RADICAL INNOVATION IN A CONSERVATIVE INDUSTRY. SELECTED CASES OF NEW PRODUCT DEVELOPMENT IN THE NORWEGIAN FOOD INDUSTRY.

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Summary of the thesis

This doctoral thesis investigates how radical innovation takes form in a conservative industry. It specifically studies collaboration activities in the context of new product development within actors connected to the industry. Food innovation is of importance for developing healthier and more sustainable food to feed the world's growing population and meet nations' desires for a high self-sufficiency rate. The food industry is old, rooted and originates from farms processing food. Food production and the processing history influences todays structure. Despite the size of the food industry, and its continuous search for new and novel nutrient sources, the diverse industry includes various actors from small family-owned companies to large enterprises. Moreover, it is understudied in terms of open innovation and collaboration for innovation. There is little knowledge about how these actors, especially the novel food pioneers, work with suppliers, research actors, governmental actors, distributors, and customers regarding new product development.

Through the lens of open innovation, questions about product development and partnership have been asked in combination with how appropriability has affected collaboration and innovation. Literature on innovation within the food sector has previously discussed how open innovation can help actors during new product development. Further, open innovation as a phenomenon fits nicely with radical product development where different technology provides higher customer benefit. This thesis is set up to fill gaps in prior research theory on collaboration for innovation within the food industry.

The study focuses on how the food industry conducts innovation processes during radical new product development. How the food industry manages innovation has been studied through cases of radical new product development. Innovation in the old rooted and traditional domestic cereal industry and innovation within the European novel food regulation system have been selected cases. While the domestic cereal industry can be looked upon as a prototypical case, the novel food industry is an extreme case. European novel food has a small number of cases and provides a transparent look at evolution over time from when the regulation was implemented in 1997 until late 2019. Case studies with mixed data were used to achieve a deeper understanding.

Findings from the domestic cereal industry demonstrate how transparency and interaction with machinery suppliers may result in successful types of innovation. Further, it exposed how mutual trust, asset control and distribution control were positive for openness during innovation processes. Findings from the novel food case demonstrated how interaction with R&D suppliers were common during the development of novel food products for companies of all sizes. In addition, it was found that the early more rigid regulation prevented innovation compared to the new regulation from 2018. However, both regulations facilitate easy routes for second-to-market approaches with their open governance. Pioneers have been vulnerable to knowledge spill over during these transparent approval processes, and a relationship between patenting and external collaboration was found. Patents with their inventors and owners reveal a pattern of selective partnership.

Finally, the thesis shows that open governance makes mutual trust and secrecy during collaboration between actors' important factors in radical product development processes. Collaboration with suppliers, business customers and research partners play important roles during innovation processes for these industries, often characterised as low technology

industries. For the more typical food industry, in contrast to the novel food pioneers, the lack of appropriability regimes makes mutual trust during collaboration and openness important. Patents, trademarks, scientific reports and health claims are all being combined in appropriation regimes for the novel food industry actors. In addition, these flag-planting strategies build value into products.

How companies involuntarily open their new product development process during new product development, with the risk of external actors capturing value from the innovation, should be of interest for the further development of open innovation theory. However, patterns of openness during radical novel food processes are not the same as for the open innovation phenomenon, which originally focuses on research mechanisms that manage spill overs with formalised plans.

Contents

1. Introduction

"For ensuring successful innovations there seems to be a broad agreement of optimal collaboration among food suppliers and grocery chain stores. Since both actors express dissatisfaction with the speed of innovation, it is difficult to interpret this differently than that the cooperation and trust between the players when it comes to innovation is poor." (Mat makt og avmakt, 2011)

New food products are being continuously introduced, driven by commercial market shares, globalisation, growing ethnic diversity and the search for new nutrient sources. Despite this, the food industry is understudied in terms of innovation (Giuseppe et al., 2017). In Norway, food industry actors represent some of the nation's biggest firms in terms of employees, turnover and revenue. These actors are a diverse group spanning from old, rooted family-owned handcraft actors, via bulk-producing companies, to modern high-tech pioneers. However, little is known about how and if these industry actors in the food system collaborate with each other regarding suppliers of goods, research, governmental actors, distributors and customers, all of which are associated with the creation of new food products. In this thesis the baking industry together with the novel food industry will be used as cases as it covers the whole range from traditional actors to high tech businesses.

How does the food industry conduct innovation processes in terms of collaboration and openness during radical new product development? The food industry's lack of protection mechanisms and weak appropriability regimes makes knowledge easy to imitate and can explain why a diverse group of food industry actors selectively choose which partners to trust and collaborate with in order to create new products. The old, rooted food industry and its trusted and selected partners seem to create new food products by following collaboration patterns that are included in the open innovation phenomenon, where inflows and outflows of knowledge are intentionally used to accelerate innovation (Chesbrough and Crowther, 2006, Saguy and Sirotinskaya, 2014).

1.1. Healthier and more sustainable food products

Future food innovation is of importance for developing healthier and more sustainable food products that can feed the world's growing population. Moreover, most nations want to be partly self-sufficient regarding food products in case of a crisis. Recent sustainability goals – where food products like meat are linked to an increase in greenhouse gases, pollution and heavy carbon footprint releases – are now affecting new product development for the food industry.

"Because much of the world's population is inadequately nourished and many environmental systems and processes are pushed beyond safe boundaries by food production, a global transformation of the food system is urgently needed." (Willett et al., 2019).

This quote describes recently pinpointed global challenges to the global food system. These must be acted upon to achieve the UN Sustainable Development Goals (UN, 2015) and those of the Paris Agreement (UN, 2016). Food sustainability goals in the EAT lancet report (Willett et al., 2019), written by a large group of international authors in various fields of science, describe healthy and environmentally friendly diets consisting mainly of fruits, vegetables and grains. This controversial and highly debated report describes a future recommended meal composition with a low amount of seafood, poultry and a near complete absence of red meat, processed meat, added sugar, refined grains and starchy vegetables. The idea of food production and composition of meals, being one of the largest drivers of environmental change, has recently received considerable attention, and it is suggested that sustainability will shape and direct food innovation in the years to come. A transformation of the global food system will require involvement from all actors in the food supply chain, as well as policy makers and individual consumers, to reach the shared global goal of healthy and sustainable diets for all. This leads to the multiple issues named "Grand Challenges" (George et al., 2016), with formulations of global challenges repeated through the UN sustainability goals, that can be plausibly addressed through coordinated and collaborative effort. Diverse sets of collaborative partners will have to join forces to tackle the world's most pressing societal challenges. The role that public policy and regulations will have in encouraging technological development that addresses pressing societal problems is a topic of interest.

This sustainability trend (Willett et al., 2019) inspires many aspects of new product development within the food industry today. For example, where the Norwegian bakery industry 10 years ago primarily innovated based on very traditional health requirements, consumer needs, consumer design and new ways of distribution, the same industry nine years later introduced protein enriched bread with insect powder, the first actor to do so in Europe. The product Mjølmums, produced by Bakehuset for the high-end profile store Meny, was a limited variety of a whole grain bread. The coarse-textured bread contained 2% grounded insect flour corresponding to around 100 larvae in each loaf. This example indicates how my thesis, centred on radical and open innovation in the food industry, with a focus on novel food innovation, has found relevant empirical material even in the traditional segments of the industry.

Novel Food in Europe is defined as food not consumed in the EU before 1997, when the first EU regulation on novel food came into force. For example, 10 years ago the Norwegian bakery industry primarily innovated based on very traditional health requirements, consumer needs, consumer design and new ways of food distribution. Nevertheless, it was the same industry that nine years later was the first in Europe to successfully introduce bread protein enriched with insect powder.

Studying European novel food regulation, and the content of 22 years of novel food application dossiers, reveals patterns of new food ingredients replacing meat with alternatives such as cell-based meats, insect proteins and novel plant proteins. The novel food category covers new foods, food from new sources, new substances used in food as well as new ways and technologies for producing food. Novel food regulations in Europe follow principles for protecting consumers from potentially harmful food ingredients, and this requires a centralised assessment and authorisation procedure (Ververis et al., 2020). Foods or food ingredients that were not consumed to a significant degree in the EU before 15 May 1997 are considered "novel" under the novel food regulation (EC, 1997). Novel food applicants must provide evidence that their product is safe by submitting a novel food dossier to the European Commission (EC), after which a scientific safety assessment will be performed by the European Food Safety Authority (EFSA).

1.2. Incremental and radical innovation

Incremental innovations may be defined as innovations with relatively minor changes in technology providing relatively low customer benefits (Chandy and Tellis, 1998). The knowledge embodied in incremental innovations are expected to be present within the firm (Kobarg et al., 2019). Radical innovation may be defined as a new product that integrates a substantially different technology and provides considerably higher customer benefits compared to previous products in the industry (Chandy and Tellis, 2000). Radical innovation is rare, novel and replaces existing solutions with something entirely new, while incremental innovation involves ongoing improvements. There are indications of less radical innovations, in terms of novelty, within the food industry compared to those of other sectors where companies in the food industry take fewer risks in order to save costs (Bayona-Saez et al., 2017). Due to a reduced risk associated with new product development in fast-moving consumer goods, new products can be seen as line extensions resulting in less surprising incremental innovations. These incremental innovations offer competitive advantages to small- and medium-sized firms, as they are more rapid and profitable (Bhaskaran, 2006). In many ways, holding on to purely incremental innovation can be a profitable strategy for the smaller companies operating in these highly competitive markets (Bhaskaran, 2006). However, incremental innovation leads to less competitiveness among national actors, which leaves the multinational actors with bigger resources and better possibility of growth (de-Magistris et al., 2015).

The difference between incremental and radical innovation may be seen in terms of whether the innovation is perceived as a modification or something unique (Norman and Verganti, 2014, Santoro et al., 2017). Improvements within a given frame of solutions can be named incremental innovations, while radical innovation represents a change of frame and doing something completely new. The work of Dahlin (Dahlin and Behrens, 2005) introduced a third criteria, in addition to novelty and uniqueness, for measuring radical innovation, namely adoption. Adoption as impact on future technology was measured through patent citations. In measuring radical innovation for the European food industry, novel food citations, as copies of already approved novel food products named substantially equivalent in EU terms, have been used the same way as patent citations in the work of Dahlin.

One challenge is that radically new food products can be classified as novel food and be forced through a rigid approval system that stagnates the development of real novel food products (Hyde et al., 2017). Further, it has also been found that the EU novel food regime has been threatening policy goals of fair markets and consumer protection and delayed new product development (Hyde et al., 2017). With this background, I settled on studying the novel food regime in terms of radical innovation and new novel products.

How the EU novel food regulation has affected radical food innovation among actors is of interest to me and this PhD project. The novel food regulation regime illustrates why there is little radical innovation. The great complexity of novel food has posed major challenges to the evaluation approach. The scientific requirements for novel food are set by EFSA, which means that a rigorous and cross-cutting approach must be taken by the applicants when they prepare scientifically sensible application dossiers (Ververis et al., 2020). These processes have been resource intensive, as they require a considerable amount of time and capital. However, the applications are partially open and therefore well documented in line with patents, which means they provide access to empirical data for research.

Few ordinary yet new food products introduced by the industry will qualify for EU novel food approval, even though both the industry and consumers claim the new food is radical and novel. Innovations, which would be classified as incremental in academia, may be presented as radical innovation by the industry themselves. For these actors, the new products seem radical, although it is not new to the world but only new for the company. I believe the academic classification for incremental and radical innovation may be of less interest for the food industry since line extensions are often where these firms make their profit. In this sense, the level of radicalness in new product development may be more of an academic classification.

1.3. Open innovation and collaboration

Recent literature on innovation within the food sector has partly discussed how open innovation can help food industry actors during new product development (Zilberman et al., 2019, Lambrechts et al., 2017, Saguy and Taoukis, 2017). In order to develop more radical ideas, firms will normally approach other actors and develop new products in networks. When firms develop products entirely by themselves, as closed processes, we find mostly incremental product changes being developed (Powell et al., 1996). Protection mechanisms in low technology industries will typically be secret, which is in contrast to the high technology industry where it is easy to patent both products and processes (Arundel and Kabla, 1998, Baldwin and Hanel, 2003, Manzini and Lazzarotti, 2016). Some in the food industry have patents as novel food pioneers. However, the combination of patents and openness can be seen as a paradox (Arora et al., 2016, Laursen and Salter, 2014), where patents both hinder and help firms in the process of opening up towards outside actors.

Knowledge of the old, rooted food system and its history in different nations is important to understanding the structure of the market. In Norway, farmer-controlled cooperatives that produce milk, meat and grain represent half of the industry, and only three distributors control 90% of all stores. During the last century there has been a shift in the power balance of market control from farmers to the processing industry and finally the distributors (Meld. St. 9, 2011, Mat makt og avmakt, 2011), and this affects innovation as illustrated in the following quote from an innovation manager in the bakery industry, documented while gathering of data for paper 1:

"It is more and more the stores [profile grocery chain stores] that make the decisions we are so dependent on distribution. This is the key to success….if we don't have distribution, we can

forget innovation… and to get distribution, we need the distribution people on our team, and then they want exclusivity on what we co-create – of course – and we will give it to them. This leads to less radical innovation." – Innovation manager in the bakery industry.

There seems to be a lack of protection mechanisms for incremental new food products, which are vulnerable to being copied in a low-tech industry. In addition, there has been a growing trend to introduce more private label products to grocery stores owned by food distributors. Private label products are challenging established brands and shifting the balance of power further out in the value chain. Copying brands and re-launching products, in form of private labels, is a threat, and it becomes more difficult for producers to maintain their power of ideas (Olsen et al., 2011, Mat makt og avmakt, 2011). Private label products provide higher margins and bargaining power since retailers have control over shelf space (McNeill and Wyeth, 2011, Konuk, 2018, Suh and Jeon, 2019). There seems to be a trust issue that affects the selective collaboration among actors in the food value chain.

The recombination of external and internal knowledge may facilitate ground breaking ideas (Katila and Ahuja, 2002), and this is why open innovation as a phenomenon fits nicely with radical product development in the food industry. These recombination's, viewed through the lenses of open innovation, is what my PhD project studies.

1.4. Motivation and development of research questions

The distribution of knowledge originating from university-based trials in science can be challenging, something I will try to illustrate with an example from personal experience. In 1997 I started my masters at The Norwegian University of Life Science (NMBU), located only 10 km from our family farm. My father, who is a grower, went to Japan to learn how to produce strawberries out of season. He and I knew that most of Japan's strawberries were produced in simple greenhouses, using June-bearing cultivars for winter fruit production with an advanced flower bud initiation technique (Yoshida, 2013). At an experimental station for strawberries in Japan in 1997, my father was handed a twenty year old article, written by Professor Ola M. Heide (Heide, 1977). This article on photoperiod and temperature interactions for the flowering of strawberries seemed central for the tacit knowledge developed further in Japan at that time. It was this knowledge we were seeking, and it had been developed decades ago in our own area. Inspired by my family business, my master's thesis focused on plant physiology concerning the production of strawberries in greenhouses midwinter with artificial light and the double induction of flower buds manipulated by daylengths (Sønsteby and Heide, 2006). After this I started running my family's farm growing strawberries midwinter in greenhouses, discovering bigger innovation challenges in the food system than plant physiology, namely collaboration on new product development for distribution and sales.

