Interaction to bridge network gaps
The problem of specialization and innovation in fish technology

Thomas Hoholm & Håkan Håkansson

BI Norwegian Business School, Oslo

Abstract

Innovation is to a large extent about trying out new combinations. Often it means bridging different types of gaps, which becomes more problematic in cases of radical innovation, as well as in cases of highly specialized actors. Starting with a case where salmon was planned to be used as an input into salami but instead became a special high-quality fillet we will try to identify the important role, as well as the problems, of bridging. Proceeding from this, we seek to outline how such gaps may be bridged across relationships and networks. Hence, this paper represents an attempt at contributing towards an interactive conceptualization of innovation in industrial networks.

Key words: bridging, network gaps, interaction, specialization, innovation, learning, path creation

1. Introduction

In every industrial network there are multiple interactions taking place continuously, where different companies are buying and selling products and services which are servicing day-to-day production. In addition there are also project related interactions focused on technological development of plants, machinery and systems within and between the involved companies. In both types of interaction, issues are constantly coming up that sometimes are solved by the companies adapting to each other in terms of performed activities and used resources. Technological development becomes interwoven with economic interaction. One important result is increased specialization for each of the participating actors (Håkansson et al., 2009).

Specialization in a network is positioning the company in relation to a number of other companies, i.e. creating differences that can be seen as distances in a spatial dimension (Håkansson et al., 2009:38-41) and it can be assumed to have a set of very positive economic effects. For example, the involved companies can economize by developing more efficient activities in relation to each other, hence both increasing differences and interdependencies. Thus, the companies can together create activity patterns which are more elaborated and efficient than before – they are utilizing their possibilities to stretch out the total action space. Another example of this is when companies combine their own resources with each other in a more elaborated way, leading to better utilization of the resources. This can be an interface between a product and equipment or the way different products or equipment are combined. Again the companies are creating differences and together the companies can create an overall resource constellation where every resource is better fitted into one expanding totality – although one out of many possibilities. Interaction is in this way a means of taking advantage of linking activities or tying resources across firm boundaries and thereby creating a better developed collective structure – but again one out of several possibilities. In other words, it is contributing to a co-evolution that fits at least some of the involved companies. On the other hand, it also affects how the companies are positioned in relation to each other, and not all actors are getting closer to each other in the general expansion of the action space.

Thus, the changed position due to the increased specialization is also creating negative effects. It can be expected to create barriers to interaction between some of the actors. Each unit becomes more specialized and one consequence of this is that the unit needs more specialized counterparts, which in turn means that it is successively getting further away from a number of the previously related companies. With longer chains and more elaborated networks, the relative distance to the large majority of others is increasing. Over time it becomes more difficult to interact with the majority of others who are successively getting more steps away, as the differences are increased. Through the development of specialized units the distance in terms of the number of steps to most of the other units will increase. Thus, the negative effect of a more elaborated structure is that it becomes more difficult to interact with most of the other actors.

The increased specialization effect on interaction might also affect the two different kinds of sources used for innovation. The first kind of sources can be identified for day-to-day interactions. Here the main source is the counterparts that the company has direct relationships with: suppliers and customers from which we can expect a positive impact of increased specialization. Each business relationship can be further developed as the units become more complementary due to increased specialization. This will probably result in an increased number of small incremental changes. Each interaction process can become richer due to the specialization and this can thereby result in more suggestions for changes. Such changes taking place within established commercial relationships are characterized by the involved companies finding possibilities to change the use of already used resources or making alterations in already performed activities.

The second kind of sources can be identified for more radical innovations. Here the increased specialization may have a negative impact. In these situations there are usually sources much further away that are used to bring in new radical suggestions. Thus, there is a need for bridging over a certain distance. This can be a distance in several dimensions, such as technology, work practice, and economic logic. With increased specialization among established partners, potential future innovation counterparts are successively moving further away – i.e., the relative distance is increasing. In this way the necessary bridging becomes more problematic. This issue is central for this paper. Bridging is and has always been a problem in business settings, and the increased specialization in today's industrial landscape might have exacerbated this. We will study bridging in different dimensions in a case study dealing with the development of an innovation within the fish industry. After presenting the case, we draw out some of the major bridging problems in the case study before we discuss two principles of bridging. First, in reducing gaps, mutual learning and teaching (Araujo, 1998; Håkansson & Johanson, 2001; Håkansson et al., 2001) to minimize the distance, as well as the number, of resource ties and activity links that need relating becomes an essential issue. Second, we frame bridging fundamentally as a resource recombination issue, drawing on theories of path creation (Garud & Karnøe, 2001), resource mobilization (Håkansson & Waluszewski, 2001; Hoholm, 2011) and learning by testing (e.g. Hoholm & Olsen, 2012).

2. Fish as a resource

Fish is a special type of resource. The category 'fish' includes a large group of different animals living in water. There are thousands of different types and they live in very different contexts. They are caught in very different manners and they are also treated and processed through a varied industrial and technical structure. Finally they are commercialized through a set of very different business units. The variety of the involved resources is huge and this is multiplied further through the way the resources are combined. This combining is vital in several respects that will be noted below.

One example is salmon where the greatest amount today is farmed. In farming we have a conscious combination of the quality and characteristics of water, the quality and ingredients of feed and a specific type of genes. One crucial aspect of the combining is, for example, how much fish meat that must be in the feed for the production of salmon in order to achieve an acceptable nutritional value, or how much additives that must be in the feed to get the desired color. Through research and development, the amount of fish meat has been decreased from 4 to 1.5 kilos per kilo produced salmon during the last few years. Research on feed products is related to agriculture, as the ingredients in part come from this sector and there are also other types of feed developed for farming of other animals. Thus, in the farming of salmon we have a systematic and increasingly specialized combining of a set of different resources. Here scientific knowledge produced by highly specialized research units plays a crucial role. A second example is when one specific fish species, such as cod, is the input into some quite different production processes ending up in different end-products (such as fresh cod, frozen breaded cod and baccalao). In all these cases we have an important interplay between the raw material and the features of the production process. The production of baccalao is a good example where salting and drying gives the final product some specific features, requiring interesting interaction between a number of technical resources and the fish. A third example regards the combination of different resources situated very far from each other. For example, the fish can be caught and frozen in Norway, then transported to China where it is thawed, filleted and frozen again before it is sent to the UK for consumption or further processing. In this case it is the cost of the filleting together with the yield in the production process, and the astonishingly low transportation costs, that are taken advantage of. A fourth but quite opposite example is when the variety existing in the fish itself is minimized in the production processes where a number of different fish species are mixed as input in producing highly standardized fish meal or fish oil.

