads to a more extended, realistic and precise understanding of how networked innovation processes evolve. It also reveals patterns that characterize the relationship between relatively stable business networks and the innovation phenomena we observe. It provides a better understanding of the mechanisms associated with some of the friction phenomena pointed out by others, expands the vocabulary to include 'confrontation', and enhances our understanding of the

controversies that are central to the divergence-convergence pattern of the innovation processes described by Van de Ven, Polley, Garud and Venkataraman (1999). Finally, we argue that the interaction between mobilizing and explorative processes provides an interesting alternative approach to, or expansion of, the "path creation through mindful deviation" approach argued by Garud and Karnøe (2001).

2. Knowledge gap and research questions

A substantial body of research has contributed to our understanding of business landscapes as being dominated by interactive business networks forming relatively stable structures over time (Håkansson *et al*., 2009). Even as we acknowledge this as a dominant characteristic of the business world, we still need to understand the processes of change, innovation, growth, decline, etc. Understanding the mechanisms of relatively stable, interacted business networks does not necessarily include an understanding of how they come about in the first place, of how they may change, dissolve or evolve over time, or of how entirely new or different networks may establish themselves among all those that are already there. We suggest that the concept of 'friction' (Håkansson & Waluszewski, 2001ab) based on the IMP understanding of embedded resources, can be fruitfully combined with a focus on controversies, and particularly what we call 'confrontations' in the relational view of network formation that can be found in actor-network theory (Latour, 1987). We argue that this combination of concepts and focus may help enhance our understanding and theorizing of networked innovation processes.

2.1 IMP and interactive innovation processes

How, then, is interaction conceived of within the 'interaction and business network approach'? First, actors do not seem to have free choice, due to their social and material relationships to others. Interactions are necessary to "be a business", and to get anything done at all. Still, when a real choice exists, interaction is sought for different reasons, including problem-solving, learning, innovation, efficiency or cost reductions (Ritter & Ford, 2004). Ford, Gadde, Håkansson and Snehota (2003:7-8) have employed the term 'networking' as a synonym to interaction in business networks, claiming that all companies engage in networking by means of "suggesting, requesting, requiring, performing and adapting activities, simultaneously". However, networks are often considered to be quite stable and difficult to change. The reason for this is said to be the result "of complex interactions, adaptations and investments within and between the companies over time" (Håkansson & Ford, 2002:133).

Johansson and Mattsson (1987) divide interaction into two categories, namely *exchange* and *adaptation*. In order to capture the interactional aspects of these categories, time needs to be included as a factor (Medlin, 2002, 2004; Dubois & Araujo, 2004; Ritter & Ford, 2004), because there seems to be a difference between *exchanges* that happen in the present, and *adaptations* that are being "planned in the present, exist as changes to resource ties and activity links in the future" (Medlin, 2002:7). Both concepts are closely related to past experience, present interaction context and future expectations. It would also be difficult to study emergent properties of networks, e.g., innovation, without devoting attention to time and timing (Quintens & Matthyssens, 2010). Overall, this resembles a research perspective investigating "the social creation of reality through interaction" over time (Medlin, 2002:4). Some authors have put resources (Waluszewski, 2004; Håkansson & Waluszewski, 2001a), and more specifically, knowledge, (Araujo, 2003; Håkansson & Waluszewski, 2007) at the centre of their analyses. In interactions, possibilities for finding new solutions are created, and

old resource combinations are confronted with new alternatives, producing additional variation based on having knowledge about different combinations (Waluszewski, 2004:146).

In their inquiry into why and how technological systems are so often difficult to change, Håkansson & Waluszewski (2001a) oppose the notion of 'inertia'. Instead, they introduce the concept of *'friction'* as representing a much more active force. They observed how resources across companies often seemed to be 'cemented' upon each other, and were therefore hard to change or replace, and yet resource combinations with seemingly unlimited stability sometimes suddenly dissolved. They defined friction as a relational concept, describing the relative force directed at each of the two interacting entities, causing them to mobilise across their interfaces. It is viewed as a transformational force, in that friction not only leads to movement, but also to transformations of the interacting entities. Furthermore, friction forces interact across historical and contemporary processes, and thereby lead to neither random nor deterministic change processes. Friction is viewed as an 'active force' in resource interaction, causing changes in existing resource combinations, with a strong tendency to favour existing (i.e. historical) values due to their accumulated weight – or 'economic heaviness' (Håkansson & Waluszewski, 2001b). Hence, although it includes the material and social aspects of resources, 'friction' is first and foremost an economic argument.

With regard to the effects of friction, it is argued that forces directed towards one resource will also affect all of the other resources with which it interacts. Hence, attention is directed toward *indirect* effects that are never merely local; such effects distribute across interfaces to other resources – also transforming them. It is further argued that such indirect effects are often more important than the direct effects (Håkansson, Kraus & Lind, 2010). One reason for the observed *stabilisation* effects in industrial networks is that friction connects the present with the past, thereby defending previous results and solutions (Wagrell & Waluszewski, 2009). This is a process of bringing historical entities together, as well as integrating new interfaces with existing ones in emerging interrelated networks (Håkansson & Waluszewski, 2001b:15). On the other hand, friction also produces *de-stabilisation* effects. Through friction, simultaneous processes are connected, allowing the same interface to be activated in several change processes. In this way, friction can also sometimes enforce change (ibid: 17).

Waluszewski (2004), Håkansson & Waluszewski (2001), Leek, Turnbull and Naude (2003), Medlin (2002, 2004) and Dubois & Araujo (2004) all call for the development of theoretical 'tools' to better analyze the dynamic aspects of networks. In starting out from studying established industrial network relationships and their relative stability and incremental changes, the IMP literature has left a gap in theorizing network formation and innovation. However, the emergence of networks and of innovation – whether in science or technology – is a core matter for Actor-Network Theory (ANT) research. Further, Mattsson (2003) and Araujo (1998) suggest that ANT could enrich and complement the IMP approach by explicating how human and non-human actors are related, and how social phenomena are 'performed' in emerging and heterogeneous networks, and by offering a more precise methodology for studying dynamics. Mattsson (2003) also suggests that ANT could benefit from the accumulated knowledge of the IMP approach when directing its focus towards economic and market phenomena.

2.2 Actor-network theory and the study of emergence

The particular strand of Science and Technology Studies (STS) called ANT has sought to describe and understand the rise, continuity and fall of socio-material networks, in viewing them as relational, heterogeneous and emergent. According to ANT, the social is unstable and

unpredictable, as any actor can, and often will, resist the exercise of power by others. Actors who are able to recruit others to their network by selling their discourse and making them dependent upon their knowledge, discourse and mode of ordering, will succeed in building their network, at least for a while. This is fundamentally a relational and process perspective (Olsen, 2011), viewing the world as in constant flux, and hence putting stability – and stabilisation – under scrutiny. This provides an interesting basis for studying innovation processes over time[1].