This PhD project, with its interest in innovation, product development and collaboration between various actors in the food system, was initiated during my studies in the 1990s. I was finishing my master thesis at NMBU in 1998 studying plant sciences. At this time, I was supervised by Professor Finn Måge, and the plant physiologist Professor Ola M. Heide was one of my discussion partners. Both professors had the ability to convey their ideas in collaboration with farmers, while at the same time getting scientific work cited. I later came to understand that this form of ambidexterity is rare. The ability to understand and be understood by different disciplines may be explained by ambidextrous theories and absorptive capacity (Cohen and Levinthal, 1990). The theory of absorptive capacity, as the ability to notice, grasp and apply new information, may explain why my professors apparently managed two different worlds this well at the same time.

Collaboration with the generic fruit and vegetable marketing association O.F.G. (frukt.no), was important for the introduction of these out of season strawberries in Norway. This non-profit association on fruit and vegetables helped connect my family as farmers to the newly Bocuse d'Or gold medal winning chef Bent Stiansen. After this, Stiansen became a guardian angel for Norwegian grown and sweet tasting strawberries from all seasons. The high-end fruit and vegetable market in Norway were fairly small, and the berries had to be distributed directly to retailers owned by various distributors every day, due to a short shelf life. High-end restaurants were also served directly. Direct feedback from distributors, blue collar fruit employees at retailers and Michelin star awarded restaurants were all part of this collaboration for product development on taste, shelf life, packaging and distribution.

These strawberries were served midwinter to The First Lady of the United States during her visit to the winter Olympics at Lillehammer in 1994 and routinely sent to our royal palaces in Scandinavia. When the Japanese Emperor visited the Royal Palace in Oslo, he was served specially selected large strawberries, distributed through a small local grocer who made a special order from our family farm. However, this out of season production was closed down after 16 years due to high energy prices and high-quality low-cost imports disrupting the market. Nevertheless, this strawberry adventure did inspire a deeper understanding of new product development and collaboration for innovation among fast mover consumer goods.

In combination with this practical experience of innovation in the food system, I have been inspired by the now retired journalist Nina Andersen who wrote food articles for Norwegian newspapers. Her news articles on annually introduced food products divided by winners and losers has illustrated the failure rate of fast-moving consumer goods at retailers for Norwegians. From 2012 till 2019 her news articles monitored new food products, where she checked the assortment the year after their launch to see if the products still existed.

In 2006 I started working at the food research institute Nofima, where I led an SME project financed under the EU's 6th framework programme. One of these projects became bogged down with a novel technology for reducing the sugar content in apple juice. This process was invented by food scientists from Weinstephan in Germany and Nofima in Norway for the Norwegian family-owned juice producer Lerum and Norwegian food and drink association NHO Mat og Drikke. The product was truly novel but could not be served before undergoing a full novel food approval procedure. Today, 10 years later, a patent is finally filed, and a novel food dossier is planned to be handed in, which exemplifies how radical food innovation can be time consuming.

The amount of goods introduced by the food industry later classified as failures has, in addition to my background as a producer, triggered my interest in food innovation and collaboration. One may argue that product life cycles have historically shrunk dramatically, leaving only 5 years for food items compared to 20 years on average 50 years ago (Cooper, 2001). This makes it difficult to separate failed products from products with a short life cycle. However, I have not found indications of food industry products having a significantly shorter life span compared to other fast-moving consumer goods like cosmetics, toiletries or over-the-counter drugs (Cooper, 2001).

With this background I have been wondering how food industry companies behave during successful new product development, and if this high failure rate of incremental products is a problem. Further questions regarding actual failure rate and possible patterns for winners and losers of new products at retailers have also been developed. However, the papers that lead to this thesis have developed further and focused on collaboration and radical food innovation.

1.5. Main research question

During my time at the food research institute Nofima, I observed how the food industry and their R&D providers behaved while running innovation and food development projects together. This is when the transition from natural science to social science started for me. During the development of the midwinter greenhouse production of strawberries, my family spent more energy on collaboration management than on plant science. Further, working closely with food scientists in innovation projects, I observed some patterns of successful collaboration within diverse groups. My practical experience on how radical new products fail to succeed in a market and become an innovation, without collaboration outside the boundaries of a firm, in combination with scientific literature, has motivated the following research question:

How does the Norwegian food industry carry out radically new product development processes, and how do openness, appropriability issues and policy regulation affect these innovation processes in the industry?

In this thesis I will present the theoretical perspective in section 2, along with further motivation and development of the research question with research gaps. In this section I will present the theory of open innovation and collaboration, which is later used to explain my findings. This will be followed by background information in section 3 concerning Norwegian food production, which describes the food and drink industry and its supply chain structure. Both agriculture- and sea-based commodities, and the unique history about these productions, will be accounted for to understand and acquire a holistic view of the Norwegian food system. Section 3 also describes the European novel food regulation. Further, the research design, with its foundation, sources and limitations, will be addressed in section 4, followed by summary of the papers' results with discussions in section 5. Finally, in conclusion, a contribution to theory and implications will be presented in section 6.

2. Theoretical perspective

Through this PhD work I shed light on how collaboration during radical new product development occurs in the food industry. I will demonstrate this through my study of successful innovation cases from the domestic cereal industry and further through European novel food pioneers. The latter represent the less traditional part of the industry, although both sectors employ radical innovations through extensive collaboration.

It has been found that many companies have moved from innovating based on internal knowledge and resources to engaging in highly collaborative innovation processes (Chesbrough, 2003). This widely emulated tendency, pioneered by a few large enterprises, has been called a phenomenon and given rise to the theory and framework of open innovation. This framework has stimulated several nuanced concepts for understanding the practices and challenges of inter-organisational open innovation, as well as promoted these as preferable approaches for companies in the current industrial environment. Professor Henry Chesbrough, as the originator and champion of open innovation, named it an imperative in his first book on the topic. The literature has grown to several thousand scientific articles alone and its interest over time, measured by a general web search, has been stable throughout the last decade. In this theory chapter, I have focused on those scientific articles that can help me understand the challenges of more radical innovation processes in an old and traditional industry.

In this theory section I want to explore and explain the open innovation phenomenon and its academic history including its fear of lost control, first-to-market approach, IPR limitations, geographical patterns, trust and paradoxes. Finally, I will account for forms of open innovation described by scholars in the food industry.

2.1. Definitions of open innovation

The concept of open innovation may be defined as "*a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model*." (Chesbrough and Bogers, 2014). Here the focus is on R&D spillover, such as ideas and concepts and the planned mechanism that structures and manages such spillovers. Through pecuniary (financial) and non-pecuniary knowledge flows, innovation accelerates and expands. Business models highlight companies' new product development strategies and open innovation activities must create value to sustain their purpose. However, since the food industry is considered low-tech, R&D will generally have fewer resources in this industry compared to high-tech industries.

2.1.1. Closed innovation

In order to explain openness, one often refers to companies that are closed during their innovation processes. However, closed innovation, that is, with secrecy, is argued to be negative for competitiveness, resulting in higher R&D costs and longer time to market (Chesbrough and Crowther, 2006, Mowery, 1983, Cainelli et al., 2004, Randhawa et al., 2016). In this closed world, organisations attain a competitive advantage through exclusive ownership and control of intellectual property (Chesbrough, 2003). Closed companies invest too much energy in resolving problems by themselves insteead of collaborateing with others to acquire ideas from the outside world (Chesbrough et al., 2014). However, in contrast to this and other signs of open innovation within the food industry (Ramirez-Portilla et al., 2016, Sarkar and Costa, 2008, Bigliardi et al., 2010, Saguy and Sirotinskaya, 2014, Procopio Schoen, 2017), it is also believed that closed innovation using internal capabilities constitutes a culture of innovation for parts of the food industry (Kratzer et al., 2017) as well as a timingly profitable strategy during selected stages of new radical product development (Bahemia et al., 2018).

While early research on open innovation focused on collaboration in general, recent literature has focused on sustained open innovation with value creation and value capturing for uninterrupted openness and competitive advantage. More recently, research has examined how open innovation requires collaboration among interdependent actors who rely on each other's capabilities for value creation and capture value generated for all involved (Chesbrough et al., 2018). A further focus for open innovation researchers has been the dynamics of open strategy from closed to open and back again depending on product development stages (Bahemia et al., 2018) as well as during life cycles of markets that favour either growth or control (Appleyard and Chesbrough, 2017).

According to the open innovation phenomenon, boundaries are permeable, and innovation is moved from location to a relational system with external partners (Bogers and Jensen, 2017). Outside high tech, open innovation adopters have been studied, and the same collaboration patterns have been discovered (Chesbrough and Crowther, 2006). Moreover, some have argued for the same openness during the innovation processes of traditional and mature industries (Chesbrough and Crowther, 2006). Companies acquire new knowledge when scanning for new technologies, collecting information, approaching external R&D providers and establishing collaborations (Chesbrough et al., 2014). Opening internal innovation processes allows the advantage of others' knowledge to speed up exploitation, both outside in and inside out (Chesbrough, 2020). Crowdsourcing can exemplify outside-in knowledge flow, while inside-out knowledge flow can be exemplified by societies of users who modify products.

2.1.2. Chesbrough

Professor Henry Chesbrough hosted the World Open Innovation Conference in Barcelona in 2016, and during the PhD seminar held in advance at the ESADE Business School, he gave the following quote: *"One challenge in the use of the open innovation concept has been the broad definition introduced by the many turning the definition of everything into a definition of nothing"* (Chesbrough, 2016). To define the open innovation concept at that time he stressed that it does not resemble non-organisational activity, intra-organisational activity and spill overs in unmanageable ways. Open innovation companies manage these knowledge flows; if not, it is not considered open innovation (Chesbrough, 2016). During his lectures at this seminar he also pointed out the importance of differentiating between R&D in research and development. If a company knows the outcome of their activity it cannot be R but D, and open innovation is all about the R where the outcome is uncertain.

To understand food innovation and gain more insight into the flow of knowledge during new product development among actors in the food system, the theoretical lens of open innovation has been applied throughout my thesis. It is suggested that the advantage of the open innovation phenomenon – with its assumption of collaboration, flow of knowledge and co-creation processes (Kristensson et al., 2008) – leads to better, faster and more efficient innovation. This reflects its broad definition and makes it easily understandable. However, when it comes to building theory, being too broad is also one of the phenomenon's biggest challenges. Open innovation and the challenges of organising openness has been studied intensively in the last decade after being introduced to practitioners in 2003 (Chesbrough, 2003) and academia in 2006 (Chesbrough and Crowther, 2006). To influence future public policy and inform both academic research and current business practice, Chesbrough has published several books. The latest illustrates examples of successful open innovation processes beyond Silicon Valley in a global context (Chesbrough, 2019). In the field of innovation management, both co-creation and open innovation build on the idea of openness concerning companies' boundaries and the external and internal innovation flow between them. However, co-creation involves a further diversity of participants with a wide variety of contributors, including students, researchers, scientists, field experts, amateurs, and innovation enthusiasts, all of whom may provide valuable input regarding the companies innovation projects (Tekic, 2016).

2.1.3. Inbound and outbound

Open innovation has become a highly debated issue in the management literature. In trying to define the concept of open innovation, we aim at a moving target since the phenomenon has matured, and the original definitions have been made more precise by its originators. Information flow during open innovation activities are often named either inbound or outbound in the same way as call centre receives incoming or makes outgoing calls. Inbound open innovation refers to purposive inflows of knowledge and capturing benefits from external sources of knowledge. Outbound, on the other hand, is the process of establishing relationships with external partners with the purpose to bring ideas to market faster and commercially exploit technological opportunities (Mazzola et al., 2012). The dimensions of inbound open innovation may be shaped differently by various types of innovation such as a radical versus an incremental approach, product complexity and various appropriability regimes. There are many alternative models of openness and closedness, and companies may not have the same strategy throughout the whole new product development process. "*There may be very good reasons for keeping an NPD (new product development) project closed during specific stages of the project, and the timing of the shift between closed and open innovation during the project may be crucial to its success*." (Bahemia et al., 2018).

2.2. Soft skills, tacit knowledge and open innovation

Challenges concerning open innovation often arise at early partnership stages for technology solutions (Lavrynenko et al., 2018), and can often be taken down to a personal level. Pioneers might find themselves facing such challenges of early stage technology since they require skills not held within the company itself. Balancing this openness can be difficult since it is not only about sharing hard skills that originate from education and training but also soft skills like behaviour and communication style. Soft skills, such as being a team player and good communicator, appear to be essential to success concerning open innovation in high technology industries like biotechnology, although soft skills are certainly essential (Lavrynenko et al., 2018).

Soft skills may be coupled towards tacit knowledge (Nonaka, 1994), which is embodied knowledge often impossible to learn without practice. It is believed that when companies open up their production sites and allow colleges and competitors in, which enables workers on the same level to exchange tacit knowledge, they might both benefit from this (Nonaka and von Krogh, 2009). The food industry, and especially its commodity providers such as farmers and fishermen, are known for being high on tacit skills brought forward among workers after learning by doing. Tacit skills may also be called silent knowledge (Molander, 1992). For the cases I have been studying in the bakery industry, silent or tacit knowledge is crucial. During interviews I gained insight into why a baker refused to invite and open up his business for a nearby college. These small-scale family-run bakeries still have machinery developed before the second world war, and if spotted inside the bakery local adjustments are easy to copy and reproduce. Since these bakeries compete by serving the same local customers with food produced in a low-tec industry, high on tacit skills, they do not invite any neighbouring bakeries into their facilities, but rather collaborate with bakers from different regions (Grimsby and Kure, 2019). The same finding with low-tech and tacit knowledge was discovered in the novel food insect protein industry (Grimsby, 2020). Further, a baker or an insect producer will not learn to be good by only studying cereal or protein technology; rather, they must learn by doing. Tacit knowledge transmitted through personal interaction will continue to play an important role in innovation (Senker, 2008).

2.3. Family-owned companies and open innovation

The food industry is coloured by the many small-, medium-sized and family-run companies (Saguy and Sirotinskaya, 2014). Engaging in open innovation is challenging for family-owned companies. Their willingness to engage in open innovation activities might be hindered by a fear of control loss and potentially conflicting goals within the company. However, family companies often have resources for orchestrating open innovation and network management with their long-term orientation and a superior ability to develop more personalised, trusted and enduring relationships with external stakeholders (Lambrechts et al., 2017). As family-run companies may build a more personalised long-term relationship with internal and external stakeholders, this can orchestrate mutual learning, fair values and mutual trust among network partners (Lambrechts et al., 2017). For small-, medium-sized, and often family-owned companies, one will seldom find a formalised open innovation strategy, but rather a continuous new product development process with external collaborating partners that combines expertise as it progresses (Santoro et al., 2017). For these old, rooted family food companies, market-based open innovation sources appear to provide more speed-to-market, whereas science-based innovation is often associated with more radical new products and processes (Santoro et al., 2017). Further, it is found that the speed at which information is obtained is positively related to innovativeness within family firms (Craig and Moores, 2006). When it comes to openness and innovation for smaller companies, in relationships with the bigger players trade secrets and timing is considered important in order to defend against potential resource misappropriation. These often overlooked defence mechanisms among smaller companies and start-ups differ from enterprises where patents are the obvious choice (Katila et al., 2008).