These four examples are all illustrations of the intricate combining of a large set of resources in the catching, production and the logistics of the fishing industry. The work of combining resources is important as it has both effects for the utilization of single resources such as a specific fish type, as well as for how resource combinations are used. Another effect is that the resources become embedded into each other over time. Through actively combining resources it is possible to utilize some of their specific attributes in a better way. In this fashion, resource heterogeneity can be exploited and value creation enhanced. However, this combining creates some specific patterns over time which also creates limitations. Through actively combining resources, these tend to become successively more directed toward specific other resources. This is likely to affect negatively on how they can be combined with yet other resources, which restricts action deviating from the established path. This is a paradox, as – because of path dependence – any resource combination is not possible, which represents a clear limitation for value creation. On the other hand, such paths also enhance value creation. Without being connected and used in interaction with other resources, they can not be expected to provide any economic value.

The above identified aspects of how economic value is created through combining fish with other resources are even more pronounced in the development stage. Development is, to a large extent, about trying out new combinations. Often it means bridging gaps of different types and sizes. Starting with a case study where salmon was planned to be used as an input into salami but instead became a special high-quality fillet, we will try to identify the importance as well as the problems of bridging.

3. A case study of fish technology

3.1. Case introduction

This case study includes two highly specialized industrial actors: Tine SA, a large dairy cooperative, and Bremnes Seashore, a family owned fish farm[1]. In addition, a few other equally specialized R&D actors were involved: The Norwegian University of Life Science (ULS), Nofima (the Food Research Institute), and the Institute of Marine Research (IMR). The case study is based on a longitudinal etnography, as reported in Hoholm (2011) and Hoholm & Araujo (2011). For the purposes of this paper, the case was re-examined and five attempts at bridging were chosen for our analysis. First, Bremnes Seashore had developed novel slaughtering technology for salmon together with researchers from the ULS, but failed in getting returns on their investments via their established distribution network. Second, Tine had been trying to combine agricultural and biomarine resources for some years, for example in a project of using milk proteins and fermentation cultures for curing fish. This project started with the idea of a researcher at the IMR to make 'salami' out of fish, which was taken forward in a constellation between IMR, Nofima and Tine. However, in the first instance they failed both in stabilizing the product technologically and in commercializing it. These two, partly failed, innovation projects then turned out to become the basis for an interesting cooperation between Tine and Bremnes Seashore, eventually leading to very successful commercialization of another product: high-end fresh loins of salmon. In the following we will organize the case description around bridging efforts in five different instances of this innovation project: examples of bridging that had to be done in order to facilitate and stabilize the recombination of agricultural and biomarine resources, both technically and commercially. We leave the question of what needs bridging – whether across relationships or across networks – an empirical question. However, in going for a case study of a relatively radical innovation, we expected to find at least some bridging efforts across networks.

1. See Hoholm (2011) for full case study.

3.2. First instance: Science policy and scientific practice

During the time of the case study, there was a governmental debate on science policy, related to what they called 'blue-green' innovation. The discussion was about how to restructure the R&D sectors related to agro-food and biomarine food in order to gain synergies from cross-sectoral developments. This resulted in a governmental white paper in 2004 called "The blue-green food alliance: Joint efforts and new structure". This discourse was later drawn upon by the different actors involved in planning and realising biomarine innovation in this case study. Already from the 1970s onwards, a couple of research groups in Norway had taken leading roles in the successful domestication of salmon. Gradually a number of other species have been domesticated as well. One of the two research groups, based at the University of Life Sciences, was led by Professor Harald Skjærvold, and consisted of a constellation of scientists involved in the breeding of cattle and pigs, aquaculture and experiment stations on the west coast. A main research activity was to combine and translate agricultural breeding technology and knowledge into salmon breeding. However, as this kind of blue-green collaboration had only succeeded in research on breeding -- but had not become widespread on the industrial side -- the blue-green policy initiative aimed at speeding up innovation in the aquaculture sector by connecting it to the agricultural sciences. The rationale seemed to be that the more advanced scientific field of agriculture could help speed up innovation in aquaculture.

In a report from the Research Council of Norway on a number of blue-green research programs, both the science-political drive for integrating blue and green research, as well as the ambiguity regarding the blue-green potential from practitioners, was presented. The managing director of the Norwegian Seafood Federation (FHL), Geir Andreassen, evaluated his experiences with blue-green innovation:

> Even the 'food program' has been directly relevant for us. [But] the value chain perspective (fish/agriculture) has possibly been a restraint to the development instead of promoting it. The conditions, opportunities and challenges in the agricultural and marine sectors are fundamentally different and may result in a vague and fragmented research focus. (Geir Andreassen, FHL, in RCN Research Report, 2006)

Andreassen had little belief that any synergies could emerge from collaboration across the agro-marine boundaries – as they are 'fundamentally different'. Noting that this was expressed in a report in the Research Council of Norway's (RCN) portfolio of blue-green projects, this has to be read as a rather strong criticism of the idea of blue-green innovation. While the whole report was designed and structured as if there were blue-green synergies in the programs, by presenting blue and green projects side by side, the only concrete example in the report of something actually blue-green was the 'super cooling' project in the 'food program' where Sintef (technology R&D), Gilde (the Norwegian Meat Cooperative) and the Norwegian Seafood Federation together developed new cooling technology and subsequently transferred it to fish, enabling the cooled storage of products at -1.1 degrees Celsius, increasing their shelf-life and quality for the consumer. All in all, the report indicates that there was still a long way to go before the blue and the green could be said to be integrated in any sense. To co-locate and co-ordinate R&D efforts across sectors does not imply that resources and activities are necessarily integrated or bridged.