ANT maintains that "entities take their form and acquire their attributes as a result of their relations with other entities" (Law, 1999:2). Ontologically and epistemologically, ANT views reality as relational, and, as a consequence, as multiple and variable. Actors[2] must renegotiate positions and roles, mediate the expectations of different networks, and relate to truths in one network that are irrelevant in another. In several studies about knowledge production and innovation, Latour (1988, 1996) has demonstrated how knowledge is never just 'flowing', 'diffusing' or being 'transferred' through the system. Instead, he introduces the concept of 'translation', arguing that the object is always changing on its way, and not moving by itself. It is always up to the individual actor to decide whether to pass it on or not, in what way and in what form. Latour's (1988, 1999) concept of *networks* is accordingly one that emphasises 'work' more than 'net'. He argues that networks should be understood as processes of translation, association, deformation and transformation. This implies that networks a priori are *unpredictable* phenomena. The possibility of controlling networks in time and space is always questionable, and to deal with this variability ANT has developed a conceptual theory where power to influence and control others results from the work to relate and stabilize heterogeneous entities so that they together have persuasive effects. Hence, power is represented by networked – or chained – power-elements, and depends on the stability of the core elements as well as the ability of the given actor-network to hold the entire chain of power-elements together (Latour, 1991). Law (1992) adds that network ordering is also a matter of the uncertain process of *overcoming resistance*, and, similarly, Pickering (1995:22) describes the production of practice as "a dialectic of resistance and accommodation". In fleshing out pathways to a process perspective in organisation studies, Hernes (2007) sums up three implications of an ANT approach. First, no social order can endure over time, except via socio-material relations (Hernes, 2007:72). Second, these heterogeneous networks are kept together in and via recursive patterns that are repeated in time and space. Third, this means that entities (actors, resources, innovations, etc) are the outcomes of their relations. However, Hernes says little about the resistances and limitations that actors experience when trying to order things into (new) patterns, whether such resistances come from materials or practices (Mørk, Hoholm & Aanestad, 2006), politics of expertise (Mørk, Hoholm, Aanestad, Edwin & Ellingsen, 2010) or interaction in more extended networks (Håkansson & Waluszewski 2007).

We view the conceptualization of resource interaction in IMP theory and the basic semiotic logic of ANT as being fundamentally congruent in being similarly based in a relational, emergent, and process view of the world. Yet, they have emerged with focuses on different phenomena and with different academic opponents, and they have developed different sets of

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[1] For this special issue on time and process, it can be noted that from such a relational and process oriented logic, time is less of an explanatory factor than the outcome of the network building activities of the involved actors. Hence, time is interesting to study not as a cause, but as an effect of networking. Hence, the *timing* of action, as well as how different activity patterns influences time in different contexts, would need to be studied further.

[2] The 'actor' in actor-network theory might easily mislead unfamiliar readers; everything that acts is assigned actor-status, resources included, and hence ANT resembles more than the logic of IMP's resource interaction perspective.

vocabulary and operational analytical constructs. Even so, we see no necessary paradigmatic obstacles to combining the two.[3] While ANT seeks to study network formation by following controversies and how they are solved (or not), and IMP theory has conceptualized friction for similar purposes, it is worth noting that the 'controversies' and 'confrontations' as captured by ANT logic, and the 'friction forces' captured by IMP have somewhat different connotations. Friction forces refer to the economic dimension; specifically, regardless of whether all controversies among related actors are resolved, investments in place can still create friction forces which compel the innovation process to be more economically conservative. This industrial economic aspect of organizational networks and the conservatism of past investments in resources are consistent with Utterback and Abernathy's (1978) argument about the impact of 'investments in place' in the innovation process. However, this is not well understood within ANT, which has mostly studied scientific and technological practices, and only recently turned their focus toward the economic sphere (Callon, 1999). On the other hand, ANT has to a greater extent conceptualized strategic aspects, or what they call 'programmes of action', where preferences, intentions, interests and power are emergent properties of collective negotiations and coalition building. Different programs of this sort frequently confront and challenge one another, particularly during the shaping of innovative solutions. Thus, we suggest that these perspectives can be combined to get a clearer view of innovation being characterized by social, political and economic roots. By combining the understanding of industrial economic networks, particularly the friction concept from IMP, with the consistent relational logic of ANT, particularly the attention to controversy and the understanding of durability as an effect of developing socio-material relations, we argue that it is possible to gain a better understanding of some central mechanisms of industrial innovation processes. Before outlining our conceptual framework, and demonstrating its analytic value through a case study, we will visit some contributions to the process oriented innovation management literature, and thereby position our contribution to knowledge of industrial innovation.

2.3 Innovation management and process studies

Innovation process studies have been conducted in a variety of research camps across the management sciences. Kline and Rosenberg (1986) researched the intertwining of technology and economy in innovation processes. They claimed that economists had black-boxed the process of technical transformation, while technologists often failed to take the 'external forces of the marketplace' into consideration. From this perspective, innovation is a complex and uncertain process, and an "exercise in the management and reduction of uncertainty" (ibid: 276). A few years later, Von Hippel (1988) became a major proponent of considering the market – in the form of users – as internal to the innovation process, granting full interactivity to those 'users', who influence the innovation and its fate by using, modifying and/or rejecting it. According to Pavitt, only two aspects of the innovation process are generic: "coordinating and integrating specialised knowledge, and learning under conditions of uncertainty" (Pavitt, 2005:109). The risk of failure in innovation processes will increase "with the number of practices and competencies that need to be changed" (Pavitt, 2005:105). Innovation typically consists of contingent processes, stemming from interaction between science, technology and markets, and thereby representing high levels of uncertainty.

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[3] We acknowledge that there are several ontological and epistemological views represented among IMP researchers. For example, Easton (e.g. 2010) has made an argument for basing IMP and industrial marketing research on critical realism, which is a somewhat different position to our 'constructivist' position. This is an interesting discussion that we cannot address within the scope and spatial limits of this paper. Still, we maintain that IMP's conception of resource interaction is congruent with Actor-network theory. See Hoholm (2011) for an extended discussion.

The longitudinal comparative studies of innovation in the Minnesota Innovation Research Project (MIRP), reported in Van de Ven *et al.* (1999), has become a major point of reference for anyone studying innovation processes. Their main thesis is that the common pattern of all innovation processes is "a nonlinear cycle of divergent and convergent behaviours that may repeat itself over time and reflect itself at different organisational levels" (Van de Ven *et al.*, 1999:213). The ability to manage complexity is viewed as being crucial for success. Again, learning is considered to be a key aspect of the process, where 'learning by discovery' is understood as "an expanding and diverging process", and learning by testing as "a narrowing and converging process" (ibid: 203). Their data demonstrate how a given innovation path typically diverts into multiple paths of exploration directed towards different perceptions of economic opportunity. In their study, they also found that managers' performance criteria shifted over time, both in relation to outcome, process and input, and in line with the changing needs of the innovation process, as well as the unexpected events that occurred. Such changes "triggered innovation managers and entrepreneurs to redefine their innovation ideas and strategies" (Van de Ven *et al.*, 1999:42). Seen as controversies these observations are concerned with fighting over alternative framings, orders of meaning and deciding where the innovation should be directed. Beunza and Stark (2004) and Howard-Grenville and Carlile (2006) support this argument, in showing how the negotiation of evaluation criteria is fundamentally a political process through which power relations are changed and re-constituted over time. In order to succeed with innovation, it is necessary to acquire and build persuasive chains of power via coalition building.