2.4. Open innovation and intellectual property rights

"…we try to protect ourselves with patents and things like that,.. you are in a phase before you can patent things where you want to be sensitive… meaning protect sensitive information, and then you have problems with the universities about such things as ownership and data…" (novel food pioneer).

Patents generally work well as they control R&D cooperation and block imitation (Veer et al., 2016). On the other hand, contracts do not work sufficiently against imitation during R&D collaboration outside academia (Veer et al., 2016). Collaborating with a potentially competing partner during innovation phases increases the risk of imitation. However, an industry partner that collaborates with universities and research institutions runs less of a risk of being copied than it does when collaborating with commercial partners (Veer et al., 2016). R&D cooperation's negative effects – due to appropriability problems, unwanted knowledge leakage, imitation and costs – are associated with this dark side of innovation (Foss et al., 2010).

Balancing tension when combining open innovation, protection mechanisms and technological growth can be demanding, and in this setting tension between value co-creation and capturing value may result in either solutions or pitfalls (Stefan and Bengtsson, 2017). These sources of tension can be divided into uncertainty, asymmetry, lack of resources and different cultures (Stefan, 2018). For the development of radical food products, asymmetry can be seen as a challenge to collaboration, since these processes, hosted by scientists and commercial companies, represent partners with contrasting organisational culture and interests. These contrasting cultures can be explained as scientists from universities and research institutes are often motivated by publications while commercial companies are motivated by profit maximisation.

Appropriation refers to capturing value and benefiting from innovation (Teece, 1986, Levin et al., 1987). Technology sharing among external actors may be controlled by appropriation mechanisms such as patents that keep key technologies protected (Arora et al., 2016). Innovative ideas, appropriability and openness can be combined (Laursen and Salter, 2014). Further, it is believed that overly protective companies might miss opportunities to exchange knowledge in the innovation system. However, protection mechanisms encounter difficulties in user-centric systems of innovation (Hipp and Grupp, 2005), when dimensions of open innovation may be shaped by product complexity, appropriability regimes and incremental versus radical approaches (Bahemia and Squire, 2010). The tension between appropriation and R&D collaboration has triggered important insights into open innovation and is a fundamental element of companies' strategy (Liebeskind, 1996, Reitzig et al., 2007, Reitzig and Puranam, 2009, Lorenz and Veer, 2017).

In the following work I have introduced flag-planting as an expression that covers the wider concept of protection. Flag-planting originates from explorers claiming ownership of no man's land. The same as many California-based innovation leaders, I find flag-planting especially useful for describing intellectual property rights situations and forms of appropriability. Flag-planting as claiming knowledge through scientific publication, patents and trademarks can be seen as a regime for avoiding misappropriation. Companies face challenges when collaborating for innovation as they must simultaneously protect themselves from misappropriation. Earlier experiences of having protected intellectual property infringed upon may result in new, revised flag-planting strategies. Patterns of less R&D collaboration after having unprotected property copied have been documented, although surprisingly more R&D collaboration has been known to occur after the infringement of protected knowledge (Lorenz and Veer, 2017). The experience of misappropriation unravels potential gaps in companies' current flag-planting strategy, which indicates a potential for learning triggered by having been copied. In the case of the food industry, flag-planting covers EFSA approved health claims, novel food dossiers as well as scientific publications, trademarks and patents. Flag-planting can describe the actions of companies that want to take a leading role in the functional food segment with diverse external collaborations (Khan et al., 2014). These diverse external collaborations are in contrast to food companies that developing incremental products (Khan et al., 2014). Functional foods may be categorised in the same segment as novel foods and share the same patterns of collaboration and appropriability regimes during new product development.

2.5. Open innovation, speed and first to market approach

Teece (1986) shows that being first to market is not always the best solution for companies, but rather second or third is preferable. How inventors lose and imitators benefit can easily be explained by the lack of intellectual property rights (Teece, 1986, Arora et al., 2016). Complementary assets such as companies' resources are also coupled to this dilemma. Patents, copyrights, and trade secrets might not stop imitators as intended, and this may result in a weak appropriability regime (Cohen and Levinthal, 1990), which puts imitators and competitors in a better position (Teece, 1986, Blakeney, 2011, Brem, 2017).

Bahemia et. al. (2018) revisits this dilemma, described by Teece (1986) in terms of the timing of openness in radical innovation. They found a two stage process in a radical innovation project that involved a shift from a closed to open model of innovation during new product development after the submission of, what was in this case, a patent (Bahemia et al., 2018). The patent could be replaced by other appropriability tools or flag-planting strategies. The second stage was an external loose strategy with complementary informal appropriation mechanisms. The reduction of the scope of tasks allocated to external partners was combined with the development of guarded relationships (Bahemia et al., 2018). In general, where companies use informal protection methods, with unprotected knowledge, innovation spillover aggravates the risk of misappropriation and loss of rents. This leads us to the dilemma of openness during collaboration.

2.6. Paradox of openness

While engaging in formal external collaboration and tapping into knowledge outside the boundaries of the firm, companies need to protect their knowledge (Heiman and Nickerson, 2004, Cassiman and Veugelers, 2002). This may be seen as incoming spillover information, and the ability to appropriate returns from this is of importance for successful R&D cooperation (Cassiman and Veugelers, 2002). The paradox of openness is found when managers open themselves to external actors while at the same time striving to protect knowledge from being copied (Laursen and Salter, 2014). This fundamental paradox of disclosure was highlighted by Kenneth Arrow (Arrow, 1972), where an inventor will have to disclose information in order to sell an idea and at the same time hold back information in order to appropriate benefit from the sale.

The tension of disclosure related to this paradox has been investigated by scholars from various perspectives. Laursen and Salter (2014) revisited the paradox and suggested a concave relationship between companies' external search breadth and the strength of their appropriability strategies. Further, Arora et al. (Arora et al., 2016) found a pattern where trade-offs between openness and patenting were resolved differently by leading companies and followers. Here leaders seemed more vulnerable to knowledge spillover and were more motivated to protect it. There is an increase in patenting due to an openness towards leaders compared to followers, and it is believed that followers, with incremental innovations, will benefit little from patenting. It is also suggested that followers will have fewer incentives to apply for patents since these formal protection mechanisms make them less attractive as partners in open innovation (Arora et al., 2016).

To gain further insight into the open innovation paradox, Stefan and Bengtsson (2017) studied how companies solve tensions during stages of the innovation processes. Solutions for managing tensions during various appropriability regimes vary, and cooperation agreements with its possible pitfalls are associated with over-focusing on knowledge acquisition. Findings show that in early stages of open innovation processes efficient collaboration with R&D partners is linked to semi-formal appropriation mechanisms, such as contracts, and negatively correlated with formal regimes, such as patents, in terms of speed (Stefan and Bengtsson, 2017). Intellectual property protection mechanisms vary during the innovation process, and while contracts and IPR are important during development and finalisation, trust is important during the early explorative phase (Olander et al., 2010).

2.7. Open innovation and trust

In this study I have examined literature on open innovation in combination with trust to understand R&D co-operation and collaboration among open innovation actors. Open innovation is based on contracts and the exchange of IPR, and during these phases trust is important in order to promote innovation effectively (Brockman et al., 2018). A deeper understanding of this multilevel trust is of interest. A challenge associated with accessing external knowledge is having to reveal internal knowledge at the same time. In order to access new knowledge and establish and deserve trust, companies will have to manage both inbound and outbound information to avoid information asymmetries for companies located in regional clusters (Nestle et al., 2018).

Both contractual and relational governance mechanisms play a role in R&D collaboration, though their importance varies during collaboration phases (Olander et al., 2010). In the exploration phase trust may substitute contractual governance; however, both types of mechanisms should be simultaneously considered throughout the collaboration processes (Olander et al., 2010). A lack of trust may be substituted by patents, or other forms of appropriability (Jensen et al., 2015), and it may be that trust in prior business dealings increases the probability of transaction success when patents are absent (Jensen et al., 2015). Companies in high trust countries produce a high level of joint output such as e.g. co-owned patents (Innocenti et al., 2020). Statistics of social trust originating from patent databases, balance sheets, income statements and a world value survey place Norway on the highest trust index level followed by Sweden, Finland, The Netherlands and Switzerland in Europe. The European countries with the lowest index level of trust are France, Italy and Spain (Brockman et al., 2018). There are thus some indications of a north-south axis regarding trust in Europe when looking at companies' patents and collaboration patterns. However, Beckeman (2013) found the lack of trust in the Swedish food industry being a major problem with respect to openness. The lack of trust was partly due to unequal power in the supply chain and a lack of integration, as there was little a transparent information flow in the chain. Further, it is obvious that excessive and naive trust will backfire since actors, who decide to trust based on limited information, will be vulnerable to disloyalty. Companies need to be prepared for situations that arise when trust is broken (Olander et al., 2010, Patzelt and Shepherd, 2008), although there is a clear distinction between trusting and being naive. In contrast to Beckeman (2013), I consider there to be mutual trust between Norwegian farmers and the processing part of the food industry. This dependence may facilitate and build trust during collaboration for new product development due to a long history and close relationships.

2.8. Forms of open innovation in food industry

The food industry relies on non-formal R&D activities as companies interact with suppliers, customers and consultants (Trott and Simms, 2017, Jensen et al., 2007, Kratzer et al., 2017, Beckeman et al., 2013), and managers of food companies are advised to adopt the open innovation approach as it is supposed to yield faster speed to market, lower R&D costs and better adaptation to customer's needs (Miglietta et al., 2018). Accordingly, open innovation does take place within the food sector (Sarkar and Costa, 2008), and it is gaining in popularity (Saguy and Taoukis, 2017, Saguy and Sirotinskaya, 2014, Arcese et al., 2015, Martinez, 2014, Garcia Martinez et al., 2014, McAdam et al., 2014, Traitler et al., 2011, Bresciani, 2017). As companies in the food industry have adopted open innovation ideas, it has been large companies that drive these open innovation initiatives (Ramirez-Portilla et al., 2016). However, the food industry is categorised as a mature industry with low profit margins and a high R&D failure rate (Tsimiklis and Makatsoris, 2015), which is very different considering where the open innovation phenomenon was developed.

The food industry represents one of the largest industries in the world (EC, 2015b). Nevertheless, relatively little innovation research with empirical evidence of open innovation has been conducted on this industry (Sarkar and Costa, 2008). Innovation paradigms developed in other industries have focused on high-technology, transparency and R&D intensity with rapid growth. R&D usage is one direction of industry classification. The old, rooted and traditional food industry is classified as low on technology with less than 1% of revenue spent on R&D (EC, 2015b). Biotechnology and pharmaceutical industries, which can be similar to novel food pioneers, often spend 5% on R&D. Covering the diversity that exists between the old rooted bakeries and high-tech novel food pioneers illustrates my challenges since the revenue these branches spend on R&D differs. In general, some of the innovation paradigms developed and verified through other industries may not be as valid for companies in the food industry since branches of this industry span from farmers to pharmacy. However, the most debated industry, when it comes to open innovation, is pharmacy. Pharmacy emerged as one of nine thematic areas explored in existing open innovation research (Bigliardi et al., 2020), and since novel food pioneers go the direction of pharmacy, this comparison is relevant. Further, this alludes to the one size fits all discussion when it comes to innovation policy and technology adoption (Tödtling and Trippl, 2005). Since the food industry is diverse and is moving from low-tech to high-tech with a mix of tacit and explicit knowledge, there are complex spatial patterns of knowledge links (Trippl, 2011).

Identifying the main thematic areas discussed within open innovation generally shows the role of external search, context dependency, technology, collaborative frameworks and performance as the most exploited areas followed by open innovation in SME's, organisational dimensions, IPR and open innovation in pharmaceutical industry (Bigliardi et al., 2020). In the same way, the categorisation of open innovation publications in the food and beverage industry show that the role of networks, innovation systems, user-innovation and R&D alliances have received the most attention (Procopio Schoen, 2017). However, there is still a demand for deeper and more comprehensive investigations into open innovation research in the food industry. This field would profit from studies on open innovation management, cross-industry partnerships with suppliers, vertical value chain collaboration and globalisation of innovation (Procopio Schoen, 2017, Randhawa et al., 2016, Gassmann et al., 2010). Market-driven health benefits and cross-industry collaboration are associated with more of these radical food innovations (Bornkessel et al., 2016). Adaptation of open innovation practices in the food industry may be explained by successful cases of collaboration with suppliers in a climate of trust, skills, tacit knowledge and new insights. Informal agreements are also relevant for understanding how the food industry innovates in selective partnership.

Innovation policy climate for food manufacturers, when it comes to collaborating activities in the chain, is considered to have big potential for improvement. *"A good start would be more transparency in the chain, education, information and more open innovation involving everyone that can contribute."* (Beckeman et al., 2013). Food manufacturers and retailers will both benefit from a common vision and organise for cooperation (Beckeman et al., 2013), meaning they gain an advantage through both competition and cooperation. Further, there appears to be a pattern where development in the UK food market affects Swedish retailers in terms of differentiating products and increasing food competence. This makes retailers strong competitors for the manufacturing part of the food industry, but also competent partners if ways are found to prevent the lack of trust and collaborate by using experiences from both retailers and manufacturers (Beckeman et al., 2013).

2.9. Other relevant aspects of open innovation.

A pattern with geographical dimensions of companies' collaboration is found (Stefan and Bengtsson, 2016) for local national collaboration under semi-formal and informal protection regimes. However, patents, which are considered formal collaborations, often explain successful international collaborations (Stefan and Bengtsson, 2016). Semi-formal regimes in this setting may be trade secrets and nondisclosure contracts associated with collaboration within R&D academic partners and companies. To continue the work on appropriability regimes, Stefan and Bengtsson discovered semi-formal regimes as nondisclosure agreements that are positive towards the idea phase, while patents were at this early stage negatively associated with performance. Further, it was found that openness in terms of collaboration with R&D suppliers such as universities and institutes contributed more to innovation novelty than efficiency during early phases of new product development (Stefan and Bengtsson, 2017).

Additionally, the concept of open innovation efficiency has been introduced, investigating how research funds provided by EU can be associated with better innovation outputs. Greco et. al. (2017) show that local and national subsidies are associated both with collaboration in beneficiaries and open innovation efficiency in smaller consortiums, leaving out the big international actors. However, in response to EU research programmes, firms and universities chose to involve unnecessarily strong international partners with narrow contributions (Bigliardi et al., 2020, Greco et al., 2017). This is associated with less efficient innovation projects. To encourage the development of novel innovations, policymakers should aim at forming networks that involve research institutions and universities giving the value of culture as a source of competitive advantage at the national level (Bigliardi et al., 2020).