3.3. Second instance: Agro-industry exploring biomarine innovation

Farming fish instead of catching wild fish means greatly enhanced opportunities for raw material control, both regarding availability/volumes and qualities. Knowledge about breeding, feeding and the health of cattle and pigs has been utilised to develop the present world class quality and cost efficiency of Norwegian salmon farming, through joint research based at the Norwegian University of Life Sciences. Thus, aquaculture has opened up for industrial production and marketing on a totally different level. At the time, however, the market system had still not gone through a similar shift, thus for the most part not rewarding 'value adding' activities, such as product development, branding, etc. Mainly generic products were sold in the Norwegian aquaculture sector, such as whole, unprocessed fish, while on the agricultural side, industrial processing, or 'value adding', of raw materials was more the rule than the exception[2]. The bridging of the two sectors had been limited, for the most part related to raw material production. As a mature and advanced industrial organization, Tine saw an opportunity in trying to take it several steps further, into the industrialisation of food and ingredients production. This has resulted in several concrete projects related to biomarine raw materials and technologies.

A portfolio of biomarine projects emerged within the Tine group from a combination of the corporate strategy processes between 1999 and 2005 -- and existing activities at Tine R&D and other departments -- related to fish. The potential scenario of international competition on agricultural food led them to identify aquaculture as one out of five strategic innovation areas to develop new and specialised ways of exploiting their existing competence in industrial production and the marketing of food. This was also related to the general optimism of the late 1990s on behalf of the fish industry, where fish farming and biotechnology brought about great promises on new business opportunities, and to the science-political discourse of blue-green innovation, mainly in the research sectors, but also on the industry side. During the fall of 2001, Tine Biomarine, a subsidiary of Tine, was established to take ownership of the development of a biomarine innovation portfolio (in particular, related to biotech), crossing the boundaries between Tine R&D, commercialisation and inter-organisational partners. Initiatives for projects from Tine R&D and their alliances, and an emerging recognition in corporate headquarters of the opportunities within the fish and biomarine sectors, became increasingly entangled, as management supported new projects, and as researchers responded to strategy signals.

There are significant historical, technological, economic and cultural differences between the agricultural (green) and biomarine (blue) sectors. An interesting question seems to be whether these differences mean that the sectors should be kept separate (no potential for synergies) or if a stronger relation would pay off both technologically and economically. A catch-based business, like traditional fisheries, has not encouraged long-term industrialised development of knowledge, technology or markets in the same manner as the agricultural sector. Further, while the fish sector is transforming towards cultivation instead of catch, industrialisation of processing, product development and marketing have not yet followed. This is what the corporate management at Tine identified as an opportunity. However, as the story went along, Tine learned that instead of focusing only on their core activities, they had to take control of a larger part of the value chain. Surprising to them, integrating backwards in the value chain became a success factor. They experienced how they had to control more of the interconnected resources than expected to make the new resource combinations (the innovations) stable, both technically and commercially. Although they did not yet go all the way back to breeding fish (with the exception of some research projects on fish feed), they started seeking to influence everything from when the fish is taken out of the water to its presentation in supermarket shelves and restaurant menus. This is not just a simple operation, as it demands both general and specific knowledge. From this perspective, Tine's specific knowledge about agriculture is not

2. To nuance this a bit: There is a processing industry for fish in Norway, producing e.g. smoked and fermented fish products, etc., often with long historical traditions. However, with the huge volumes from fish farming, Norway may lack the capacity to do the volume oriented parts of the processing, leading to highly internationalized activity networks. In the national market for agro-food, with relatively small volumes, the actors have had the incentives to add value via processing and quality. In the salmon farming industry, on the other hand, income has been increased by producing and distributing higher volumes rather than increasing quality and price.

easy to translate to fish. And even Tine's 'general' knowledge about producing, distributing and marketing food probably needs altering with the new resource in focus. In other words, Tine learned from their biomarine ventures that they needed to know more about the specificities of the new sector in order to succeed with applying their own expertise to that sector's raw materials, products and markets. In this setting of highly specialized agrofoods, and the dairy industry in particular, Tine sought to use their specialized knowledge and technology in a very different setting: the biomarine domain. It became clear that it is not enough to have a clear strategic ambition to manage bridging; resources and activities also have to be changed.

3.4. Third instance: Translating meat technology to fish

When thinking about the industrial opportunities for fish, Professor Erik Slinde at the Norwegian Institute of Marine Research had the idea of testing fermentation, making 'salami' out of fish. He wanted to contribute to developing 'value added' products from Norway's rich source of seafood raw materials. The project started out with informal lab experiments at Nofima (the Norwegian Food Research Institute) during the fall of 2000. Slinde had previously been working at Nofima, and, while borrowing a laboratory at Nofima for testing his idea of fermenting fish, he incidentally met Berit Nordvi, a researcher of milk proteins[3] at Tine R&D, in the canteen. They decided to cooperate on adding milk proteins to Slinde's fish fermentation to see if this could help stabilise fatty acids, and together they wrote the application for funding of a research project – the Neptun project.

The idea of combining fish with fermentation technology from meat thus evolved further in conjunction with a group of researchers from the Institute of Marine Research, Tine R&D, Nofima and the Norwegian University of Life Sciences. Their competencies within biological and food sciences, and their curiosity with regard to new ways of developing industrial food production made them interested and fascinated by the novel idea of applying 'salami technology' to fish. The potential for utilising milk proteins to stabilise the product strengthened its relevance for the Tine researchers, and helped legitimise such activities within the realm of a dairy company. In this initial phase, the Research Council of Norway found this to be a promising exploration of blue-green innovation, and allocated significant funding to the Neptun project that was conducted from 2001 to 2005.

Nordvi had already been working on milk proteins for a while, and this opportunity to explore a brand new application and hence understand more about how proteins work was indeed attractive to her research community. The surplus of whey from the production of cheese appealed to the 'product optimisation' logic of Tine as an industrial actor. Opportunities for utilising, i.e., creating economic value from, more of the raw material was encouraged, and the commercial use of whey was yet limited.