Garud and Rappa (1994) observed how beliefs were externalised by creating routines, which in turn were used to evaluate the technology in a self-reinforcing circle. However, the influence went both ways, as the technical artefacts also severely impacted what types of evaluation routines could be employed. On the 'positive' side of technologists' blinkers, Garud and Karnøe (2001) have investigated the role of (and space for) agency in shaping new technical paths. They argue that 'mindful deviation' is a central characteristic of how entrepreneurs contribute to 'path creation', and thus towards implementing new ideas in the economy. However, none of this really explains how and why controversies, confrontations and frictions emerge, how they are important, or how and why particular pathways get chosen before others. Hence, it is still quite unclear how stability and change are related in innovation processes.

2.4 Research questions

Latour (1987; 1996) explicitly advises the researcher to trace controversies, since this is where the 'black-boxes' are destabilising, and hence enable an observation of how 'new' socio-technical networks come about. In order to identify a suitable case, we elaborated on Van de Ven *et al.*'s (1999) definition of a 'generic innovation journey', emphasising innovation processes whose purpose is to develop a novel idea, yet constitute substantial uncertainty regarding the market, technology and organisation. Furthermore, they emphasise processes that entail a collective effort over time, and require greater resources than those possessed by the people who undertook the efforts (Van de Ven *et al.*, 1999:22). This resembles the IMP's argument for making relationships the unit of analysis, as well as the call for more studies of the dynamics of interaction (e.g. Ford & Håkansson, 2006).

As shown in the literature review, innovation processes are highly interactive, involving a number of both human and non-human elements, where the outcome – on almost any parameter – is not given at the outset.

We posed research questions that could help us capture at least some of these aspects, and we started out with two premises: (1) From IMP we learned that 'new' entities are never created out of the blue; they will always be derived from something that already exists (past activities and investments). (2) From ANT and its 'material semiotics' we might say that it is the *association* that is new: Ideas of how to re-combine, translate or transform existing entities into something new. Thus, the research questions we pursued were as follows:

- *How do interactive innovation processes evolve over time?*
- *How is knowledge translated, transformed and combined in processes of innovation?*
- *What are the contrary forces (frictions) of innovation processes?*

In starting out by acknowledging the presence of controversies in innovation, we wanted to understand more about what dynamics produce and fuel the inherent tensions of innovation processes. Further, we seek to understand how these dynamics influence the process, and how the conflicts are settled. 'Knowledge' is here understood and studied in a particular way: it is only analyzed in terms of how it is materialised in technologies and work practices. The focus is on *knowing*, or the doing of knowledge. It is a performative construct inseparable from the historical, social and technological setting in which it is embedded (Law, 1994; Araujo, 1998). Moreover, innovation is about the entire process, from an idea's inception until its eventual implementation/commercialisation (or failure).

2.5 Methods

The case study was part of one of the author's PhD-projects, and was mostly conducted as real-time ethnography (Hammersley & Atkinson, 1995), which entails observing the actual processes as they happened in order to produce 'thick descriptions' (Geertz, 1973). We have therefore been able to reconstruct the innovation process without some of the well-known methodological problems of post-hoc rationalization and 'closure' of the story by the involved actors (Law, 2004; Watson, 2011; Hoholm & Araujo 2011). In addition, it was necessary to trace parts of the process back in time via document analysis and interviews, because it turned out that certain historical events became important to the subsequent process (Hammersley & Atkinson, 1995; Quintens & Matthyssens, 2010). Several months were spent conducting participant observation at the focus firm (Tine BA, a Norwegian dairy company). Over that period 35 formal semi-structured and open-ended interviews were conducted (including both corporate management and a set of partnering actors), and all available project documentation was examined. Ethnographic field notes were written during participant observation, and all interviews were taped and transcribed. The analysis was a circular process, moving back and forth between literature and empirical data, searching for 'patterns, contrasts and paradoxes' (Coffey & Atkinson, 1996). The model presented and discussed in this paper was constructed as an outcome of this process (Visconti, 2010), and then used to interpret the case and pull out the implications for innovation process research and practice (Hoholm, 2011).

3. The case study setting

Agriculture has developed into a highly industrialized and an increasingly global sector. Tine SA has for decades been the dominant actor in the protected Norwegian market, although it is increasingly experiencing pressure from international competitors. Hence, it has identified innovation to be crucial to its future success. While the seafood sector is transforming more towards cultivation than catch, industrialisation of processing, and also product development; marketing has not yet taken full advantage of this increased control over the raw material. Tine R&D had already been working on a few bio-marine projects, seeking to combine

ingredients from milk and seafood in various ways, e.g., applying marine oils in dairy products.

What we will describe is the emergence of a possibility: the possibility of radically advancing into the production and marketing of unique seafood products, and several very early attempts at doing so. We traced the departure of the process back to Professor Slinde at the Institute of Marine Research in Bergen, a creative scientist who tried to use a technology known from agricultural products; fermentation, to help advance industrialization of fish. Tine SA sought new opportunities for business in the bio-marine area to expand on the back of its established knowledge and technologies within the dairy industry. In addition, Bremnes Seashore, a seafood farming company, looked for ways to generate more economic value from its investments into new technologies for processing of supreme quality salmon. Along with a research group from the University of Environment and Life Sciences at Ås, Bremnes Seashore between 1993 and 2004 had invested around 40 million NOK into developing technologies for slaughtering and processing salmon, however, this failed to yield positive economic rewards during that period. Hence, they sought out partners that could help them commercialise on the new technology. Then Tine arrived on the scene, representing an opportunity for them to acquire a share of agricultural competence and infrastructure for product development.

The product that during this process came to be named 'SALMA Cured' was in the most basic sense a combination of fish as raw material and fermentation as technology. Traditional salami recipes served as the point of departure for the project. However, in the end, the product that the consumer could find at restaurants and in supermarkets was very different: 'SALMA Fresh', loins of high-end quality salmon. Still, the story behind this product is much more complex than the neatly designed transparent package of high-end salmon would suggest. It is a socio-material drama consisting of several partly overlapping episodes[4], in which the actors struggled to cope with a broad set of challenges.

4. The case study: The making of Salma

The story can be said to begin with a single researcher within the food sciences. Having worked as a scientist both at the Food Research Institute and at the Institute of Marine Research, Professor Slinde wanted to encourage product development of fish: *"Let's take some food technologies, and then apply them to fish, using fish as raw material, and using agro-food processes, and one of the processes that I know really well is production of salami. I thought to myself, ok, we can make a salami out of fish" (Prof. Slinde, Institute of Marine Research).* From this experimental recombination of technologies and materials, the idea of making salami out of fish was tested. It soon became clear that the high fat content in salmon (between 10 and 30%) would be a technical challenge. To enable stabilization of the fluid fatty acids, a mix of red and white fish was deemed necessary. In addition, white fish, such as saithe, was much cheaper than salmon. The first experiments did not go very well. Yet, even though he thought of the experiment as a failure, Slinde still brought the results back to his fellows at ForInnova, the University of Bergen's Technology Transfer Office, and the Norwegian Research Council: *"And then I went back home, and arrived with these nice packages, right, a little like 'decorating the bride'. And these guys ate it, and said it tasted delicious. So, I thought that, if three economists are sitting here telling that this is good stuff, then I am sure I can make it better" (Prof. Slinde, Institute of Marine Research).*

[4] For the complete case study, see Hoholm (2011).