To summarise the theoretical open innovation phenomenon, as described in the literature, I have combined openness with tacit knowledge where embodied skills are brought forward by workers and not codified for others to learn. Further, I have investigated family firm innovation patterns with inherited trust. First to market strategies and the dilemma that puts imitators and competitors in a better position have been examined, and was followed by various forms of IPR. Further, geographical collaboration patterns, with multi-level trust collaboration in combination with various appropriation mechanisms, have been introduced. Finally, I have presented relevant forms of open innovation research conducted by studying the food industry and its claims of being understudied in terms of open innovation. All these topics have their own forms of explanation when it comes to understanding the innovation and flow of knowledge across organisational boundaries. In my work through selected cases of innovation I have mapped and analysed the flow of knowledge in the food industry by combining openness with collaboration for innovation in order to understand new product development patterns and innovation as alliances and collaborations within communities - both open and closed.

3. Background

Norway is a food nation, with 109 billion NOK in total annual food exports. Food represents the biggest industry in mainland Norway with 52,900 employees and 2900 companies (Prestegard, 2018, SSB, 2020a). However, the growth is coupled with the blue sector through fish. Commodities from the green sector of the food industry originate from 39,000 farms with 45,650 employees providing the food industry with goods. These farms have an annual turnover of 46.300 million NOK (Hjukse, 2019). I want to present both green and blue sectors as important background since the novel food cases in my work are all subgroups originating from the blue food industry in Norway.

3.1. Norwegian food industry

In order to understand the food industry, some knowledge of the agricultural landscape is needed. In Norway, the food industry is not located in clusters but employs people living in rural areas. For the food industry in Norway, there are patterns of a national innovation system and not regional clusters typical of other industries (Sæther, 2012). The milk and dairy industry can be seen as the motor in the green sector, and since there are milk producers spread throughout the country, the dairy and meat industries follow the same pattern (Sæther, 2012). Norwegian farming is tightly regulated with a system of production quotas. This makes it possible for farmers to survive in marginal areas. A complex system of price regulations and subsidies promotes self-sufficiency and keeps jobs in the districts (Hegrenes et al., 2002).

In Norway, rural policy and agricultural policy merged in the post-war period and have overlapped since the introduction of the channelling-policy (kanaliseringspolitikken), which was an agricultural policy instrument moving food production in various directions according to growing conditions (Melås, 2019, Almås, 1984, Bunger and Tufte, 2016). The channelling-policy prioritised grain production in the best agricultural areas around Oslo and Trondheim, while animal, milk and feed production were pushed out to the west coast, which for various topographical and environmental reasons were not suitable for grain production. Norwegian rural and food policy has ensured food production over the entire nation in combination with settlement patterns. Because of this Norway has scattered settlement, where 7% of the population still live on private family-owned farms (SSB, 2020b, Almås, 1984, Bunger and Tufte, 2016). These farms with forests inherited through generations represent two thirds of mainland Norway. Comparing Norway with other Nordic countries' settlement, Norway has a more rural settlement while Sweden, Denmark, Finland, and Island have more urban settlements. Agriculture and the agri-food industry are in many ways interdependent. In this way Norwegian agriculture policy can be seen partly as a rural policy instrument that impacts food innovation (Hegrenes et al., 2002).

The Norwegian food industry relies heavily on domestically produced meat, milk, eggs, grain, fruit and vegetables and toll protection regarding imported goods (Bunger and Tufte, 2016, Meld. St. 9, 2011, Mat makt og avmakt, 2011, St.meld.nr.19., 1999). The market protected small-scale Norwegian agriculture may be classified as post-productivist agriculture, which is hindering any unintended consequences of intensive industrial agriculture (Evans et al., 2002). However, for Norway, the relatively small-scaled farming system can be framed as a multifunctional agriculture (Bjørkhaug and Richards, 2008). The Norwegian multifunctional agriculture has developed within a protectionist setting with support from policy makers, public meanings, as well as state and food industry actors (Bjørkhaug and Richards, 2008). Nevertheless, during the last 30 years the number of active farms has been reduced from 100.000 to 39.000 farms in Norway (SSB, 2020b). Due to rented farmland the production area has retained its volume, with fewer farmers running the same amount of land. The average size of an active Norwegian farm is still only 250 daa (SSB, 2020b). Only private persons can own farms, and by law owners of farms have to live on the farm and ensure high quality food is produced on the land at all times (Meld. St. 9, 2011).

Only 3% of Norway can be used as farmland, and two thirds of this area can only be used for producing grass as feed. This is a very low share compared to our neighbouring countries, where Sweden has 8% arable land and Denmark has 63% (Tufte, 2019). Today there is a significant degree of self-sufficiency regarding Norwegian food quality wheat, with up to 75% produced domestically, in contrast till 1970 where 100% of food quality wheat was imported from the US and Canada. Researchers at the University of Life Sciences NMBU, NIBIO and Nofima have been conducting projects on protein optimisation in wheat varieties grown in Norway and how domestically grown wheat has affected baking quality over the last three decades. Wheat cereals with high protein and baking quality have been selected, and novel baking strategies for domestic wheat have been developed. This development of food grains in Norway is an example of how research has generated new implemented and applied knowledge. In this way, Norway has strengthened the negative trend regarding self-sufficiency (Tufte, 2019). Figure 1 illustrates yearly production from agriculture in Norway with 1250.000 tons of grain, 554.035 tons of fruit and vegetables and 351.850 tons of meat. In addition, the agricultural sector delivers 1.543.000 tons of milk and 71.000 tons of eggs (SSB, 2020c).

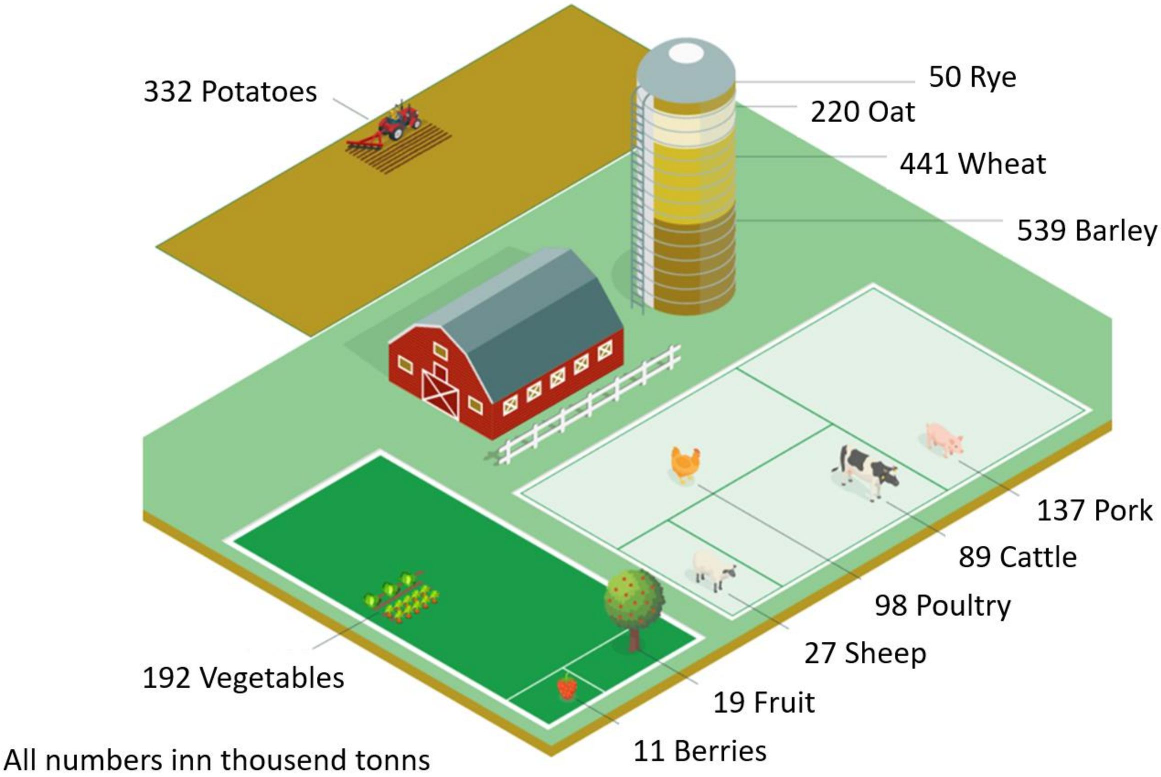

Figure 1: Total of agricultural products in Norway 2018, All numbers in thousand tons (SSB, 2020c)

Fruit and vegetables represent those goods from the agricultural sector that are exposed to most competition from imported goods, and during the last three decades imported products have tripled (Nilf, 2010). The volume of domestic production is 60% for potatoes, 50% for vegetables, 26% for berries and only 3% for fruit. In total, 29% of this volume is of domestic origin. However, since domestic goods represent heavy low-cost vegetables such as cabbage, and the imported goods represent high-end products exemplified by ripe packed avocado, imported goods have a higher price per volume. The total sales of fruit and vegetables from retailers represents 20 billion NOK, though Norwegian products are estimated to represent only 15% of this value (Rebnes, 2019). In addition to sales through retailers, HORECA (hotels, restaurants, and cafes), online stores and others consume and distribute a volume of 21% of all fruit and vegetables in Norway (Flesland markedsinfo, 2020).

The main share of food and beverages in Norway are bought at retailers and consumed within households (Kårstad, 2015). For the last 20 years there has been an significant increase in imports of food and beverages with a growth value from 13 to 44 billion NOK (Prestegard, 2018, Kårstad, 2015, SSB, 2020a). If fish is excluded, the development of exports has been quite moderate with 12 billion NOK in total for 2019 (Landbruksdirektoratet, 2020), see Figure 2 where fish is included.

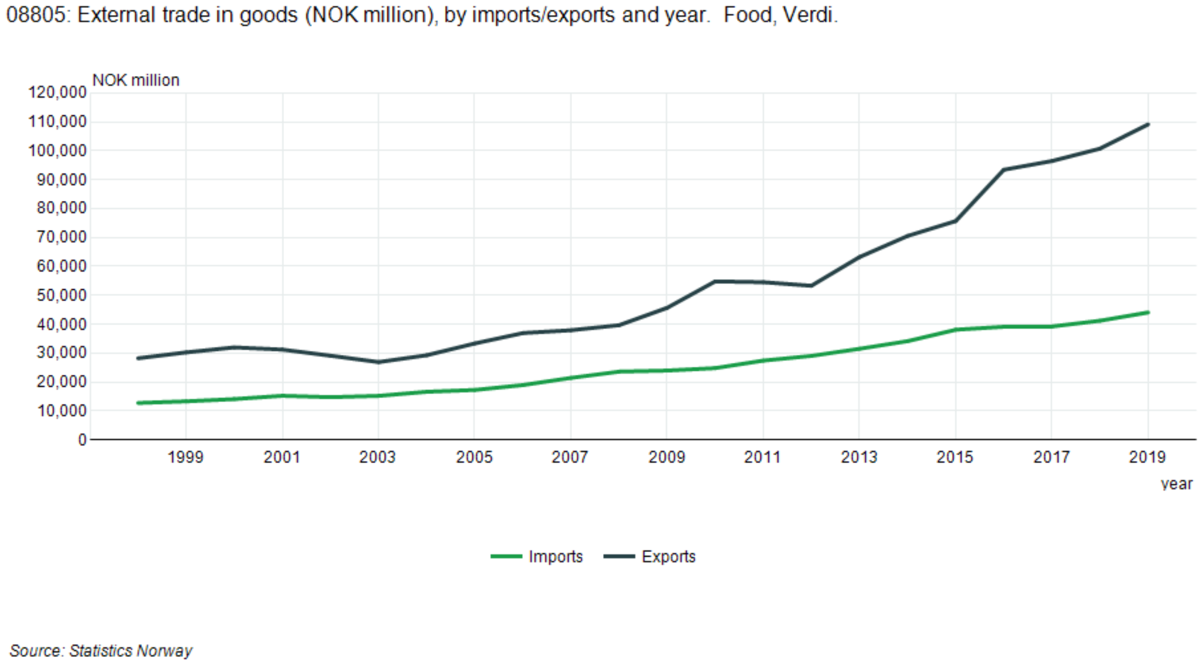

Figure 2: 20 years of external food trade for Norway. Green line imports. Black line exports.

The green and blue sectors within the food industry have different commodity needs and thus different political framework conditions. This influences the structure of the food industry. The land-based industry in the far north is maintained despite often consisting of smaller less productive tracts of farmland with short summers and challenging climatic conditions. The blue ocean-based industry has, on the other hand, some of the most optimal conditions on the planet with cool nutritious fjords and marine areas. Therefore, policy regulations for the green and blue sectors are very different. The green sector is sustained for national self-sufficiency reasons and is claimed to be the worlds most protected and subsidised agriculture, while the blue sector represents the second largest export of goods in Norway.

Based on raw materials and products, the food industry can be sectioned as meat, fish, fruit and vegetables, oil and fat, dairy, cereals, feed, sweets and drink. In paper 1 I study the development of crisp bread in Norway, where the introduction of fully atomised crisp bread factories started exporting an agriculture product. The green agriculture based part of the food industry in Norway has very few exporting examples. This makes it unique when Norway in 2019, reached 2 billion NOK of export of crisp bread to Europe and north America. There were close to no crisp bread production nor export five years earlier, see Figure 3. This is a rare example of a Norwegian export from the green sector, and it can be seen as a radical product development.

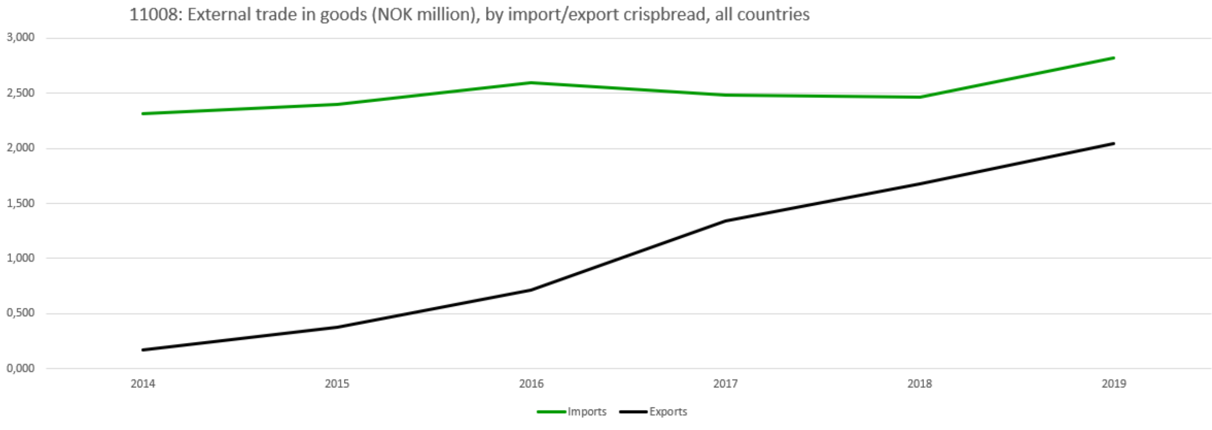

Figure 3: 5 years of the import and export of crispbread. Green line imports. Black line export.