Slinde's 'fish salami' recipe was from the start based on a frozen[4] mix of red and white fish. The function of the white fish was to balance the content of fat in the product. During this early period, the participants focused mainly on technical problems related to texture (stabilising fluid fish fats), durability (stabilising fish fats from oxidation/getting harsh) and colour (white/red combinations often becoming colorless/grey). They also worked on other problems related to the microbiological quality of available raw materials. In particular, fish coming from the catch side, or white fish such as cod and saithe, did not meet the standards perceived necessary to make the technology work. This was explained by the participants as resulting from different practices and regulations regarding hygiene and nutritional standards between the fish and the dairy industries, and they found it hard to change the suppliers' practices in accordance with their demands.

During the same time period, a fish farm, Bremnes Seashore, had been working with another research group at the University of Life Sciences to develop novel slaughtering technologies. Throughout several years of collaboration, novel technologies for processing had been patented that enabled so-called 'pre-rigor' processing to be possible with great results documented on quality. These were new slaughtering and processing technologies for farmed salmon, which reduced the stress levels of the fish and enabled pre-rigor[5] processing of the fish to an extent that no competitors could achieve. In addition to the advantage of time, i.e. getting fresher fish out to the customers, the raw material proved to have some new and very interesting characteristics regarding colour, texture and gaping. This new way of slaughtering the salmon gave a significant rise in the quality of the raw material. Hence, Bremnes Seashore developed some highly specialized technologies for slaughtering fish,

3. Whey is a byproduct from the production of white cheese; only a small portion is utilised within the food industry, and the rest is unprofitably sold as animal feed. Hence, Tine is constantly seeking new opportunities for economising on this 'idle resource'. Whey consists mainly of carbohydrates and proteins, and in this case it was the proteins – and milk proteins in general – that were under investigation.

4. In the meat industry, frozen raw materials are used for fermenting salami, mainly to increase the outtake of water in the process.

5. Pre-rigor processing means processing the fish before it becomes 'death stiff' (rigor mortis), thereby, getting very fresh filets of extraordinary high quality. Rigor occurs just a few hours after slaughter, and it is not possible to take away skin and bones industrially during this phase. Therefore, all fish to be processed are stored for around three days before processing according to the common procedure. This storing can also be done on a trailer on its way to Denmark or France, hence there seems to be less advantage in post-rigor processing in Norway. Bremnes' new method, based on cooling down the fish, extended the time window for pre-rigor processing.

but nevertheless they failed to create (more valuable) use within their established network. The major distributors in the fish industry were not interested in paying a higher price for this premium raw material. It is not enough to develop a technology so that it functions, the function has also to find a commercial use and this is done through finding a suitable combination with other resources.

3.5. Fourth instance: Hiring experts to bridge industries

Later on, Tine bought the patent application from Slinde, and a product development and commercialization project (Umi No Kami) was launched alongside the ending phase of the previously described Neptun project. In the Umi No Kami project, Tine quested for higher quality raw materials, i.e., seeking to control the practice of suppliers. Gradually, and in learning what specific knowledge they lacked, they supplemented the team in 2002-2003 by hiring aqua-culture scientists and product developers from a research group at the University of Life Sciences. They hired Lars Petter Swensen for the Umi No Kami-project to help them develop methods (infra-red scanning) for sorting salmon based on its fat content (high variation with salmon), which again would make it easier to control the fermentation process in the fish salami. Swensen gradually became more involved in the project, and later, when UNK was moved from R&D to the line organisation, he became project manager on the R&D side. Shortly after Swensen was recruited, his supervisor at the University, Per Olav Skjervold and two other senior colleagues (Svein Olaf Fjæra and Odd Ivar Lekang) were hired for coordinating all the biomarine research activities through a program called 'fiskekraft'.[6] This new group of people created new dynamics in Tine's biomarine activities. Having worked on improving processing technology for fresh salmon for many years, mainly together with Bremnes Seashore, this group had easy access to pre-rigor raw materials of superior quality. Subsequently, Swensen and Skjervold informally started testing Bremnes' pre-rigor salmon in the Umi No Kami-recipe with good results. In Swensen's view, this change from using frozen fish (white and red) to fresh fish (salmon only) was a seminal breakthrough in the production of the salmon salami. Moreover, when management and product developers at Tine got to know and taste the superb quality of Bremnes Seashore's pre-rigor salmon, they became very interested. By mobilizing such a resource on the supply and production side, they managed to stabilise a number of technical issues, but they still had the problem of moving the innovation closer to commercialisation.

3.6. Fifth instance: Industrial production and commercial use

The product in the Umi No Kami project gradually found its shape, and a brand profile for the salmon salami called 'Salma' was developed. An international marketing tour was done with Salma Cured in the fall 2004 and the winter 2005. Existing business relations, food fairs and new contacts were visited in the US, France, Singapore, Brussels, Moscow, etc. Feedback from and interaction with different actors in these locations came to have a great impact, with the adaptation of the sausage, both to Asian restaurants and German retailers, ultimately involving a reworking of the entire innovation before launching in the Norwegian 'home market'.

While visiting Hong Kong, the team met representatives for FoodCorp[7], a multinational restaurant corporation. It was seen as the "ultimate customer" for Salma at this stage, representing everything they hoped for: Restaurant chains (relatively easy logistics), world-wide distribution and association with acknowledged brands. The R&D director at FoodCorp suggested that it could be tested in their Japanese restaurants as their 'monthly special' campaign later the same year, with TV-commercials and special offers in the restaurants. This would have meant massive attention to Salma Cured among some of the most open-minded, but also demanding, consumers in a huge market. However, this customer also had some demands, and to be able to properly answer the question of feasibility for warm food, Salma Cured had to be taken back to the laboratory. From (finally) being stable both in shape and production, its identity was again in question, or opened up. After altering some of the steps in processing, the results were positive. Unfortunately, in the meantime, FoodCorp had dropped the contact. The customer had, for unknown reasons, lost interest, and the attempt to mobilise the desired customer had brought about both a great deal of work, and a failure.