Slinde's interpretation of the situation, even in hindsight, was ambiguous. On the one hand, the first experiments failed, and he was actually heading home without positive results. Still, just to be able to show *something*, he 'decorated' the fish salami and let the businessmen have a taste. One of the Research Council representatives later said he thought the product tasted "awful", but that they thought it was a fascinating project. Some of them had a good relationship with Slinde. Thus, it was decided he should conduct further experiments and start developing a business plan for the project. After more testing, and finding that the technology would be feasible, Slinde filed a patent application. Along with the technology transfer office, Slinde started presenting his invention at national and international food fairs to find partners or to sell the patent. The dairy cooperative Tine had been collaborating with him in the early product development stages through one of their researchers and by supplying some ingredients. After some time, Tine decided to buy the patent application and start a project they called "Umi No Kami", for product development and commercialization of fermented fish products.

Umi No Kami had to get a professional team of people involved: scientists, technologists and people with expertise in marketing and design. In addition, it was strictly tied in with Tine's innovation strategy, hence also involving the top-management when setting or changing the direction of the project. The objective was ambitious: *"The purpose is to develop a series of fish products that take part in creating a whole new category of fermented and dried fish products in the food markets that are profitable, and that the consumer wants. The product is to be sold both in Norway and internationally" (Status report, Umi No Kami 2003-06-20, Tine R&D).* They knew the project would require time and money, and to legitimate this use of resources, expectations of great profit had to be demonstrated. The first hypothesis had been (partly) confirmed: it was possible to make salami out of fish. Now the issue was about making the product edible and stable in production.

4.1 Is it possible to get better raw material quality?

Based on their experience from the agricultural industry, the project team was conscious of the microbiological challenges associated with the product, and another hypothesis emerged: raw material quality can both improve stability in production and make the product more edible. From this perspective, the supply of fish – especially white fish – was a severe problem. Several suppliers were tested, and the team worked with some of them over time to have them improve the microbiological quality of their processing, but did not succeed. This led the technical project participants through a long exploration process. First, raw material variation was explored by testing different combinations of saithe and salmon, along with tests of several other white fish species. Second, they experimented with frozen raw materials to enhance the drying process. Third, they pushed harder to obtain from their supplier a higher microbiological standard (i.e. hygiene). Finally, the alternative idea of using only salmon – or at least as much salmon as possible – remained an option, even though costs were substantially higher.

In order to manage the problem of fat content in a pure salmon product, near-infrared spectroscopy (NIR) was launched as a tool to sort out fish with low fat content. Swensen, a researcher who had been working with NIR-technology at the University of Life Sciences, was hired. Controlling the fat percentage in the fish was thereby improved, but then only the best parts of the fish could be used. This was very different from meat salami where low quality trimmings are commonly used in the recipe. After two to three years of research, the product developers could be quite specific about the transfer of this meat technology to fish.

While the bacteria culture worked in a similar way with fish as well as the subsequent pH- and drying processes, stabilising fat was a lot more complex with fish. They needed to strictly control the fat content, add proteins to encapsulate and stabilise the fatty acids, and use fresh premium raw materials instead of frozen trimmings. In sum, these were significant changes needed to adapt the technology to fish, resulting in the product being both more expensive and more challenging to produce.

4.2 What is 'fish salami'?

Next there was the question of the market. Should the product be targeted towards the exclusive 'gourmet' segments, or towards the larger market for 'everyday products'? In the high-end segment the competitors were considered to be fish products, like smoked salmon and 'gravlax'. In the segment for mundane everyday sandwich fillings, competitors would be various meat products, like salami, ham and pepperoni. Broadly speaking, these two competing suggestions about what the market for this invention would be, had been present from the very start. Thus, early in the process the project team went abroad to study food cultures and potential markets. Both the idea and a prototype of the product were presented to industrial firms in each of the visited countries. According to Mogård, who was responsible for the internationalization of the project, these very early market studies identified "areas in which such a product could work", most likely within the fermentation traditions in Spain, Italy, Germany and in Asia, particularly Japan and Korea. These countries were also identified as markets with substantial purchasing power.

The initial motivations that formed the vision and business plan for the Umi No Kami project were important for its direction, formatting its 'framework conditions'. This was partly the result of the top-management's decisions to buy the patent, formalize and fund the project, and partly due to the patent application itself: *"One of the conditions that was very important was that we had to use white fish, mixed in with red fish. And then, when we started developing a communication platform and name, we talked a lot about 'Sea Salami', and all such 'salmon'-things, right, but this was out of the question, as we would then be limited exclusively to salmon, and we could not do that" (Torvanger, Tine R&D/marketing).* At the time, these preconditions were experienced as being rigidly stable and restrictive, and attempts at modifying the framing were not approved by the top-management. Later in the process, however, things could suddenly be changed. An increasing impatience within Tine's management, combined with the initiation of a new relationship between Tine and Bremnes Seashore via newly hired researchers - and a new raw material; pre-rigor salmon, changed the 'rules of the game'.

A new director, Hovland, was hired for the business unit now denoted Tine Biomarin, at a point when Tine had invested a great deal into agro-marine venture activities without seeing any signs of success. Although Tine Biomarin had a long-term perspective, it was time to start demonstrating some commercial results. This was around the same time Swensen and a group of researchers were hired by Tine R&D. They soon learned they shared some common interests. Hovland interpreted his mission as being one of "cleaning up the mess", i.e., structuring and organising the activities more efficiently, and evaluating what to do next. Swensen called this a 'coup' of the Umi No Kami project, in order to generate more momentum towards commercialisation. Moreover, the shift enabled a radical break with the original Umi No Kami concept. The result was a shift in the project, from being a R&D-based project to becoming a commercial venture.

The original project group had feared Hovland's scepticism to the entire project; that he would close it down as part of his task to restructure Tine's bio-marine activities. But then Hovland was introduced to the pre-rigor salmon from Bremnes Seashore. This triggered enthusiasm and new hopes for the Umi No Kami project. The use of pre-rigor salmon in the recipe turned out to improve the technology, the texture and the taste. It was decided to remove white fish from the recipe, something the earlier project group had not been allowed to do. The framework conditions had changed. Tryggestad, who was a member of Tine's board of directors, could confirm the story of 'the coup' and of impatience with the management regarding the Umi No Kami project. They were uncertain about whether the project should be pursued further, and if so, how? Hence, the shift was accepted as a 'necessary change' due to the declining belief in the earlier approach among top-managers. Following this shift, the project team was radically altered, and the new commercialization manager, Kiland, soon went out to present the product internationally. With the new raw material, the innovation shifted to become a pure salmon-based product, called 'Salma'.