In terms of successful product development and innovation, exporting outside the boundary of one's area has been proven to give a positive effect (Acosta et al., 2015). When it comes to factors affecting productivity, the size of the company, investment intensity, international competition, and having foreign participation in the company are all positive factors for companies' successful product development and innovation (Acosta et al., 2015).

Other exported products from the green sector are a selection of cheese and meat. These dairy-based products are dependent on various forms of subsidies to compete on the international market and are in this way vulnerable. These companies receive more national funds to invest in R&D than firms that are not provided this type of public support, which results in a greater impact on exports (Acosta et al., 2015). This makes the crispbread case even more interesting since production has been minimally supported by national funds and the raw materials originate from a less optimised industry. In 2019, Norwegian seafood exports reached 107 billion NOK due to growth, increased prices and a weak Norwegian currency. 71% of this value originates from aquaculture, with salmon by far the largest species in terms of both volume and value. Wild fished cod is the second biggest food export product followed by mackerel and farmed trout (Guldberg, 2020). Europe is by far the biggest market for these products, with 70% of the volume, followed by 20% in Asia (Guldberg, 2020). Through the last five years, the Norwegian food industry has experienced a growth of 8% in both production value and results. The growth in the seafood industry is far stronger than in the rest of the food industry. Food grade fat and oil products based on marine resources have also experienced strong growth. All industries in the food sector have shown higher than average growth. The food industry in general has registered an employment increase since 2006, while other Norwegian industries have reduced employment in the same period (Prestegard, 2018). There is a big contrast between the green and blue sector in the food industry in Norway. The green part is surviving despite difficult conditions while the blue part is growing because of optimal natural conditions. This again is colouring domestic food innovation policy of the domestic food industry. There are different ownership, structures and history of the governmental grants subsidising research in the two sectors, and it is believed that cultures from the two diverse sectors are colouring dynamics of open innovation. One example of this is how the blue sector are filing patents while the green sector has no culture for using this appropriability regime.

Small-, medium- and micro-sized companies represent 94% of the food industry and nearly half of the value creation occurs within these companies. Micro-sized companies, with less than four employees, represent 33 percent of all small- and medium-sized companies. Larger companies with more than 100 employees represent half of the turnover and less than half of all employments (Prestegard, 2018). Half of all employees in the seafood industry, and one third of food industry workers overall, have a foreign background. Although a significant number are often unskilled, 20% of all employees have a university or college degree.

There is a great variation in turnover for the various sectors within the food industry in terms of value and employment. The seafood industry has the highest turnover, the meat industry has the most employees, while the processing value per employee is highest in the dairy sector (Prestegard, 2018). While investments in other industries has stagnated since 2015, the food industry has been experiencing a yearly increase since 2004. Most investments have been in the seafood sector followed by feed, meat and dairy (Prestegard, 2018).

3.2. The novel food industry and its regulations

According to the European Commission (EC), foods that were not consumed to a significant degree by humans in Europe before 15 May 1997 are defined as novel foods. Novel food in Europe needs premarket authorisation for consumer safety before being put up for sale. New ingredients, new food processes or food sources not traditionally eaten in Europe are all considered novel to the European Union (EU). Phytosterols – often used in margarine as a functional food ingredient – krill oil and the nutraceutical vitamin K2 are all known examples of radically new health ingredients. New combinations of food processes such as UV light or high-pressure treatment, as implemented for food safety, are also considered novel and therefore sorted under the same regulation. Food sources not traditionally consumed in the EU such as noni juice, baobab seeds and chia seeds have also been authorised as novel foods. Indeed, centuries ago rice, potatoes, and coffee were also considered novel when originally introduced from other parts of the world.

Food safety, proper labelling and nutrition level are crucial considerations when introducing and putting these new food products out for sale. The first EU regulation concerning novel food was 258/97 of the European Parliament and Council passed on 27 January 1997 (EC, 1997). Novel food regulation provided a framework for the entry of radical new food products into the European market, see the flowchart in Figure 4. For new producers who wanted to trade in already approved novel food products, the old novel food regulation contained something the EU named substantial equivalence notification, where only a simple dossier showing significant comparability to the authorised product was needed.

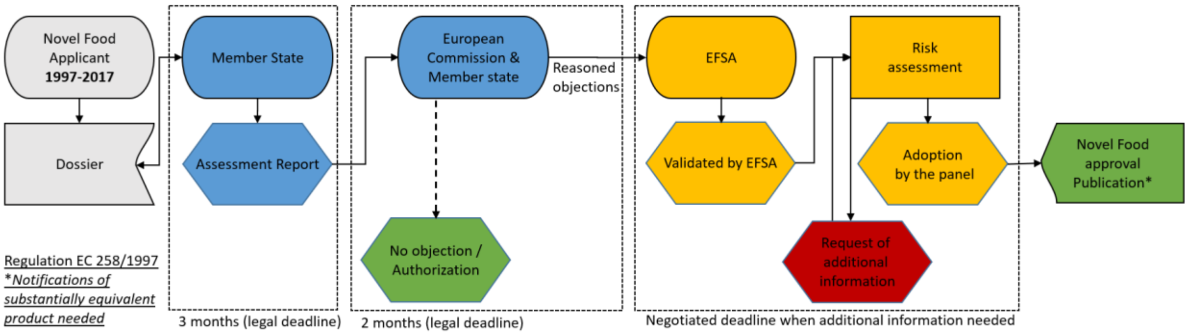

Figure 4 Flowchart of novel food authorisation process from 1997 to 2017 (EFSA, 1997, EC, 1997).

In 2018 a new novel food regulation (EC, 2015a) was implemented, replacing the original one. Key differences in the new legislation include a centralised evaluation process to reduce application time and a change in the protection of property rights (Ververis et al., 2020). This new regulation with shorter deadlines is illustrated in a flowchart in Figure 5. In this new regulation market, authorisation granted by the EC after 2018 is made generic by default, eradicating the need for notifications of substantially equivalent products. In this case, the EC grant data protection applicants receive five years of market exclusivity. This protection is somewhat fragile compared to patents, however, since it relies on secrecy concerning toxicological data. In the new regulation, EFSA has a 9 month deadline, although EFSA often asks for more data to extend the process by several years, as in the earlier regulation (Holle, 2018).

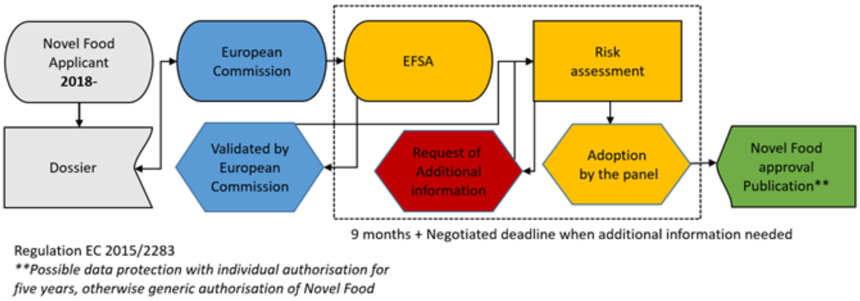

Figure 5 Flowchart of the new centralised novel food authorisation process from 2018 (EFSA, 2018, EC, 2015).

Requirements for the preparation of scientific dossiers for the two regulations are similar to comprehensive scientific studies (de Boer and Bast, 2018). Preparation of dossiers for authorisation of novel food, supported by comprehensive scientific studies, has been costly and time consuming for food companies.

How these regulations have, with open governance, affected collaboration and openness during the food industry's radical new product development is of interest when studying innovation. Since firms originating from Norway are overrepresented among these novel food pioneers', access to their product development histories has been less complicated for me being a domestic researcher.

I find the novel food phenomenon interesting in terms of radical food innovation. Having worked in the food industry for many years, I observed that the companies' product development was often line extensions under established brands. Further, the growth of private label assortment with low cost alternatives to established brands has little R&D cost attached to it and can be seen as incremental product development (Olsen et al., 2011). Sorting radical and incremental product development processes can be challenging (Kobarg et al., 2019, Norman and Verganti, 2014). In this study I have been looking for patterns of openness and collaboration during radical product development and needed a selection for this. By starting with approved novel food products, I assume to have a selection of radical food innovations when it comes to new ingredients and processes. However, food sources not traditionally eaten in the EU and their novel food approval will not be considered radical product development in my research.

4. Research design and methods

Throughout this PhD project I have studied innovation in the food industry to fill gaps in prior research elaborating existing theory. In this context I have found radical food innovation more interesting than incremental product improvements, since my studies have been focused on R&D collaboration and open innovation. Beckeman et.al. (2013) found, through a case study among Swedish food firms, few if any indications of real radical food innovation products. In Sweden, food manufacturers develop products in house, not working with consumers or adopting the open innovation mindset. Interestingly, a lack of trust in the supply chain limited information exchange, although horizontal collaboration with manufacturers abroad was observed (Beckeman et al., 2013). In my case with the old, rooted and traditional domestic cereal industry, partnerships and alignments were made upstream with suppliers regarding food machinery, food ingredients and food packaging. Case studies with mixed data was used to achieve a deeper understanding. Vertical collaboration and openness has in this manner been previously described as open food innovation by scholars (Beckeman et al., 2013, Bigliardi et al., 2010, Bigliardi and Galati, 2013).

It was interesting to grasp novel food development in Europe as it is well documented but has never been studied in terms of open innovation. While the domestic cereal industry can be seen as an prototypical case the novel food industry is an extreme case (Pratt, 2009, Pettigrew, 1990) compared to the traditional food industry. Novel food as a phenomena have a small number of cases and the progress provide a transparent look at evolution over time giving a longitudinally sequence (Pettigrew, 1990). What struck me at an early stage when familiarising myself with these firms was the high-tech level of intensive R&D collaboration and long-term strategies that differentiates this part of the food industry from the old, rooted, traditional and less risk-taking industry often described. Novel food pioneering companies differ from the average food industry actors, and they might have more in common with the pharmaceutical industry, with end products being closer to nutraceuticals than food. Although these novel food pioneers were all classified as food industry actors with links to the same policy regulations, associations, and R&D partners, they share the same educational system and partly the same distribution network as the traditional cereal industry studied in paper1.

4.1. Philosophical foundation

I started my research with an inductive approach. Inductive reasoning, often associated with qualitative methods, is more open-ended and exploratory as it examines patterns or trends. My background in the producer's side of agriculture, in combination with many years working with food science running bottom-up induced projects, has resulted in observations that lead me to theories. This PhD project started without experience in terms of altering theoretical direction, and theory has been acquired through the process. Observations of innovation in the food industry have allowed for the detection patterns and regularities, and this has formulated beliefs to explore and developed conclusions. In the same way that running research projects is classified as bottom up, controlled by industry partners initiated by a problem described in the industry, the inductive approach to this PhD project is generated by challenges and patterns observed. In this work I have moved from observation down to theories and back again to observation. However, I have not observed patterns in the data that lead me to develop entirely new theories that might come as an output of an inductive approach. I have ended up supporting and combining the phenomenon branches of open innovation elaborating existing theory.

Open innovation was presented clearly to me during my first PhD course in 2013. During this course, hosted by NTNU, Professor Laursen from Copenhagen Business School presented innovation management, where companies systematically source inputs externally. In order to understand innovation that originates from external sources, the highly cited paper "Open for innovation" (Laursen and Salter, 2006) was presented in support of the phenomenon of open innovation. Collaboration and interaction among specialised professionals were at this point explained with labels such as user innovation, co-creation, crowd sourcing, and open source. It was first three years later – after my second course with Professor Laursen during the world open innovation conference (WOIC) in Barcelona in late 2016 – where I ended up favouring open innovation as the theory for explaining the food industry cases of interest to my study.

The purpose of this thesis is thus to uncover how the Norwegian food industry acts during radical innovation processes and how selective partnership, appropriability regimes and food policy affect product development. I will argue that the three papers that comprise my thesis are all single case studies. Papers 2 and 3 have the same focus on novel food, while paper 1 has the cereal industry as its basis. The thesis can thus be classified as a multiple case study.

4.2. Explanatory sequential mixed method design

I consider both quantitative and qualitative methods to be valid approaches. While the quantitative research quantifies the problem, the qualitative research is primarily exploratory to gain a deeper understanding of the underlying reasons, opinions and motivations (Creswell, 2013). Qualitative researchers seek answers to questions like how a social experience has been created and how this can be interpreted. Quantitative researchers, on the other hand, measure and analyse causal relationships between variables, not processes (Denzin and Lincoln, 2011). Qualitative research with interviews and observation provides new insights into problems and helps to develop ideas or hypotheses for following potential quantitative research. This lead to blending methodologies, often referred to as mixed methods (Creswell, 2013). During my work I have been using mixed methods to gain a deeper understanding of radical innovation in the food industry.

I have chosen an explanatory sequential mixed method for my papers with case studies. This comes natural for me, having an originally quantitative background with the intent to use qualitative data to help explain in more detail the initial quantitative results. According to Creswell's (2013) classification, the two last papers may be classified as multiphase mixed methods, with longitudinal multi-projects informing each other.

Paper 1 started with quantitative data collection from an open innovation cereal industry scheme. This then led to quantitative data collection of 10 years of crisp bread sales, which again led to interviews and finally interpretation. Papers 2 and 3 also followed an explanatory approach with three phases, where the quantitative part merged into the qualitative part with interviews, and this was followed by further quantitative data collection from the new novel food regulation and interpretation, see Figure 6. Paper 3 followed the same route as paper 2, although with quantitative data collection from patents added in the third phase before interpretation.

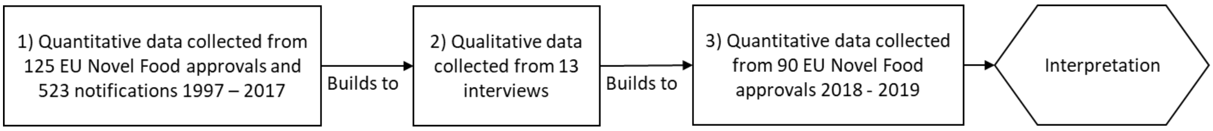

Figure 6: Example of explanatory mixed method design used in paper 2.

I have focused on interpretations of cognitive categories, prototypes and meaning, as well as how various interpretations can give different meanings. How diverse groups put different meanings into the same notions has been important for me to understand during my PhD work, as I blend data in my case studies. Mixed methods are a methodological approach that comes naturally when studying social science. However, critics are concerned about how mixed methods might privilege discourses that fix otherwise "messy" content (Denzin and Lincoln, 2011).

Different views raise the question of whether scientists are, as experts, biased. Scientists will usually work close to what is being studied, and industry sponsorship and affiliation might affect the direction and size of reported effects. Virtually all scientific work has the potential to be affected by some kind of bias; however, the industry sponsorship bias seems to be a minor problem compared to studies that have small sample sizes but report large effects (Fanelli et al., 2017). The problem is that one does not see one's own bias, despite being in the middle of it. The effects of scientists' bias can be illustrated by the Stockholm syndrome (Gulbrandsen, 2011), as when hybrid research institutes, partly funded by the industry, are accused of cherry-picking positive research results. However, ethical guidelines will prevent publication of non-reproducible results. For Nofima as a food research institute, the variation of industries within the food area will be diverse. Cherry-picking scientific results for one part of the industry will, apart from violating the ethical guidelines, ruin the possibility of future industry-sponsored projects for competitors.