When Tine's agent for the distribution of cheese in Germany, Detlef Martens, expressed interest in Salma Cured, plans for distribution to retail chains in Germany started to emerge. In March 2005, an agreement was signed between Martens and Tine for test sales of Salma Cured in German hypermarkets. However, Martens was uncertain about the suitable categorisation of the product, related to the shopping practices of consumers. While emphasising its similarity with meat products, he still chose to locate the product together with smoked salmon and other cured sea-food products. Associations with meat salami were helpful for communicating use, but the nutritional value and of course the raw materials were more similar to fish products, and hence both sides were sought to be maintained by calling it 'lax salami'. A number of purchasing managers were convinced and willing to give it a try, and so Salma Cured was launched for test sales in 90 German hypermarkets. However, the sales of the 'Lax Salami' did not go particularly well, and

6. Referring to the double meaning of 'fish stock' and 'fish power'.

7. Not its real name.

after adjusting packaging and marketing a couple of times, it was then put on hold.

Salma had still not found its final shape with regard to what customers wanted to buy. Strategic considerations of brand development and positioning, and decades of experience with the food industry could not settle Salma's identity. Its fate was fully in the hands of the customers (industrial actors) and their customers (consumers). Hence, it was easier for the team to go back to the laboratory and the marketing department to develop new versions of the product, particularly products that came closer to already existing products in the market. At this point, a couple of ideas that had been considered for a while gained strength. Under pressure for economic results, the idea of marketing the fresh salmon loins instead of curing them, as well as the idea of working with Tine's established market relations in their domestic market got strong support. As opposed to the salami version, the marketing of 'Salma Fresh' was launched in Norway, a familiar setting where Tine already had relations, recognition, and a strong market position with several other brands and products (dairy and easy-meal products). Neatly cut premium loins without skin and bones were packaged in transparent foil and with the same minimalist Salma design/brand concept. The strategy for Salma Fresh was to start with the best stores, and a 'gourmet supermarket' immediately became interested, and agreed on a test campaign in September 2005. After having the product out in test stores for a couple of weeks, it was discovered that the package was too long, and did not fit in the consumer's fridge, hence yet another adjustment had to be made. Still, the consumer response was very good. Because the supermarket was associated with a large retail chain, Norgesgruppen[8], -- a long-time customer of Tine's dairy products -- access to nation-wide distribution opened up. Distribution of Salma Fresh was gradually rolled out in Norwegian and German supermarkets, as well as a number of high quality restaurants from 2006 onwards, finally making a success-story of Salma, which ended up without a radical product innovation as part of the product, but still with a relatively radical production technology.

4. Bridging efforts and problems

Above, we have described five different examples of bridging in a case about product and process development in the salmon industry. We have identified five attempts to bridge and we have witnessed that in all these cases there have been severe problems in achieving it. In all the five instances there were ambitions and conscious efforts made by the actors. In all the examples there were also competent and skilled people involved. They also had substantial resources behind them. Nevertheless, in all the examples they met unexpected difficulties. It was more problematic to combine different activities and resources than was foreseen. They seemed either to be more adapted to its present use or more difficult to adapt to the new use than was perceived by the economic actors.

The first example regards research. It is easy to understand the Norwegian government ambition – there is extensive research in the agriculture area that should be possible to use for the less industrialized aquaculture sector. There are similarities, particularly related to issues of "farming", where genetics and feed are two essential ingredients with overlapping knowledge in use. But as expressed by the managing director of the Norwegian Seafood Federation – there are fundamental differences in used resources and performed activities, particularly related to industrial production, distribution and marketing, in the two sectors which make bridging, also of applied research, problematic. The problem in this instance is related to such differences in used resources and performed activities that are not easily bridged.

The second example illustrates the above difficulties but is also an example of the problem of bridging from science to industry. Tine had problems applying its specific as well as general knowledge to the aquaculture setting. One reason seems to be that the knowledge was embedded into the interfaces via linked activities and tied resources between different actors, and in order to grasp this, the company had to become involved in more or less the whole aquaculture industry. It is impossible to just isolate and use a smaller and more precise technique – there are too many embedded and interrelated other resources and activities. This is also typical for moving from science to industry. In science it is possible to explore certain mechanisms and relationships, while keeping other elements and the circumstances under control. Basically it means isolating one specific section from the influence of the environment. However, when moving from this 'artificial' world to industry these constraints will come to life and affect the process. Then a large cluster of activity links and resource ties will have to be dealt with. The fundamental differences between the methodological control of science and the heterogeneity and pragmatics of business are thus more problematic than much innovation literature seems to imply.

The third example describes some of the technological problems more in detail. One issue regarded the differences in hygiene between the two sectors. While it is of extreme importance in dairies which have to be perfectly "clean" it is not at all of the same importance when traditionally dealing with fish. When trying to translate one type of production process – fermentation – from agriculture to aquaculture this became an unexpected problem. Hence, Tine had to become

8. "NorgesGruppen is Norway's largest trading enterprise. The group's core business is grocery retailing and wholesaling. Through its [retail] chains, the group holds a market share of 39.2 per cent of the grocery market. (…) A total of 1,919 grocery stores and 790 kiosks are affiliated to NorgesGruppen", (downloaded 2009-05-12 from http://www.norgesgruppen.no/norgesgruppen/norgesgruppen/english/).

Table 1: Examples of differences producing gaps in the spatial dimension.

DIFFERENCES?	BETWEEN WHAT?	PRODUCING SPATIAL GAPS
Resource constellations	Firm resources or network resources	-Lack of connections between the new and the old resources/activities
Activity patterns	Firm activities or network activities	-Lack of social relations across settings
Degree of heterogeneity (controlled vs complex)	Networks (science vs industry, and agriculture vs aquaculture)	-Lack of ability/knowledge/ resources to connect or re-use resources and to translate activity patterns -Lack of product similarity -Lack of product complementarity -Context specific knowledge, integrated in established interfaces

involved in the early part of the fish production process and therefore developed a relationship with Bremnes which later proved to be an important resource. The latter had also had a bad experience of developing a novel production method, which was seen as of little interest to its established customers. This illustrates that bridging problems goes in both directions. It is difficult to bridge to distant actors but there might also be a problem bridging to close partners when you have something new to transfer. New elements (i.e. inventions) are often disconnected from crucial parts of established practice. It is therefore both problematic to change established connections and to create new connections from scratch.