Large restaurant or catering actors were regarded the 'ideal customers' in this project, probably demanding fewer adaptations – and thus lower costs – particularly with regard to packaging and logistics. After conducting promising meetings in Asia with a multinational restaurant corporation, Salma was taken back to the laboratory. In order to bake well in a pizza oven, it needed less drying, probably no smoking, and could possibly accept lower quality standards; in other words, it could become a product that was easier, faster and thus cheaper to make. However, when returning to the company with the good news, nothing happened. Whether they had lost interest in the product, lacked trust in Tine, or if their contact person had gotten a new job, we do not know. Anyway, the prospect of what had been considered the 'ultimate customer' had reached its end.

Next, Tine's German agent became interested and wanted to test it in German hypermarkets. He soon put the initial, unsliced package out for sale in KaDeWe, Berlin's huge and prestigious demonstration store for food products: *"We had promotion women presenting it and giving it out to tasters, and in a few days we sold 10 cartons, 100 salamis. What we saw was that without tasting it and with very little knowledge among consumers, and a high price, it was very difficult. However, when people got to taste it, most liked it" (Martens, DM-Nor).* Several lessons were learned in this German market test. First, customers required knowledge about the product: what it was, how to use it, its benefits compared to alternatives, etc. This had to be inscribed on the packages and presentation materials. Second, slicing the product and reducing its size would be beneficial. A new design and packaging for the German market was developed, and sizes were adjusted. Armoured with presentation materials, a suitable package, and a novel and branded product, Martens went to the retail chains with the product. Salma was ready for test sales in 90 German 'hypermarkets'. But the sales of the 'Lax Salami' did not go particularly well. From this test, it was realised that Salma, in this form, had little chances of commercial success in German hypermarkets. Thus, one by one, the hypotheses about Salma's market potential were rejected.

4.3 How can hygiene be improved?

While planning for the scaling up of production, a joint venture was established between Tine and Bremnes Seashore. Bremnes had the role of producing Salma, and processing facilities had to be built at their property. A discrepancy between the two companies on production practice already started to appear when buying machines. While Tine normally would buy brand new and high-end equipment, the management at Bremnes mainly bought used machines. When the production started, the difference also became apparent through their

rather different routines related to hygiene; both during production and cleaning. The first problem that occurred had to do with mould. Suddenly, a couple of weeks into production, the entire batch of salmon salami in the drying facility was covered by mould. At the same time, Kiland had made plans for an international marketing tour, to be started just a few weeks later. This triggered an intense period of identifying and fixing the problem: the technical facilities needed to be upgraded and adjusted, and the control routines were tightened. The second problem was related to microbiological activity within the product. Tine, who had a great deal of experience with the processing and distribution of fragile dairy products, was surprised by the low standards of the fish industry with regard to bacteria levels. This affected the shelf-life of the product, and hence costs and logistics. Tine R&D mobilized some of their biologists and production specialists to teach the Bremnes management and train its production and cleaning personnel, and after a few months of hard work they were able to reduce the total bacteria counts in the products by around 75 percent. In sum the main aspects of technology development, several intertwined technical and biological problems had to be solved before being able to produce the fish salami with the expected biological and nutritional quality.

4.4 Do you want salmon salami or salmon loins?

As hinted at in section 4.2, a competing hypothesis about the market was emerging in the Salma team: the idea that the prerigor salmon loins had their own commercial value and did not really need to be combined with the salami technology. By this time, Tine and Bremnes Seashore had invested quite significant amounts of time and money into the salmon salami project, and it was not uncontroversial to admit that the salami was difficult to sell, and that they should focus on the raw material instead. In visiting various marketing arenas, Kiland was continuously seeking to make sense of the project through meetings with customers, colleagues and partners. Sometimes, he was almost doubtful about the potential of selling the sausage at all: *"If you have the best beef in the world, and then you mince it and make a sausage out of it, and you sell it for a high price, then you would think that you also could sell the beef. If you had started this from scratch, you would never have started with the line extension; you would have started with the salmon" (Kiland, Tine SA).* In his customer presentations, he spoke first about the superior pre-rigor salmon filets as a prerequisite for the salami, and thereafter, he presented the salami. In the back of his mind, he had a feeling that the raw material, the pre-rigor salmon filets, could be easier to market and sell. This was clearly confirmed on several occasions by potential customers, so Kiland and Hovland gradually developed the argument for including a fresh salmon loin product under the Salma brand, and eventually succeeded in convincing the top-management in Tine to endorse this change of direction.

Then Kiland brought his delicate packages of salmon loins to a high-end supermarket; Jakob's in Oslo, and their fresh product manager immediately became interested. Within a couple of weeks, they were ready to start an introduction campaign in the store, which resulted in great sales for the new product. Jakob's was associated with Norway's largest retail chain; Norgesgruppen (controlling 40% of the Norwegian food retail market), which also got very interested. Tine already had a close relationship to this retail corporation through its dairy products. Soon a roll-out plan was launched to promote Salma Fresh in a number of its 'Ultra' and 'Meny' supermarkets. At the same time, several gourmet chefs had found Salma loin to be a great raw material, and became charismatic advocates for it. Suddenly, Salma was moving towards becoming a commercial success story. From this point the salami was no longer mentioned as part of the concept, at least not in public; the twisted path towards this success story was carefully being reconstructed and at least partly deleted. The stories about

the roots of the Salma project stopped being represented. The research to figure out the receipt of a fermented fish sausage, the tremendous work to stabilize fatty acids, the role of milk proteins, etc were all moved aside and forgotten.

5. An analytical model for innovation processes

From oscillating between established theory and case study, we have developed a conceptual model for the study of innovation processes. We suggest that innovation processes may fruitfully be conceptualised as a dual process: After garnering attention for the innovative idea, and thus *staging* it for further exploration, a process of *mobilising actor-networks*, or getting the rights, alliances, space, time and resources to innovate is set in motion. This forms the basis for a process of *knowledge exploration* in formulating and testing propositions about reality, which also means interacting: because reality, people and things, often 'speak back'. Thus, we suggest a bipolar model (figure 1), in which the particular dynamics between the two poles of a concrete innovation process become a central part of explaining that case.

(Figure 1 here)

Figure 1: An innovation process model.

It is clear from our empirical research that the processes of exploration and mobilisation are neither completely separate, nor completely intertwined[5]. How and when these sub-processes *interact* and the implications of this interaction seem to be important for understanding innovation processes. Sometimes these 'sub-processes' draw on each other. At other times, they do not interact at all, and at still other times, they *confront* each other – with potentially serious implications for the innovation. In addition, this dual process occurs within a *network of interconnected processes* (figure 2), which creates resistances and constraints, as well as enablers for innovation to move in certain directions rather than other. Hence, friction forces will always be present between the new and the old.