4.3. Interviews and interpretation

Concerning my PhD project, I believe that working for a food research institute such as Nofima, combined with extensive work experience in adjacent industries, is crucial for access to and understanding the food industry. With regard to my own experiences of merchandising in grocery stores, this can be seen as tacit knowledge (Nonaka and von Krogh, 2009). I believe that one cannot learn tacit knowledge by reading about it; rather, one must learn through field experience: learning by doing. Preconceived attitudes about bias are something I can accept when considering the knowledge I gain of the food industry. Openness on these terms with the outside world is important, especially when earning trust about science among laymen.

Boundaries between cognitive concepts may differ from language to language, which means that translation work can be challenging. This also applies to any interpretation of language among various scholarly disciplines or between non-professionals from different social backgrounds. In this sense, food scientists, various employees in the food industry, distributors and regular consumers do not always share the same language, and none speak the language of innovation scholars. A focus on these challenges has been useful during interviews and when coding of findings in papers 1-3.

Semiotics investigates human signifying practices in specific social and cultural circumstances and the meanings that they give. Semiotics is thus the study of how people express themselves and how this creates meaning (Eco, 1976). Interpreting various cognitive categories, structural metaphors, symbols, signs and the status of the informant or writer has been an effective tool and methodological step for analysing data. To delve deeper into interviews, or text, during analysis, identification and meanings of symbols revealed by the informant's attitude towards a problem have been important for my interpretation. In semiotic analysis, different approaches or concepts are used to describe what we see, and I have divided this into direct and indirect meaning. The indirect additional meaning, or undertone, can be a result of cultural or personal associations (Mick, 1986).

A linguistic example from my interviews is the word "crofters" (husmenn), which is used as a metaphor during description. A deeper examination of the metaphor's meaning illustrates a shift towards an upstream power balance in the food value chain. When an employee at a large food producing enterprise refers to himself as a crofter, as a farmer of rented land, it is interesting to analyse the use of words or phrases that when applied do not literally denote the object or concept. Historically, crofters were placed in the lowest part of the value chain and financially dependent on the property owner. This originates in hierarchical structures from two hundred years ago in many parts of Europe. When employees at a large enterprise feel like crofters during the pitching of new products, I find patterns of power distributed upwards towards distributors and grocery chains stores. Even though this incident happened during interviews for paper 1, I have noticed the same hints of power balance being distributed from producers towards distributers and retailers during novel food interviews for paper 2 and 3. This has happened during discussions of new product development and private label growth and is often articulated more carefully in order not to offend.

Processed food, and especially processed meat, is described as unhealthy foodstuff in public health recommendations (Helsedirektoratet, 2011). In my work I find the word "processed-food" an expression that has different meanings for various groups with different backgrounds. The term is used inconsistently even in epidemiological studies. Judgements and recommendations are therefore less clear than they could be (World-Cancer-Research-Fund, 2007). The challenge is that all food that consumers buy in stores is processed, except for unwashed fruits and vegetables. As an example, milk is a highly processed ingredient after separation, pasteurisation, homogenisation and packaging, and the same goes for juice, bread, ham and all kinds of simple conserved food if frozen, dried, canned, fermented, irradiated, etc. In my work, products that originate in the cereal industry, as described in paper 1, are typically referred to as non-processed while the novel food products in papers 2 and 3 are seen as super-processed by most informants. However, the cereal products in paper 1 are all a result of the new product development of processed food, having undergone advanced milling with fractionation and baking with fermentation, proofing and heating.

The consideration of various cognitive categories, prototypes and meanings has been crucial to my interpretations of informants' contributions through interviews. Sharing a common language and reference points has provided both trust and understanding, resulting in new knowledge that corresponds closely to reality. The chosen qualitatively inductive methodology is used to support existing theory through conceptualizing data involving a systematic qualitative rigor (Gioia et al., 2013) through grounded theory research.

4.4. Data sources and collection

Having access to data and a background in the industry have been prerequisites for a correct interpretation of the interview objects in their settings. I believe my background in food research, combined with extensive work experience in adjacent industries, has been crucial for access and understanding. I believe that access and trust among researchers and interview objects has provided me with accurate and valid findings. Prerequisite assumptions behind these qualitative studies are informants being knowledgeable agents able to explain intentions and myself being able to identify concepts, contrasts and relationships.

Table 1 sums up the various data sources for all three papers in my PhD thesis. Paper 1 studies the traditional cereal section of the domestic food industry in terms of more radical new product development and collaboration. Papers 2 and 3 share some of the same novel food data, although it is used to interpret different settings. Paper 2 compares the effect of old and new novel food regulation in terms of innovation practices, while paper 3 clarifies how novel food regulations have affected patents and collaboration in terms of appropriability.

Table 1 Data sources and collection

	Data sources and collection
Research paper 1 How open is food innovation? – The crispbread case	1) Collecting, reading and sorting 2312 qualitative documents from the open innovation cereal scheme 2010 – 2011. Includes descriptions of work, an analytical phase, an idea generation phase, an idea development phase, experimentation, miscellaneous, pictures and dissemination and exploration. The politically supported scheme was initiated to create a series of innovation platforms and representatives with 25 per cent of all cereal industry actors actively participating. 2) Collecting and analysing quantitative data from ten years of bakery products sales. 3) 10 interviews covering important actors in the Norwegian cereal industry.
Research paper 2 New novel food regulation and collaboration for innovation	1) Public data from 163 novel food applications and 523 novel food notification applications. Quantitative data from novel food approvals from 1997 till 2018 including a description of novel food; an initial assessment of the company dates, names and addresses; and the status of the novel food application. 2) 13 interviews covering six Norwegian novel food pioneers followed by 7 expert interviews. 3) Public data from the first 90 novel food applications from 2018 to July 2019, downloaded from the EC database.
Research paper 3 European novel food, patents and brokers of knowledge	1) Public data from 163 novel food applications and 523 novel food notifications. Quantitative data from novel food approvals from 1997 till 2018 including a description of novel food; an initial assessment of the company dates, names and addresses; and the status of the novel food application. 2) 13 interviews covering six Norwegian novel food pioneers followed by 7 expert interviews. 3) Public data from the first 90 novel food applications from 2018 to July 2019, downloaded from the EC database 4) Worldwide patents originating from Norwegian firms 2004 – 2019, downloaded through EPO's database. 88 patents with titles, numbers, dates, inventors, nations, owners, applicants, classifications and citations.

For all papers a semi-structured interview guide was developed in advance to give answers to preliminary research questions. These guides included descriptive questions asking about phenomenon's difficult to observe directly. It was asked about new product development experience, behaviour during these processes and further about informants' opinions, values, background and history. Response from the following up questions gave the most valuable new insights. For papers 2 and 3, a semi-structured interview guide was developed with background details from the open innovation literature in the theory section. This interview guide also included mapping figures from the first 20 years of novel food applications, see Appendix 2. Figures in the appendix, with data from 163 novel food applications and 523 novel food notification applications from novel food approval 1997 - 2018, was sorted by type of application, source, and most applied notification of substantial equivalence in the original dossiers.

4.5. Analysing and coding

All papers have a combination of quantitative and qualitative data. To sort insights and details from both interviews and case studies, the quantitative data analysis software tool Atlas.ti has been used for all papers. Atlas.ti provided help in coding findings, weighing and evaluating data importance, and visualising the complex relations between data. Interviews and earlier documentations have been coded and categorised to reveal meanings and patterns. In paper 1 I ended up with 201 quotations divided by 25 initial codes similar to the first order concept described by Gioia (2013). Further, these codes were grouped into four main orders like a second rigoristic inductive research order (Gioia et al., 2013). It was first after putting my findings into a fleet scheme with boxes and arrows developed with a background of an earlier open food innovation case (Bigliardi et al., 2010) where I managed to aggregate dimensions of collaboration and knowledge flow in the Norwegian cereal food industry during radical product development.

Paper 2 and 3 resulted in 267 quotations divided by 64 codes. These codes where put into orders of open innovation, closed innovation and surprisingly findings. These codes and their relationship to the informants where illustrated in a social network created by the program Atlas.ti after adding nodes and relationship. This was used for reducing complexity and gaining overview during abstraction (Gioia et al., 2013), though these network of codes has not been implemented in papers. However, social network of novel food applications on firm level, before and after new regulation, was illustrated through the program Atlas.ti. This figure is published in paper 2 illustrating important findings where a few pioneering novel food companies, regardless of size, are represented firmly during a period of 22 years.

For the two last papers, the software tool Power BI has been used to unify data from various sources to create interactive reports providing new insights. Power BI is an analytics service tool providing interactive visualisations. Parts of these relationship has been illustrated through pivot tables in Microsofts excel for summarizing and making sense of these large data sets. However, the Microsoft program Power BI appeared to have better functions on geographical patterns and was thereby preferred during the quantitative data interpretation. In addition, the visualisation software tool Gephi, a widely used open-source free software tool, has been used for network analysis with edges and nodes. Major finding with network of novel food inventors has been visualized through the software program Gephi in Paper 3.

4.6. Limitations

This exploratory work has several limitations. The research design of mixed methods is complex and time consuming, and how to bring different data sources into meaningful contact is not always clear. The integration of qualitative and quantitative datasets into one study can be challenging, although separate data sets presented by themselves are less fruitful. Further, both the case of the domestic cereal industry and novel radical food innovation can be seen as instances without general validity. Qualitative research should not be used to develop generalisations, but rather to develop theoretical ideas that will have general validity (Strauss and Corbin, 1994). Another limitation might be the reflective perspective in the study. I have tested any possible biases by integrating data from interviews with secondary data, although being too close to the material may yield cognitive blind spots and biased interpretation. To avoid any form of bias I have used third-party advisers and triangulated data whenever possible.

The novel food cases might be an instance of the phenomenon of radical food innovation, and these novel food pioneers can be seen as a subgroup of the food industry with products that fit better into categories of nutraceuticals than food. Another limitation might be the reflective perspective in my studies. Even though I have reduced my biases by combining these data from interviews with secondary data, there will be limitations linked to the subjectivity of informants in recalling the processes of their new product development process years earlier. However, the results obtained should provide a foundation for further studies, both regarding innovation and food.

The contribution to open innovation research and radical product innovation, using European novel food regulations as a case, can help future researchers to better understand how the regulation of openness impacts companies' protection regimes. IPR measures have been combined in various blends and used for preventing knowledge spill over, justifying novelty, and marketing purposes.

These ground-breaking radical food innovations are dependent on regulations and policies. Regulations, as novel food governance, are rarely positive for innovation. However, the EC are unwilling to compromise food safety. Further studies of novel food and open innovation may benefit from a wider systematic patent search and studies of cases that involve litigation and lawsuits. In addition, I believe that mapping food industry actors' previous work background, educational training and geographical location would be of interest to better understand preferred collaboration partners during an external search for knowledge.

5. Summary of paper results

New knowledge of how the food industry gains competitiveness and comes up with new successful products and services is of considerable interest for the industry themselves as well as for innovation researchers in academia. Furthermore, new knowledge of successful food development will help the food industry and its partners waste fewer resources on products and processes that fail. Awareness of how efficient innovation within the food industry will save costs for these actors is vital, and new insight into selected and trusted partners during new product development processes for an industry, often given weak appropriability regimes, should be of interest for researchers studying collaboration, flow of knowledge and understanding of openness.

The three research papers are summarised in Table 2, with their research question and contribution. This creates the foundation of my PhD thesis. Questions on how innovation in selective partnership has been conducted, what the innovation practises are and how appropriability has affected collaboration, are all studied through the lens of open innovation. The research papers are all case studies and empirically driven with mixed sets of data analysed quantitatively and qualitatively in order to better answer complex questions on processes and collaboration.

5.1. Paper 1: How open is food innovation? The crispbread case

The purpose of this paper is to reveal how the Norwegian cereal industry innovates in selective partnerships by studying the cereal industry and crispbread success in terms of how openness jointly shapes new product development. Three sets of data were combined: a case study, sales figures and interviews with ten major actors in the Norwegian cereal industry. Findings illustrated how transparency and interaction with machinery suppliers appeared to result in a more successful type of innovation. In practice, companies acted more openly than they realised. Factors such as mutual trust, asset control and distribution were positive for openness during innovation processes with suppliers. Prior to 2011, Norway had no large-scale commercial crispbread production. However, six years later Norwegian production equalled the leading Swedish brand Wasa's sales figures.

5.2. Paper 2: New novel food regulation and collaboration for innovation

The purpose of this paper is to study the novel food industry in Europe and how regulations affect companies' collaboration and openness towards other actors during new product development. The research question is "How do the European NF regulations affect radical innovation in the food industry?" A multiphase mixed-methods design was used to combine three sets of data: the NF applications and notifications from 1997 to 2018; interviews of novel food pioneers and experts; and finally the applications in the first 18 months of the revised novel food regulation after 2018. Interactions with R&D suppliers seemed common during the development of novel food products for companies of all sizes. In addition, it was found that the decentralised novel food regulations from 1997–2017 prevented innovation while comparing it to the new regulation. However, both the old and the new novel food regulations facilitate easy routes for second-to-market approaches in the novel food regime. It was also found that companies of all sizes apply for novel food under the new NF regulations, which ensure data protection.

5.3. Paper 3: European novel food, patents, and brokers of knowledge

The purpose of this paper is to study how regulations affect companies' appropriability regimes during new product development in terms of collaboration and openness. While the paradox of openness in the literature describes conflicts between patent spill over prevention and organisational openness, patents from the food industry are rare and less studied. Data from the EC with novel food approval regulations were combined with interviews and documentation from the European patent office. Patenting and external openness occurred as mutual decisions made by companies during new product development within the novel food approval regime. It was found that novel food pioneers had been vulnerable to knowledge spill over during approval of these new radical food products. Further, it was found that there was a relationship between patenting, guarding unintended spill over and external collaboration in IPR strategies. Closed and open innovation patents, with its inventors and owners, also proved to be a pattern of selective partnership with R&D providers.

Table 2: Research papers

	Main research question	Contribution to the thesis
Research paper 1 How open is food innovation? – The crispbread case	How does the Norwegian cereal industry innovate in selective partnership?	Transparency and interaction with machinery suppliers leads to more successful types of innovation. Companies are more open in practice than they realise themselves. Factors such as mutual trust, asset control and distribution are positive for openness regarding the food during innovation processes with suppliers.
Research paper 2 New novel food and innovation	This paper asks what the innovation practices of novel food companies are and how the new novel food regulations have influenced them.	Interactions with R&D suppliers appear to be common during the development of novel food products for companies of all sizes. Regulations facilitated an easy route for a second-to-market approach. Companies of all sizes apply for novel food. Ownership of knowledge and a conscious intellectual property rights strategy are important for companies' openness during radical innovation and collaboration. Monitoring novel food dossiers in terms of food sources, ingredients, and nutrients gives an updated view on dietary trends and points out the direction the food industry is heading. The mix of new novel food dossiers, with data protection, ingredients and company sizes are presented in Appendix 3.