One possible way of bridging is to use people, as exemplified in the fourth illustration. Through hiring experts from a certain field the company was not just getting new competence but it was also getting a whole set of new relationships. In this case the new group of researchers brought in Bremnes Seashore as a potential cooperation partner. This can obviously not be regarded a guarantee for success, as the complexity of an interrelated business setting is too large, but in our case study it certainly reduced the bridging problem significantly. Lack of social relations may often inhibit bridging of gaps. Organization theory has conceptualized 'brokering' as the role of exploring and translating knowledge across boundaries (e.g.Wenger, 1998; Carlile, 2004), however, most often without the ambition to change the boundaries (e.g. connect and reorganize practices) (Mørk et al., 2012). From our perspective, we would add that even if 'pure' social relations have little ability to tie resources and link activities[9], experts with ability to 'translate' knowledge across networks may indeed facilitate, not only spanning or brokering boundaries, but also the bridging of gaps.

Finally, in the fifth illustration we first have the problems of finding a suitable commercialization of the Salma Cured (salami), ending in a total failure. Tine was trying to find matching partners all over the world and tested the response for different types of applications. But in all cases it failed. A consumer product has to fit into an assortment of the retailers or of other consumer oriented companies. It has to find a "logical" place. This is the interesting aspect with the final application in our case study. In assortments of fish products there were few high quality special products. The new Salma Fresh filled a gap in the assortment and, especially when Tine could use its old relationships to bring this product to the consumers, the bridging became so much easier. In the final stage the successful bridging included Bremnes, Tine, the retailers and the final consumers. The actors managed to find a way to bring all these together in a fruitful way. The key to bridging was first to decrease the gap before bridging it. Obviously, it is easier to bridge smaller gaps; hence part of the solution may often be to diminish the gap before trying to bridge it[10]. But we have to remember that it was the salami that brought Bremnes and Tine together and so the salami can be seen as an important bridge between the two partners. Hence, lack of similarity, lack of complementarity, and lack of ability to connect (or re-use) established resources and translate activity patterns represent serious challenges for innovation. To sum up, even in cases where it is easy to assume clear similarities and great transfer opportunities, innovating firms and networks may turn out to have fundamental differences. They are positioned in a multi-dimensional space with certain gaps to each of the counterparts including their activities and resources. The differences in our case study were mostly related to different resource constellations, different activity patterns, and different degrees of heterogeneity. Related to

9. See e.g.Law (1994) for a discussion of the rare instances of 'pure' social relations, and how social relations in most cases – at least if they prove durable – are both socially and materially constituted.

10. See also Hoholm (2011) and Hoholm & Olsen (2012) for a related discussion of 'simplification'

innovation processes, such differences will always produce gaps between the involved actors, between the old and the new, between knowledge situated in different networked practices, etc. Naturally, the next question is how such gaps may be bridged, and it is to this we now will turn.

5. The bridging principle

The basic assumption behind the bridging principle is the existence of a certain gap that has to be bridged. In all the examples above we can see both the existence of gaps and attempts to try to bridge them. There were attempts to combine activities or resources that previously have been developed in different settings – such as research, production, technologies or products. In all the attempts there were problems in combining them, indicating that there was a certain "gap". Some kind of a bridge was certainly needed. But what can also be learnt from the case is that bridging is hard work. In principle we have very few successful examples of bridging in the case. It was when the actors together found an application where the gap was smaller, hence minimizing the bridging requirements, that they succeeded with the innovation process. From this we can learn two things. One is that it is difficult and resource demanding to bridge; to relate resources and activities that have very separate locations in the economic world. The other is that the gap is not a constant or a given. Rather, it is related to how it is formulated, or to which formula the combining is following. In the following we suggest that the bridging principle consists of two basic mechanisms: First, gaps often need to be reduced through processes of specific mutual learning, where it is more the formulation of the gap that is changed than the gap itself. Second, bridges need to be created by developing relations and associations capable of holding the mobilized elements together – it requires a network solution.

5.1. Mutual learning to reformulate and reduce gaps

Resource ties and activity links are shaped in and by interaction. Hence, when starting processes of combining resources and/or activities in novel ways (i.e. innovation), a characteristic of such processes is uncertainty. Different kinds of uncertainty have been identified in the innovation and entrepreneurship literature (e.g. McMullen & Shepherd, 2006). But the particular kind of uncertainty we have observed here is the uncertainty of what happens when resources are combined in novel ways. Although industrial actors often are very knowledgeable about their resources, their current combinations and use, we find that they, in reality, know close to nothing about how to relate them to new ones. And this is perfectly logical – if it is a new combination there can not be any earlier experience. This inherent uncertainty of what it takes to relate them has to be overcome, through learning processes and various attempts at finding the tools, mediators, techniques and mutual adaptations needed to make novel connections work. It is this network learning process (see also Araujo, 1998) – of testing techniques, developing tools, and adapting the resources themselves – that we suggest to conceptualize as 'bridging'. One important part in bridging is to find how the combining can be done, i.e. to find out the dimension where the "gap" is smallest, and then explore potential bridging methods. Hence, an important part of bridging activities includes how to reduce the need for actual new links between activities or new ties between resources.

To formulate the identity of a resource or a product is indeed to position it and thereby to formulate the character of the gap. This is an uncertain and propositional activity. In order to identify a gap the spatial dimension has to be explored and delimited – in order to identify a gap we first have to identify the basic aspects to which the gap is related. The identification of this spatial dimension and thereby a gap requires an active actor, and the innovators have to use previous experience as well as imagination and research to propose what their invention may be (used for) and how it may be connected with other elements without yet having tested it out in practice. Thereafter, a specific dimension must be proposed and tested out. But to formulate the gap is also to give direction and limitation to the further development process, hence producing some kind of 'formula' of how to connect resources, how to conceive of the innovation, and how it could (or should) be used. Such formulas may prove to work when tested in practice, while more often during innovation they fail. In the case study, as long as the innovation was formulated as a salmon salami it was impossible, but when it was reformulated (and then transformed) into a fresh loin it was not at all so difficult.