From this model, we get two different perspectives on the time (and timing) of innovation processes: first, the time of a particular innovation process, and its 'program of action' (strategy, interests, and the reach of its relationships). Second, there is the heterogeneity of time frames present in the larger network (figure 2), related to all sorts of interacting processes (and their strategies, interests, and relationships), and to which the particular innovation process will have to connect in order to move towards realization. Although the particular innovation process will build its own path, and gradually become embedded in its own set of actors, resources and activities, it seems to be primarily within the larger network that it is likely to provoke a clash between the old and the new. The ability to adapt to the established network, with its 'investments in place', or 'economic heaviness', represents a crucial test for the innovation. Nevertheless, innovation is fundamentally about creating new

[5] When we use the terms 'process' and 'sub-process', we do not mean to say that there is an objective 'whole' that may be divided into distinctive parts. Rather, as with most conceptual models and analytic frameworks, this is a matter of delimiting cases, research objects and research questions. What we call sub-processes in our case study may well have also been parts of other processes, serving other interests, and in fact this is part of our argument. The interconnecting or embedding of different processes with different time frames and different interests serves as a crucial challenge during the innovation process. The model depicts aspects of innovation *processes*, and does not refer to particular entities or actors, but rather to kinds of activities and processes and their logics.

combinations and relations in space and time. Hence, there is a necessary gap to cross between the old and the new. Innovation inevitably takes the innovators further away from the established network practices and the heaviness of previous investments, thus leading to more open confrontations and greater challenges of both relating and adapting to what already exists. Thus, it becomes very clear, not only how difficult it may be to develop the innovation itself, but even more how complex it may be to realize and stabilize innovations in, or even worse, across, industrial networks.

(Figure 2 here)

Figure 2: Innovation processes, situated in networks of interconnected processes.

The framework we suggest here did not emerge *before* the fieldwork; rather, it is an outcome of the combination of process-based theory and observations in the field, of recording these and trying to discriminate between what kind of activities and 'sub-processes' are happening in practice, and pairing them with the logic of an interaction process view. Below, we develop some theoretical implications.

First, we need to ask whether a productive distinction can be made between these two processes of mobilising actor-networks and knowledge exploration. Is knowledge exploration also a matter of mobilising actor networks by negotiating socio-material relations? If so, what is the difference between the two? Several of these activities, although analytically separable, actually interact with each other. Mobilisation of actor networks and activities may have more or less immediate influence on the exploration, and vice versa. However, it takes different tools, including skills, strategies and resources, to (1) recruit and mobilise elements, and (2) make them fit and hold together. Thus, we see two main processes inside developing an innovation, the first, called 'mobilising actor-networks', typically consists of the political activities of (re)presenting, convincing, forcing and negotiating. The second, 'knowledge exploration', consists of knowledge generation. This involves exploring and stabilising relations between elements, such as ideas, materials, technologies and procedures, as well as formulating propositions and testing them in practice.

6. A theoretical interpretation of the case

6.1 Staging of innovation processes

The initiation of innovation processes, what we call 'staging', is when something happens somewhere: someone asks a question, investigates something or incidentally discovers an opportunity. In the case study we saw how new techno-scientific ideas emerged from curious experts through spanning the boundaries of their knowledge, facilitating interaction between actors such as Tine SA, and various elements from different epistemic and industrial fields. An idea emerges from the meeting of different perspectives, realities, knowledge and experience. As demonstrated in this case, technologists are often seeking to supplement technologies through re-combination or the idea emerges from the investigations into potential use of and markets for their inventions. At other times, it is marketers or customers who express a demand for a solution to some particular problem. At still other times, it may be managers who seek to renew their organisation. In this particular case the top-down development of Tine's agro-marine innovation strategy clearly supported the bottom-up initiative of the R&D department. What all such situations share when initiating an innovation process, is that an idea has to be brought to attention, generate the interest of various actors and mobilise a minimum of resources spread through space and time. Sometimes it is

necessary to stick with the initial question for a while before finding an opportunity to do something further with it, that is, stage a new process of exploration and mobilisation of resources (Spinosa *et al.*, 1997). This cultivating of the ability to formulate questions beyond the present knowledge domain and industrial path is what Garud and Karnøe (2001) associate with the ability of 'mindful deviation'.

6.2 Mobilizing actor networks

After formulating the question, putting it on the stage and generating some interest in it, the problem immediately arises of how to mobilise the time, space, actors and resources needed to start the innovation process. In our case study, Professor Slinde had to show that there was something to explore, through conducting initial experiments and making convincing presentations of the premature materialisation of the idea. Further, he had to enlist actors with money and expertise to participate in its further development, in this case by exploiting his established relationships with people within funding bodies, a technology transfer office and at his present and previous research institutes. However, this was not a one-time operation. Throughout many of the processes in this case study, the innovators repeatedly had to mobilise renewed support and more resources from their allies, and find new partners: Tine's owners and management had to be convinced time after time that the project had potential. New employees were hired to improve the aquaculture knowledge in the project. Bremnes Seashore and their excellent raw materials were mobilized to advance both the product technology and the market potential. Finally, a number of market actors were recruited – or sought, such as the restaurant chain, the German hypermarkets, Jakob's supermarket, and Norgesgruppen food retailing corporation.

We also saw how a number of arguments were used, and how several actors were appointed as representatives for the project – or rather for the *potential* of the project. Most notably, this could be seen in the Umi No Kami business plan related to certain 'food cultures' and aiming for a huge international market success. Also, when mobilizing both the Tine and Bremnes managements for including fresh salmon loins under the Salma brand (a French distributor was used as a possible buyer, along with anecdotes about certain positive responses from US retail purchasing managers). This is a pragmatic process: making the most of what one has in convincing and negotiating to expand the actor-network and access resources. Following the semiotic argument relatively coherent *chains of arguments* have to be constructed to mobilise time, resources and decisions. In addition, there is the work of enrolling and aligning a set of actors and resources into an 'actor-network', getting them to represent and support the project, and keeping them interested over time, while also doing the exploration work. The immature object has to be taken through several translations: from idea, to prototype, to research application, to patent application, to product, to use and exchange, etc. This partly depends on mobilisation of the actor network, the construction of meaning and the mobilisation of chains of trustworthy arguments.

6.3 Knowledge exploration

Exploration, on the other hand, is about testing whether these ideas and propositions hold up technically and in the market. Is (or can we make) this idea technically feasible? Does it (or can we make it) fit within the distributor's product categories? Does it (or can we make it) fit within the using practices of consumers? How much are they willing to (or can we make them) pay for it? When they have actually succeeded in mobilising some resources and convincing some people to give the idea a try, then they have to make it work in practice. This process of knowledge exploration, of 'making things work', involves a process of formulating and re-formulating propositions about the potential 'reality' of the innovation, and then testing

them out in practice. It is a two step process: first of creatively imagining potential social and technical relations and then testing in practice whether – and in what way – such relations are possible. An analogy to this process would be that of the scientific method, of formulating a research question or a hypothesis, and conducting practical empirical experiments to see if an answer to the question can be found, or if the hypothesis may withstand the test. This is not a one-way street of actors seeking to impose their will onto others, but rather an interactive, or we could say, negotiated process. When testing a relationship between elements, e.g., between fish and fermentation culture, between proteins and fatty acids, or between salmon salami and its users, the innovator enters his own picture, so to speak, and becomes involved with – and a part of – the object. Thus, not only does the innovator test a relationship between elements, but the innovator himself experiences how the elements 'speak back', i.e., accept some relations while rejecting others.