Research paper 3 European novel food, patents and brokers of knowledge	Clarification of how novel food regulations have affected collaboration among novel food pioneers in terms of appropriability.	First movers have been vulnerable to knowledge spill over during the approval of new radical food products. A relationship between patenting, guarding unintended spill over and external collaboration posts an intellectual property rights strategy exists. Further patents with its inventors and owners prove a pattern of selective partnership with R&D providers.

5.4. Discussion and future perspectives

Regulatory openness leads to less open innovation, and this can be seen as a paradox. However, that the fear of regulatory centralisation leads to less collaboration among actors in the novel food industry (Hyde et al., 2017) has been exaggerated. There are no indications supporting this fear of lost dialogue in my case studies involving novel food pioneers. The assumptions of lost dialogue (Holle, 2018) concerning the new regulations with data protection have not come to pass. This might be due to apparently successful collaboration among food companies of all sizes and R&D suppliers managing IPR challenges.

Flag-planting strategies during radical innovation in the food industry can be seen in the form of patents, trademarks, health claims, publications and novel food approvals, which is consistent with earlier studies of innovation and protection regimes (Santoro et al., 2017, Teece, 1986, Arora et al., 2016, Khan et al., 2014). Protection regimes are combined with openness. However, in the case of novel food, the openness may be involuntary due to open governance. Open governance makes mutual trust and secrecy during collaboration among actors important factors in radical new product development processes for these food companies in the same way as for the earlier open innovation researchers (Chesbrough and Crowther, 2006).

Further, the cost of sustaining a protection is the cost related to openness and flag-planting strategies. Due to weak protection regimes, easy free riding with application notifications, and access to the EU's novel food union list, novel food has affected radical innovation through the publication of dossiers revealing ideas and technology. In addition, the costly scientific dossiers, with risk assessment, have affected innovation speed and novelty. Whether this is due to safety being hard to prove, or novel food pioneers unwillingness to invest in risk assessments, is unclear. The novel food pioneers differ from the traditional food industry by acting more like the nutraceutical industry. This may explain why open collaboration towards R&D suppliers follows patterns from more typically high-tech industries. Furthermore, informal collaboration such as participation in associations was found to be important for this part of the food industry.

Inbound open innovation has been observed and is considered important for new product development in the food industry. Open innovation in the food industry, consisting of many small actors, often family-owned companies, is hidden and not organised, as it is for the larger enterprises. However, these companies have resources for orchestrating openness with their long-term orientation and more personalised and trusted relationships with external stakeholders (Lambrechts et al., 2017). Collaboration with suppliers, business customers and R&D partners play important roles in the innovation processes of these industries, often characterised as low technology industries. For the more typical food industry, in contrast to the novel food pioneers, the lack of appropriability regimes makes mutual trust during collaboration and openness an important factor during collaboration.

For more radical food innovations, with more possibilities for protection mechanisms regarding novel food, mutual trust must still be in place for openness among actors to occur. However, for these novel food pioneers, the same patterns described by Arora (Arora et al., 2016) and later by Stefan and Bengtsson (Stefan and Bengtsson, 2017), where company size decides the strength of the appropriability regime, is important. For larger enterprises, the appropriability regime seems to be strengthened compared to small-, medium- and micro-sized companies in the food industry. In line with Stefan and Bengtsson (2017) and Greco et. al. (2017), I found geographical patterns of collaboration. This also supports findings with indications of a north-south axis regarding trust in Europe (Brockman et al., 2018).

Most food industry companies rely on secrecy as their intellectual property rights strategy, forcing companies to close the innovation processes perhaps too early, thereby preventing the ideas from maturing and being further processed until they are sustainable. This is in line with findings from firm culture where the most common form of innovation is closed innovation with internal capabilities such as doing, using and interacting (Kratzer et al., 2017). In addition, findings from Sweden (Beckeman et al., 2013) suggest food companies have not adopted the open innovation mindset.

Bigliardi et.al. (2010) provides insights into open innovation practices in the food machinery industry, and the illustrated models used. However, the main conclusion was a lack of evidence of open innovation strategies. Figure 7 is inspired by the open innovation supply chain for new product development in the food industry, as illustrated earlier by Bigliardi et.al. (2010) and modified in paper 1 in order to fit the case of Norwegian crisp bread development (Grimsby and Kure, 2019). This illustrates interaction between actors of the supply chain for the food industry. The linear stream of food actors shares knowledge during the value adding of products, while suppliers such as external R&D, official instruments, associations and competitors accelerate internal and external innovation during interaction. In Figure 7, the dark grey actors are most important during collaboration for product development. Further, in line with Beckeman et. al (2013), I find that co-creation with end consumers is not a widespread strategy for the food industry. This is in contrast to many scholar's definition of open innovation, where co-creation can be seen as a subgroup of the same phenomenon (Tekic and Willoughby, 2017).

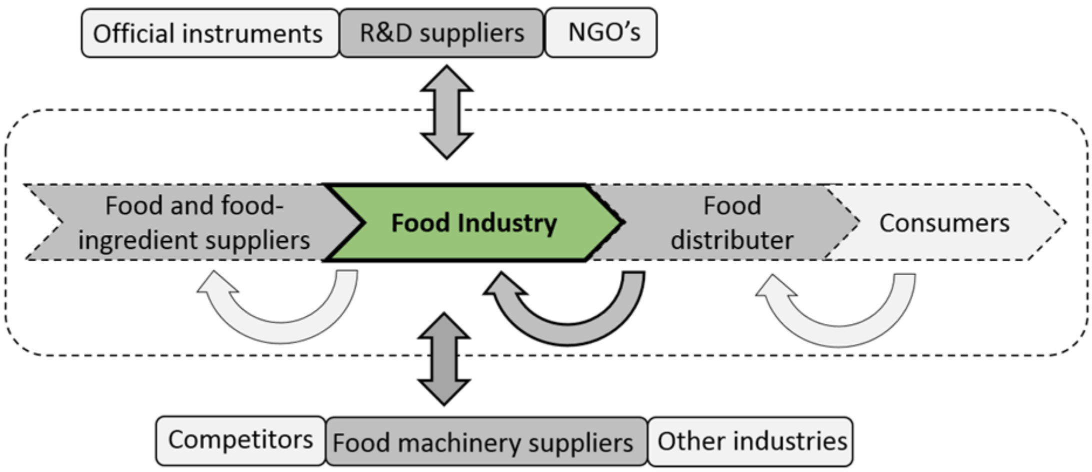

Figure 7. The open innovation supply chain for new product development in the food industry; arrows and their colours represent flow of knowledge among actors. Inspired by the food-machinery framework and the open food supply chain (Bigliardi et al., 2010, Traitler and Saguy, 2009, Grimsby and Kure, 2019)

My contribution to the open innovation research phenomenon is oriented towards new product development processes with external collaborating partners. The open innovation phenomenon has helped me to better understand the innovation process in the food industry in terms of openness, secrecy and co-creation among suppliers, governmental institutions, and R&D providers. I do find patterns of openness, but not in the same way as the open innovation phenomenon that originally focused on R&D mechanisms that manage spill over with formalised action plans. I find patterns of interplay with suppliers and personal long-term relationships of trust. In addition, I have found indications of silent or tacit knowledge being a challenge for openness. Examples of this concern how similar actors in low tech industries close their doors for competitors since they are easily copied. This arose from both the bakeries studied in paper 1 and the novel food actors in papers 2 and 3.

Patterns of selective openness support previous findings from scholars studying openness in the food industry (Bigliardi et al., 2010, 2009, Lambrechts et al., 2017, Menrad, 2004, Rama, 1998, Trott and Simms, 2017, Bigliardi et al., 2020, Sarkar and Costa, 2008).

6. Conclusion and contribution to theory

In my work I have found transparency and interaction with suppliers leading to successful types of innovation in the Norwegian cereal industry. Further, I have found mutual trust, asset control and control of distribution as positives for companies' openness during these innovation processes. For radical and novel European food product development, I have found interactions with R&D suppliers to be common and fruitful. However, I have found the first movers under the European novel food regulation to be vulnerable to knowledge spill over. This has resulted in conscious intellectual property rights strategies and ownership of knowledge to protect unintended spill over.

How companies involuntarily open their new product development process during new product development, with the risk of external actors capturing value from the innovation, should be of interest for the further development of open innovation theory. Patterns of openness during radical novel food processes are not the same as for the open innovation phenomenon, which originally focused on R&D mechanisms that manage spill overs with formalised plans.

Similar to the results of Procopio (Procopio Schoen, 2017), intellectual property rights policy instruments were found to be important for balancing collaboration among novel food applicants, R&D suppliers, and government actors. Innovation literature for companies in the food sector has paid more attention to the integration of suppliers than to the general research involved in open innovation (Procopio Schoen, 2017). Open innovation can be a phenomenon for explaining industrial innovation beyond high-tech and through to more traditional, mature industries. However, the novel food actors differ from the traditional food industry in many ways, being more of a nutraceutical industry, and this may be why open collaboration towards R&D suppliers are of the same importance compared to more typical high-tech industries.

Flag-planting strategies during radical innovation in the food industry is formed by patents, trademarks, EFSA approved health-claims, scientific publications and novel approvals. Spill over prevention strategies are where intellectual property rights measures are combined with openness; this is a widespread appropriability strategy for the novel food actors and in line with findings from Arora et al. (2016), Stefan and Bengtsson (2017) and Bahemia et al. (2018). However, the cost for a company to sustain a high protection regime can also be the cost related to the flag-planting strategy.

The research question for my thesis is: "*How does the Norwegian food industry carry out radically new product development processes, and how does openness, appropriability issues and policy regulation affect these innovation processes in the industry?*". The short answer to this would be by selective openness and collaboration with suppliers coloured by trust and various flag-planting strategies. Further, I claim that policy regulation has hindered radical innovation by making it costly and difficult to protect NF products from second-to-market actors behaving like freeloaders.

6.1. Implications

My findings should be of interest for policymakers and public funded innovation schemes to reduce the gap between R&D and the commercialisation of new foods. With this new insight, policy makers can provide more efficient R&D schemes and regulations. Food industry actors will gain new insight into collaboration and openness and learn how these can be combined with various appropriability regimes. R&D providers should take into account the food industry's flag-planting strategies by integrating these into contractual regulations. Further, I believe R&D providers like Nofima should put more effort into trust building activities as well as balancing various contractual and non-disclosure agreements towards industry partners.

Originating from an agricultural background myself I have been fascinated by the academic description of tacit knowledge and how this not codified silent knowledge can be important for knowledge creation and its following innovation (Nonaka and von Krogh, 2009). Transfer of tacit embodied knowledge among food industry actors is challenging due to open innovation theory. In line with Nonaka (2009) food company performance and behaviour toward each other are influenced by factors such as diverse technical languages and perspectives due to actors having different backgrounds and not communicating on the same level. In line with Lambrechts (2017) the old-rooted family-owned low-tech handcraft actors in the food industry high on tacit knowledge, have little willingness to engage in open innovation activities blocked by the fear of control loss and conflicting goals within the family-firm. In addition, I believe these often geographically locked in family-run companies selectively open up more easily towards colleagues located less close geographically than towards their local competitor competing after the same customers for generations.

In line with Brockman (2018) I find societal trust to improve efficient innovation, and activities balancing tension of openness and protection mechanisms capturing value, fits the phenomenon of open innovation nicely. In contrast to Beckemann (2013) I believe there to be mutual trust between the processing part of the food industry and its suppliers. Flow of knowledge are intentionally used to accelerate innovation for the food industry. Although, there is a carefully balanced selective openness in line with earlier findings where defence mechanisms differ from SME's and enterprises (Katila et al., 2008). The fundamental paradox of disclosure during open innovation is valid for the food industry as for other industry, and in line with Stefan and Bengtsson (2017) I find over-focusing on pitfalls being associated with less collaboration and openness. Further, I have indications of patents saving tension during stages of innovation processes during novel food product development.

The old novel food regulation from 1997 to 2017 (EC, 1997) involved few possibilities for data protection, and was criticised by many (SANCO, 2008, Hermann, 2009, de-Magistris et al., 2015). The first 20 years of novel food regulation was decentralised, resulting in a long winded and costly process, where it on average took 3-8 years to have a novel food product finally approved. For other producers to trade with already approved novel food products, the regulation contained something named in EU terms substantial equivalence notification, where only a simpler dossier showing significant comparability to the authorised product was needed. Ten years before the new novel food regulations (EC, 2015a) were implemented, a briefing paper was published suggesting an exclusive access right to the market to provide better incentives for novel food pioneers (Brookes, 2007).

However, the new novel food regulation has also been criticised for hindering innovation (Holle, 2018), although the criticism of the new regulations has been too harsh according to feedback from the interviews I have conducted. The mix of applicants are now companies of all sizes. However, entering the market second and not first is still a cost-efficient strategy under the new novel food regulations. Patents, trademarks, scientific reports and health claims are all being combined in appropriation regimes for the food industry actors. In addition, these flag-planting strategies build value into products and are used in the sales and marketing of new food products. NF pioneers are collaborating, and patterns of openness during radical innovation is present in line with earlier findings and suggestions, although these companies have conscious strategies on IPR and protection mechanisms in order to protect themselves from unintended spill over under these open policy regulations.

Unintended knowledge flow where employees and patent inventors change work in additional to common backgrounds like educational training, flow of knowledge, openness and trust are all factors resulting in collaboration and co-creation among food companies and nearby actors. Further, I find indications of small geographical clusters in the food industry giving competitive advantage through absorptive capacity for all parts of the food industry.

This study supports both policymakers as well food industry actors with more insights regarding radical food innovation for Europe. In addition, this study will aid policymakers in providing better organisation with regard to new radical food products and safety for future consumers. The food industry and its suppliers will benefit from holistic insights regarding collaboration in networks as a way to guide their innovation initiatives. The food industry will gain more accessible knowledge of novel food regulations and the way they affect open innovation and forms of collaboration. The study illustrates which regions of Europe can be seen as being the most innovative and the drivers of radical new product development in the food sector.

6.2. Further research

Further research on innovation and openness among firms in the food industry should look for patterns of trust in multiple levels such as individuals, groups and among companies. Further, I believe research on interaction during new product development between producers, the food supply chains and consumers is still lacking.

Opportunities to create ground-breaking radical food innovations are dependent on regulations and policies. Regulations are rarely positive for innovation, and when it comes to food and the possibility of unintended side-effect for consumers, governments are unwilling to compromise. Further, studies of radical food innovation and openness would benefit from a more systematic patent search and studies of cases involving litigation and lawsuits.