Bridging is a very active process and certainly includes learning in a number of ways, but it can also be important to notice the criticality of teaching (Håkansson et al, 2001). In the case study we could see how the involved actors had to put resources both into learning and teaching each other about a set of critical issues: While Bremnes had to teach Tine about raw material variation in Salmon and how to control the raw material input in production, Tine had to go much further than anticipated in teaching Bremnes about nutrition and hygiene standards, food production practices, the relation between production control and branding, and the effects of production on use. In this sense, teaching involves not only transfer of knowledge and practices; it also involves mobilizing the power needed to get the other party to change their practice through negotiating, convincing and sometimes using force by imposing new practices upon the other.

One way or the other, reducing gaps and building bridges are likely to require mutual efforts; both sides have to be active. In the case study both Tine and Bremnes were actively trying to build a suitable bridge and in the end Tine finally found some retailers who were willing to try to do the same. In order to reduce gaps and find bridging opportunities the motivation on both sides seems to be a key issue. Such motivation, at least in our case study, came out of (and sometimes missed due to) (1) the perceived fit of the innovation in the participants' portfolios of activities and products, (2) the perceived complementarities of the innovation related to the participants' other activities and products, and (3) the participants' interests in terms of exploring new directions, exploiting idle resources, economic value creation, and strengthening market position. As the two first are perceptions, the third point very much affects also these two.

5.2. Bridging gaps and creating paths

In the economic and historical literature, path dependence has been used to describe how historical contingencies, often accidental events, may create more or less irreversible 'lock-ins' and 'dominant designs' that limit and determine the subsequent direction of the industry: "A path-dependent sequence of economic changes is one of which important influences upon the eventual outcome can be exerted by temporally remote events, including happenings dominated by chance elements rather than systematic forces" (David, 1985:332). In a critique of David's historical determinism and focus on accidental events, Garud & Karnøe (2001) suggests that paths can be influenced by entrepreneurial and 'mindfully deviant' actors. Within the interaction perspective suggested in this paper, path dependence simply means that every innovation process is situated within an economic, historical, geographical and cultural context giving it a specific location/position, which certainly affects what is possible. Actors are limited by their previous relations, experience, and investments. Path dependence may be related to local and global political regimes, which are different between agro-food and seafood, different technical systems, different market networks, different cultures, all of which then influence production practices, distribution practises and cooking and eating practices.

For the most part, path dependence has been described in the literature as a barrier to innovation, 'framing' innovation processes, and forcing companies to act rather conservatively within, or close to, the actors' existing set of relations and practices. For example, Bremnes Seashore was not able to economise on their technical innovations within their existing marketing practices, their existing distribution network, and due to their location within a 'spot-price' market for fish as raw material. On the other hand, path dependence may also explain why and how some kinds of innovations are possible within particular settings, e.g., it was possible for Tine to invent and commercialise new food products within their setting due to being a central part of a 'heavy' techno-economic system able to handle technical development, distribution and marketing of differentiated food products. However, when crossing sectoral boundaries and venturing new business between agri- and aquaculture, it was no longer obvious how to innovate, and whether they would succeed or not.

Håkansson and Waluszewski (2001) observed how resources often seemed to be 'cemented' upon each other, thus being hard to change or replace, and yet apparent stable resource combinations could sometimes suddenly disintegrate. Movement in such embedded networks creates friction, which is both a creative and a destructive force, although due to the 'economic heaviness' of prior investments, friction tends to work in a conservative manner, similar to path dependence, privileging continuations and incremental changes of the existing practice. It is hard to bridge established constellations without provoking friction and change for all the involved parties. Hence, effects of innovation and bridging are never just local; they become distributed through friction with other interfaces with other resources, transforming them too. As we saw in the second example, bridging implies change. Because resources are heterogeneous, and thus require mutual adaption to enable combining, change is unavoidable when relating previously unrelated elements. Bridging is in this way a process of bringing two or more paths together, with an uncertain outcome and no 'best' solutions, and with a challenge of integrating the new elements with different network practices.

Path dependence, in this version, includes all developments that take place around the actual project, and sometimes such 'friction' may even be an important enabling factor for the innovation process (Håkansson & Waluszewski, 2001). In some fortunate situations, there are specific developments and movements in the innovation process' wider network that are compatible with the innovation, and which therefore may help bridging the innovation with potential allies and users, hence contributing to path creation (Garud & Karnøe, 2001). In the 'outwards' organising of the project, Tine and Salmon Brands were very conscious in including the consumer in their product development, researching various consumers' environments, and asking samples of consumers about their responses and potential use of a fish salami. But from their reluctance to involve distributors early in the process, they failed to get answers to the crucial question: Within whose product range would the innovation be a good fit? In order to create use for innovations, other networks often have to be mobilised and redefined. It is clear that networks and network bridges are never created from scratch, but there is (sometimes) room for renegotiating and reformulating the interests, programs and constellations of networks. In the industrial world, actors seek to create new paths and build bridges all the time, more often than not without success. It seems clear, however, that those succeed that are able to mobilize others to join the project, like Tine did towards the end of our case story. Such network mobilization, however, is likely to influence the project in unpredictable ways. In this case, the salmon salami proved difficult to commercialize, while the interaction process took the project towards a simple but high-end salmon loin which became a great success.

If we now return to look at bridging processes in relation to the introductory discussion of specialization and the problem of radical innovation, one interesting aspect is that the specialization is not necessarily reversed. While on the one hand, the level of specialization was somewhat decreased in the shift from salmon salami to salmon loins, on the other hand it had to be driven further on some aspects – as a new spatial dimension was identified within the network. The activities and the use of resources became even more specialized. The difference is that the specialization takes a new route – it is not just continuing in the old path existing before the new combination. In this way every new combination increases the specialization and thereby the total space even further. The use of resources in the activities becomes even more intricate. The new bridge is therefore not just a new relation between two activities or two resources but a network of relations between a whole set of resources and activities. Following, there is a distinction between creating new relationships on the one hand, and utilising and redefining established relationships on the other, and we argue that new user-producer relationships are hard to establish during innovation, and that they will be fragile due to a lack of tangled interests and resources, often providing too little commitment from the (new) user.