Moreover, this testing and making of relationships changes the innovation - often in unpredictable ways. Although it equips the innovator with some creativity and agency, innovation as a recombination of resources and restructuring of activity patterns is not a matter of the heroic entrepreneur's unlimited agency. The proposed relationships between technical, social and economic elements have to be tested and negotiated, and then reformulated and renegotiated, often several times between the involved parties. Precisely because exploration starts out with imagination, and because the objects being explored 'speak back' and bring in their own preferences, it is not possible to be sure whether – or how – the imagined recombination of elements might work. Knowledge exploration produces development risk, as there will always be uncertainties, and, in the case of more radical re-combinations, the number of such uncertainties causes indefinite development risk. This part of the innovation process is about developing 'chains of propositions' – from testing whether a technology is feasible, to testing whether such a product will find paying users and hence produce economic value.

6.4 Interaction and controversies between sub-processes

However, as previously mentioned, the processes of mobilising others and of knowledge exploration are not fully separable. Sometimes 'chains of power/arguments' (mobilisation) and 'chains of propositions' (exploration) interact with each other; borrow elements from each other or confront each other's aims and outcomes. This does not happen continuously. After mobilising a set of actors and resources and starting the exploration process for shorter or longer periods, there may be limited or even no interaction with the mobilisation process and the original idea and perceived opportunity. When observing such processes over time, we can see that there are discrepancies between what was agreed upon in the mobilization of decisions and resources, and what actually ends up being explored and realized, whether they be technical or commercial issues. Yet, when resources run out and new resources have to be mobilised, or when allies start getting impatient (i.e. the management at Tine), or are disappointed (i.e. Bremnes management and Tine R&D), the exploration process may be confronted for its lack of progress, its departure from the original vision or its need to reorient towards enrolling other and different actors and resources, as in our case study. Such confrontations between the mobilized idea network and the actual exploration/realization process will often threaten the whole project, and if it is allowed to continue, it is likely to change direction.

Discoveries and knowledge generated in the exploration process may challenge the mobilised actors to rethink and change their ideas, interests and participation, thereby supporting the project in exploring new directions and propositions. The ways in which such interactions and

confrontations come about and what they lead to should be of particular interest to researchers of industrial innovation, as this would reveal some of the generative and limiting dynamics of innovation processes. Where new meanings are negotiated, choices have to be made and new courses of action pointed out.

7. Theoretical implications

7.1 Contrary forces

By constructing and amplifying the distinction between mobilisation and exploration in a bipolar model like this, we find that we can explain some of the micro-dynamics of innovation processes from an angle that, to the best of our knowledge, has not yet been sufficiently described in the literature. First, during (sub-)processes of *mobilisation*, actor-networks are recruited and committed to things with which they are initially unfamiliar: an idea, a prospect or a prototype of something that may or may not become feasible and usable. Yet, to enable mobilisation, a degree of certainty has to be presumed. Second, during the (sub-)processes of *knowledge exploration*, the aim is to create knowledge – to explore the object and its potential – and therefore change is unavoidable. Moreover, this process of generating knowledge tends to multiply the alternatives of the object, and hence increase, rather than decrease, the uncertainty/complexity – or development risk – of the project. Mobilisation and exploration are contrary forces in this model, and sometimes it almost appears as if the innovation process is at war with itself. Whereas mobilisation is directed towards aligning interests and reducing risk, exploration is directed towards formulating and testing propositions about reality. While mobilisation seeks to converge, exploration frequently leads to divergence for the innovation. This suggests a revision of Van de Ven *et al*'s (1999) model that depicts divergence and convergence as sequential parts of the innovation process. Divergence and convergence should instead be analyzed as the effects of contrary forces within the innovation process, sometimes sequentially following each other, but more often running in parallel and leading to friction when they interact. Finally, the *interaction* between mobilisation and exploration processes on the one hand, and between different actor-networks/organising processes on the other, often leads to controversies and compromises that may send the project off in new directions. This means that innovation outcomes are never given 'by the order of things', but instead are the result of a series of negotiations and knowledge explorations over time.

7.2 Uncertainty, knowledge and power

The presence of a number of uncertainties – 'nobody knows' problems – frequently produces high development risk in innovation projects. Although they are experts in their respective fields, we argue that the innovators lack of knowledge has to do with the connection and translation of knowledge and technology between settings. In putting knowledge and knowledge constraints at the centre of attention, the framework suggests that innovators have to produce two different kinds of activities. First, to gather a chain of arguments suited for convincing, mobilising, maintaining and removing parts of actor-networks and their resources. Second, they need to produce testable propositions about reality, e.g. how to make the technology work and what users might have an interest in such a product.

Innovation processes are propositional at their core. The original idea is a proposition about the potential that may stem from a new combination of elements. This idea needs some resources to get started, and then the idea needs to be explored in practice – testing whether and how the proposition may hold. This will normally happen by breaking the original idea into a series of new and 'smaller' propositions; as the innovation is opened up and investigated, it is revealed as being a more or less complex set of problems, all having many

different solutions *in potentia*. However, in order to enlist allies, it is necessary to make the idea and concept converge on a number of aspects, and this will often create a 'lock-in' for the subsequent process – at least for a period of time.

The mobilisation of actor-networks is based on a relational logic of 'power production', i.e., of carefully building, or connecting to, networks of human and non-human elements with interests in realising the innovation. In this sense, this part of the process is about producing power effects, i.e., mobilising actors and resources on behalf of the innovation, and translating their interests into a common project. Still, if and when an actor-network is mobilised, the elements employed in the chain of arguments may produce frames and evaluation principles that define the project's room for action. Hence, temporal lock-ins may be enforced that cannot be easily broken out of in the subsequent parts of the innovation process.

In the interaction between potential allies during efforts to stage and mobilise resources for innovation, space and time is created for the *exploitation of knowledge uncertainty*. Different actors have different experiences and expertise related to the characteristics and potential of the elements recombined into a new idea, and they are situated within different sets of relationships. However, few – if any – know what it takes to relate previously unrelated elements to each other. During the process of building arguments to convince others to support an innovation, presumptive competent actors are mobilised to represent the innovation as something worth pursuing. However, a part of this is also that asymmetrical knowledge and experience may be used by the more informed and experienced actor to influence – and sometimes manipulate – the other. Such manipulation is obviously also about mobilising apparent, at least temporal authority. Hence, if more 'radical' ideas will be impossible to evaluate in objective terms, those who have more experience with some of the elements involved may be able to exploit actors with less or other types of experience. Choices regarding innovative ideas always have to be made based on limited knowledge.

7.3 The learning paradox

Uncertainty, or the lack of knowledge, in innovation is a problem that calls for 'exploration': an active learning process of testing and developing the innovation. The exploration process is supposed to move asymptotically towards solid knowledge. The paradox is that while the aim of exploration processes is to produce knowledge, they almost always produce complexity, multiplicity, ambiguity and choice. Even if the knowledge generating process occasionally succeeds in providing clear and singular answers, most of the time in this case study the object and its complex potential relations expanded during exploration. This has partly to do with the innovation, at least in its early phases, being unstable within several dimensions, and that its stabilisation requires exploration of a number of interconnected issues. In addition, when experts start investigating an idea, making it into an 'epistemic object' (Knorr Cetina, 2001), that idea opens up and becomes a complex of interesting problems and opportunities. Paradoxically, in industrial settings, exploration is a process that aims to expand and generalise the concept, which often involves hypotheses about appropriation and economies of scale. The innovation has to be brought towards stabilisation as a general concept and thus be possible to scale up. This presupposes that the concept is both tested in practice, and demonstrated to hold up to such tests.

7.4 Time and simplification

A main point in our analytic scheme is that, for longer periods of time, processes of mobilisation and exploration do not interact, and when they do interact, controversies in the form of frictions and confrontations are often produced. Learning often leads to a departure

from the original idea, which may create a mismatch to the extent that a struggle over the future direction is unavoidable. Therefore, interaction avoidance seems to be a common challenge of innovation processes, basically stemming from the need to handle and reduce the divergent and expanding aspect of exploration. Actors tend to avoid interacting with others during exploration processes due to the risk of being influenced. Moreover, the battles that innovators engage in are only the ones they think they can win. This is, so to speak, creating parallel space and time, where rather different conceptions of the innovation may emerge alongside each other. We also saw in the case study that after a successful mobilisation, creating new space and time for the next phase, the resulting framework is kept tight until new confrontations and reconfigurations enforce or enable a renegotiation of either the framework conditions or the actual innovation.

Not only do sub-processes of innovation sometimes interact, the innovation process also interacts within a larger network of interconnected processes (see figure 2 above), thereby considerably increasing complexity and uncertainty. We suggest that, based on a process perspective, path dependence is better understood as encompassing relatively slower processes maintained via intertwined networks of heterogeneous elements that are carefully assembled over long periods of time. Movement in such embedded networks creates friction, which is both a creative and a destructive force. Friction privileges continuations and incremental changes of the existing practice in both the direction of improvements across interfaces and the direction of economizing in a way that gradually adapts the new activity to the requirements of the surrounding economy. This view of path dependence explains both some of the slowness and some of the unexpected outcomes of innovation processes: (1) why innovation processes tend to take significantly more time than expected, and (2) why 'successful' innovations often are realised as incremental changes or marginal additions to an existing set of relations and activities.

Building the innovation into commercial relations is likely to de-stabilise it and produce new phases of development, both of mobilisation and exploration. Hence, finding or creating *use* for the innovation by others means that the innovation needs renegotiation. As mentioned previously, confrontations between mobilisation and exploration are often destructive; thus, actors avoid involving themselves in more relations than necessary, and a simplification of networks might be required. Further, while sometimes necessary, this reluctance to interact may again lead to sub-optimal mobilisation or exploration. When partially stabilised innovations and their internal propositions about users are tested with potential users, new propositions and adaptations of the established setting will arise, and thus lead to new development phases and new selection processes. In order to minimise such challenges, and thereby reduce development costs, businesses are forced to radically simplify the innovation and its network, and adapt to what already exists in response to friction forces within the established network.

8. Conclusions

This study has indicated that in order to expand our understanding of innovation processes, we need to address more precisely how the "physical processes of time", that we associate with the emergence of new products and new business activities, relates to different mental and social processes of time and the divergent activities these tend to generate. Mobilizing processes has to do with particular kinds of interactions between mental and social processes on the one hand, and resource related processes on the other, that are both communicative and economic of nature. The outcomes of such processes are typically "commitments" to the innovation projects. Knowledge exploration processes on the other hand, has to do with the

search for correspondences between mental propositions and the realities as represented by a variety of feedback processes to the various dimensions and features of the proposed innovation. The outcomes of such processes are new pieces of knowledge and understanding that move the innovation in different directions. The innovation management process can accordingly be seen as an interacted agency activity over time that incorporates these divergent activities. To align and realign contradictory forces is at the core of what innovation managers do.

In sum, we maintain that this study has contributed to our understanding of industrial innovation processes by challenging and complementing perspectives of punctuated learning (Van de Ven *et al*., 1999), path creation (Garud & Karnøe, 2001) and user-producer interaction (Håkansson & Waluszewski, 2007; Pinch & Oudshoorn, 2008). The analytic model and subsequent theorising is consistent with the methodology of actor-network theory, IMP's view of resources and recent developments within innovation studies. However, our study differs from many accounts and conceptions within actor-network theory in its attempt to handle industrial innovation rather than science and technology development. It also differs from the related and emergent field of the sociology of finance (Callon, 1999; Knorr Cetina & Preda, 2005) in dealing with 'less pure' settings thus we have found reason to combine it with important insights from the IMP approach.

We have emphasised the controversies of innovation as being confrontations within the actual process, and between the innovation process and its related network of interconnected processes, as well as (indirect) friction forces within the already existing business network. *Confrontation* refers partly to the occasional interactions between the mobilized network and any actual learning that takes place within the process over time. It also partly refers to the effects of interaction between the old and the new, between the 'investments in place' and the innovative solution. When something new is introduced to a setting, confrontations often arise, as the new element tends to confront power constructions and established practices. This may produce blockages by some actors, and mobilization efforts by others. Therefore, over time the innovation will repeatedly have to align with new elements in order to maintain or gain power. *Friction* refers to the indirect effects of the innovation programme. When the new intervenes with the old, there will be forces and counter-forces activated between the existing interdependent resources, sometimes triggering creative efforts of problem solving, while other times serving as an obstacle. Based on the assumption that resources are heterogeneous and interdependent, Håkansson and Waluszewski (2001) have conceptualised how investments in place represent 'economic heaviness', which produces resistance, or 'friction' (Håkansson & Waluszewski, 2001). This mechanism tends to favour incremental innovation, and requires innovation projects to work hard to adapt the new to the old. Friction frequently also leads to unintended consequences because all network elements are embedded.

We maintain in this study that it is productive to business network research to explicitly open up the black box of innovation processes. Innovations will have to find their places within and among established business structures, which can also be described by business network concepts that are able to deal with and explain various dynamics. Still, studying innovations offers opportunities for investigating the more radical creation processes that are less stable, less material and more controversial than businesses that have already proven themselves by practice.

For further research, we suggest that there is a need to test and tune process-based models, like the one presented in this paper, in more settings. This could take place at more 'strategic levels' of organisations, or within various other industries, which would enable a testing of the model's relevance, as well as a comparison of innovation processes across industries. Furthermore, the relevance of the model in settings of both service innovation and entrepreneurship has not been discussed in this paper, and we would be curious to learn about the differences that would appear if this were done. We think that the insights produced from the analysis of this case study are not exhaustive. At the level of detail provided within the empirical descriptions, more could be gained than we have been able to offer in this paper. In particular, we suggest that it would be interesting to identify more of the various strategies used for coping with the controversy and interaction: first, between the mobilising of actor-networks and the exploration of knowledge, and second, between the innovation process and the network of interconnected processes in which it is situated.

From a pragmatic business perspective, we believe the suggested model and the findings we have presented could serve as a useful framework for managers to interpret, communicate and structure their efforts in dealing with or managing innovation projects and processes. This model is a way of making sense of such complex activities, and might help in the structuring of a critical and analytical examination of what characterizes innovation processes and their relationships to the broader business networks from which they emerge. Particularly important are the study's implications for policy, specifically the idea that public support for industrial innovation should not isolate its criteria to the innovation project in itself, nor to the innovating organizations' immediate environment/network. Rather, it should seek to greatly emphasize the capacities of the innovation actors and network to adapt the innovation to their larger networks.

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