6. Concluding discussion: what does bridging mean for creating business?

We argue that the analysis of bridging may provide understanding of the fundamental industrial challenges of building relationships, and also of bridging across networks. Central questions are how constellations of actors and resources become socio-materially embedded over time and are creating a network space, and how this produces the great difficulties of innovation, particularly on the more radical side. Bessant and Rush (1995) used the term 'bridge-building' when describing how consultants could take an important role in bridging the 'managerial gap' for technology transfer, thus taking an actor-centred approach on how to broker knowledge across actors, networks and systems. Suchman (2000) used the same term – in both a metaphorical and a concrete sense – in an ethnography of actual bridge building, emphasizing the alignment of social and material elements into a stable artifact. However, from an interaction perspective, we wanted to get a grip on the actual organizing and economic exploitation of resources when recombined, as well as the re-organizing of activities across networks during innovation, taking into account the increasing specialization of actors in industrial networks over time.

It is pertinent to question what constitutes a gap that could or should be bridged. Of course not all gaps need to or are worthwhile bridging. On the one hand there is a more or less objective side to this: What is the size of the gap, related to the potential benefits of succeeding with bridging it? Size here would be operationalized as the degree of change needed and the number of elements involved. The potential benefits, as with all innovation activities, are related to some kind of expected value: economic value, use value, social and environmental value. On the other hand, there is the more subjective side: How is the potential outcome of the bridging perceived, and how does this 'storytelling' contribute to actually creating novel and valuable solutions? It is a well established insight in innovation studies how creative imagination is a crucial aspect not only of discovering, but also of creating value creation opportunities, e.g. through processes of 'mindful deviation' (Garud & Karnøe, 2001). While Garud & Karnøe (2001) described how new paths could be created by entrepreneurial actors through 'mindful deviation', and Håkansson & Waluszewski (2001) provide explanation of why paths tend to change in very incremental steps due to 'friction' and 'economic heaviness', in this paper we have emphasised how path creation may happen by bridging previously unrelated resource constellations and activity patterns within and across industrial networks.

We found that the fundamental differences across seemingly similar industrial networks (agriculture and aquaculture) made both bridging efforts from policy makers and from industrial actors hard to achieve. Moreover, to enable the use of own knowledge requires a lot more knowledge about the new setting than the actors in our case study anticipated. In the specific question of bridging science and industry, we saw how the methodological control in science is impossible to maintain when transferring knowledge to industrial settings because of the increased heterogeneity and thus the more pragmatic practices in industry. To an extent, the mobilization of people with expertise from the other setting may help reduce and bridge gaps, although still being dependent on matching opportunities between activities and resources. In the last instance of our case study, we found how gap reduction and bridging had to go together, even if – somewhat paradoxically – the unsuccessful product (the salmon salami) also served as a crucial bridge for the product that became successful in the end.

Through difficult learning processes of reducing and bridging gaps, new paths may sometimes open up and provide grounds for large scale investments in, and exploitation of, novel combinations. Thereby new paths may be created, expanded, and eventually stabilized as part of business practice but they will always have to start in the existing structure. Furthermore, by taking friction into consideration, we argue that established paths represent both barriers and opportunities for innovation. While innovation processes often fail, when they succeed they are likely to have both exploited the resource constellations in the established path, while at the same time breaking with parts of it. The resulting distribution of unpredictable effects through the network(s) through friction will need to be dealt with, whether they benefit or weaken the process.

So, what does it take to recombine resources and activities across highly specialized industrial networks? Further research is needed to specify this even more, but our study indicates that it – at the very least – has to do with the diminishing of gaps by redefining the dimension in which the gap is determined through mutual learning (and teaching), and the careful association of new, as well as expanding established, social and material relationships, i.e. resource ties and activity links. Mutual learning and teaching actualizes not only sharing of knowledge and knowledge transformation, but also the mobilization of power to convince or enforce partners to change their practices. We also emphasized how very knowledgeable and specialized actors know close to nothing about how to combine their resources and activities in new ways across their established networks; hence innovation always represents considerable uncertainty. Due to specialization, novel solutions will always need the crossing of some kind of gap within or across networks; the more novel the solution and the more specialized the actors, the bigger gap to bridge. Motivation for participating in such uncertain processes requires the innovation to have a degree of similarity and complementarity with the actors' established product/service portfolios, as well as alignment of the actors' different interests and agendas.

In light of the challenge of increasing specialization, a follow-up question is whether and how firms and networks may prepare for innovation. We suggest two possible non-exclusive strategies to handle the challenge: On the one hand it is possible to imagine a strategy of recapturing and regenerating a wider knowledge base and scope, and thereby become less specialized. In order to increase innovation capacity, it is useful to improve the ability to understand others, and thus possibly also making own knowledge and resources understandable and recombinable. On the other hand, one may acknowledge that increased specialization is unavoidable, and hence seek to explore and mobilize bridging mechanisms that can enable the coordination of activities across the vast 'ocean of uncertainty' during radical innovation. In both alternatives, further specialization will be necessary, at least in some particular areas related to actual innovation processes, although these may move in new directions and towards shaping new relationships. In our case study it is then an interesting question whether such bridging ultimately is about bridging established networks in a more limited sense, or if it is about developing a new network in between. Longitudinal studies of such processes beyond single projects would be necessary to provide good answers to this. In the further research of bridging, it could be fruitful to define and map out types and sizes of gaps, as well as bridging mechanisms/strategies and the elements in use.

This paper represents an attempt at contributing towards an interactive conceptualization of innovation in industrial networks. At its core it touches on the fundamental question of what interaction means in industrial networks. While much has been done on buying, selling, and other kinds of economic interaction in established networks, there is still need for studying and conceptualizing interaction for development and innovation. Together with well established concepts such as recombination and friction, the concept of bridging contributes, we argue, towards a terminology of industrial network innovation that both needs to be better understood in itself, and supplemented.

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Thomas Hoholm, Associate Professor in Entrepreneurship, BI Norwegian Business School, Oslo, Email: thomas.hoholm@bi.no

Håkan Håkansson, Professor in International management, BI Norwegian Business School, Oslo, e-mail: hakan.hakansson@bi.no