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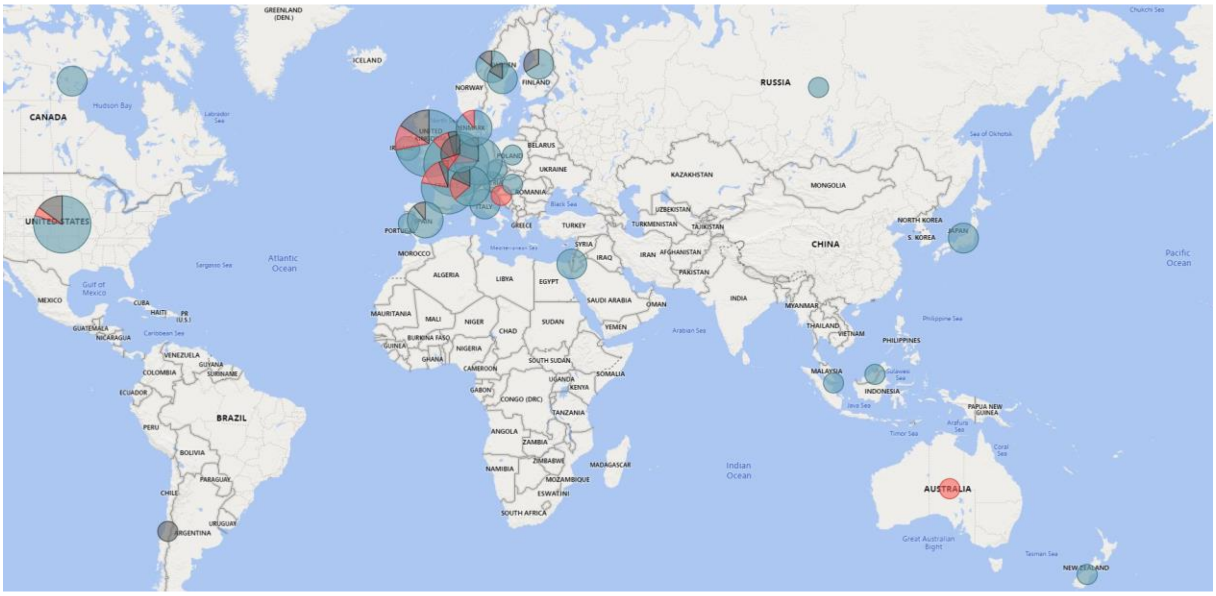
Appendix 1

Platforms developed:	**Solutions not problems (Need)**	**Self-done is well done (Personal)**	**Where I am when I want (Distribution)**	**Natural wellness (Healthy)**
Consumer observation and insights:	***No one purchases gifts at the bakery. Oatmeal is considered a commodity in the same way as flour. For the weekends, consumers will seek extra treats. Stores underestimate seniors as economically interesting customers. Carnival is the only festival in the baking industry***	***Customers want to do some parts of the cooking themselves, but not necessarily from scratch. Customers say they make jelly from scratch when they stir jelly powder in water. The smell of freshly baked goods in bakery stores are ventilated out.***	***Vending baking machines abroad. Fresh bread is bought for a whole week, then sliced and frozen in consumer sight. The bakery goods perceived most fresh are found at petrol stations.***	***Householders eat the same dinners but different bread types per person. When households are out of bread, they eat crispbread. Health and wellbeing is a trend. Food nutrition and composition (balance) is a natural part of the meal in Japan.***
Business opportunities: *Business opportunities presented as designed solutions by designers and taken further through minimum viable products. **Business opportunities presented as designed solutions by designers, taken further through minimum viable products and tested as prototypes	****1. Straight from work:** Employees can order bread at work and pick up a bread bag when workday is over. ***2. Delicacy bakers:** Extension of the range with complementary products to today's bread and pastries with.local gourmet products. ****7. Breakfast kit:** A simple, healthy and filling meal easy to transport. The kit makes it possible to mix different combinations of cereals and toppings. ***10. Cake Gift:** A great gift box with fresh taste sensations. An equally appropriate gift as fine chocolates, wine or flowers. **12. Dinner at home:** The dinner for the day should be picked up at the bakery in practical packages. ***17. Freeze package for the lunch box:** A special device in the freezer tray for storing sliced bread.	***3. Baking-talks:** We make baking fun by using both traditional and social media. We produce TV programmes and create celebrity bakers. ***9. Cake-kit 1-2-3:** Professional confectioners have assembled the kit, but customers may put their personal final touch on the work. ***13. Bucket Dough:** Fresh basic dough for sweet bakery products or whole grain bakery products.	**4. The breadbox:** We develop a bread mailbox for delivery of bread to households. We take ownership of a new channel for direct home delivery. ***6. Lunchbox:** Supply of lunchboxes to schools that includes a healthy lunch that excites kids. Parents make a subscription for a school year. **8. Bread Basket Lunch delivery:** Offer work places without canteens delivery of fresh, warm bread every day. **14. Bake by the way:** Bakery along commuting roads or highways as drive in bakery sales stations. ***15. Machine baker:** Baking vendor machine centrally located in relation to where people hang out. **16. The mobile bakery truck:** Can be placed where customers are located. The bakery truck has its own oven so that it can deliver fresh products at any time.	***5. Crispy-bread:** Develop an entirely new category of products that will compete with crispbread, flatbread and biscuits. The products will be modern, crispy, healthy and super tasty. The products will represent an entirely new category, although they resemble crispbread. The products will be packaged in a modern designed package e.g. cellophane showing the unique content. The products may have a lower shelf life compared to today's crispbread. Products will fit well with Parma ham and soup as well as be a better combination with cheese and port wine than today's biscuits. A better tasting lunch than today's crispbread and brown cheese. **11. Mill-SPA:** Adopt abandoned mill buildings, rebuild them into a cereal-spa, rustic, and calming environment with saunas and hot tubs.

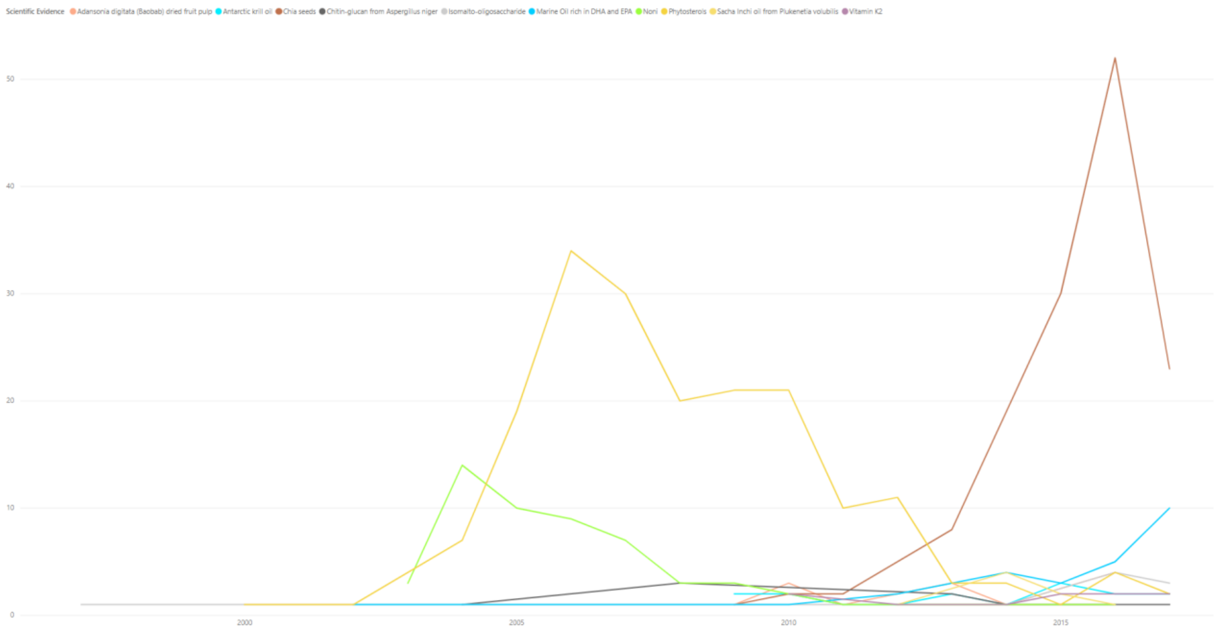
Findings from the open innovation cereal scheme 2010-2011, 4 platforms developed and 17 following business opportunities where the crisp bread case was studied.

Appendix 2



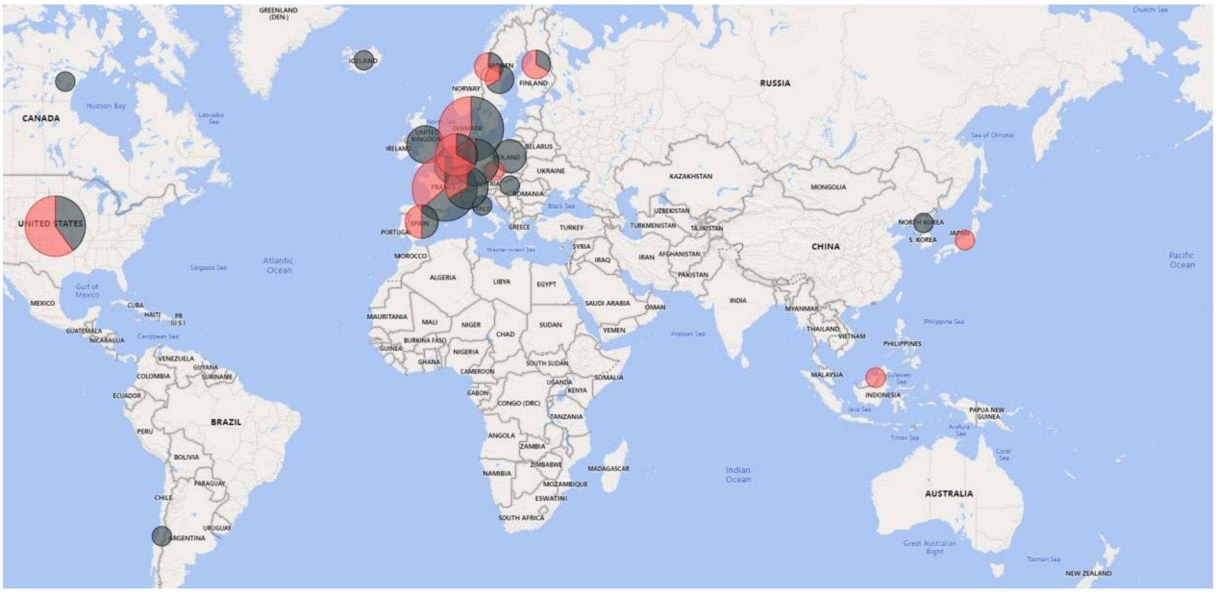
The 125 European novel food approvals from various countries from 1997 to 2018 sorted by ingredients in blue, processes in red, and sources in black.

All 523 European novel food notifications from various countries from 1997 to 2017, sorted by sources. Noni juice in green, phytosterols in yellow colour, chia seeds in brown and Antarctic marine oils in light blue.

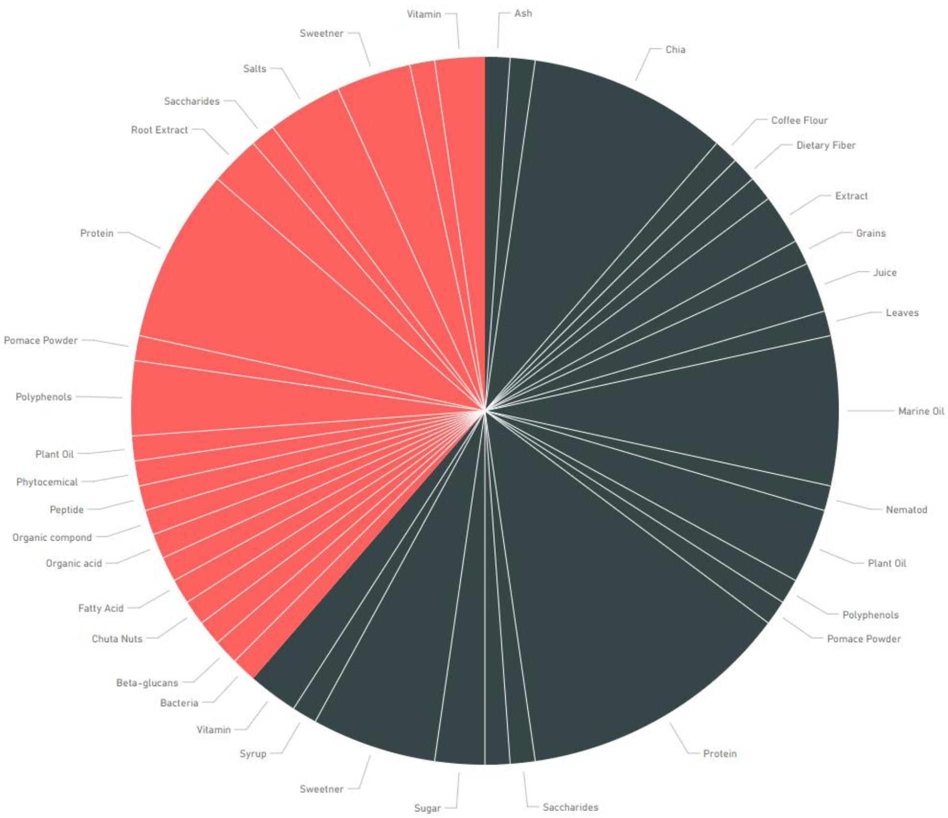


The ten most applied novel food notifications in Europe from 1997 to 2017 spanning from 8 to 188 notifications of substantial equivalence to the original dossiers. The green line represents noni juice, yellow phytosterols, brown chia seeds and blue marine oils.

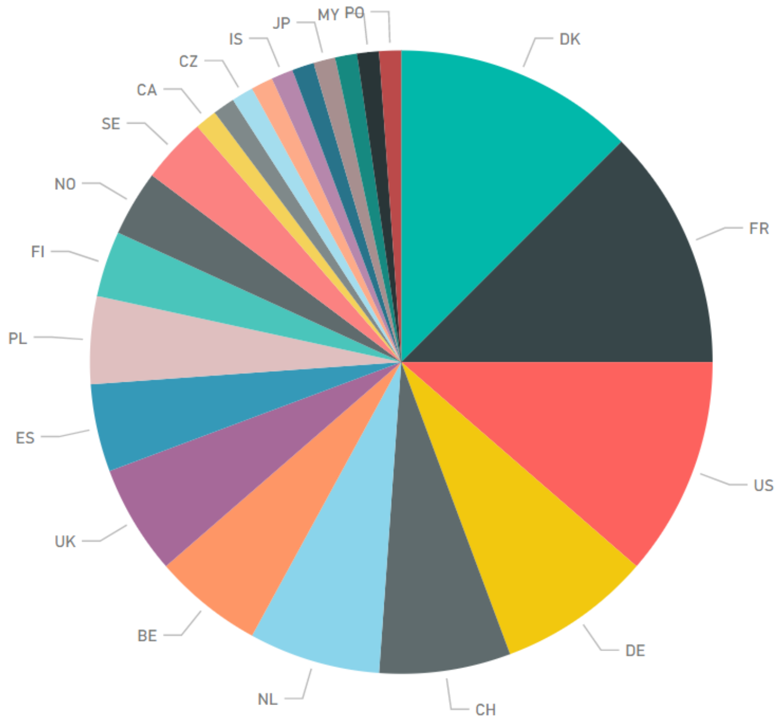
Appendix 3



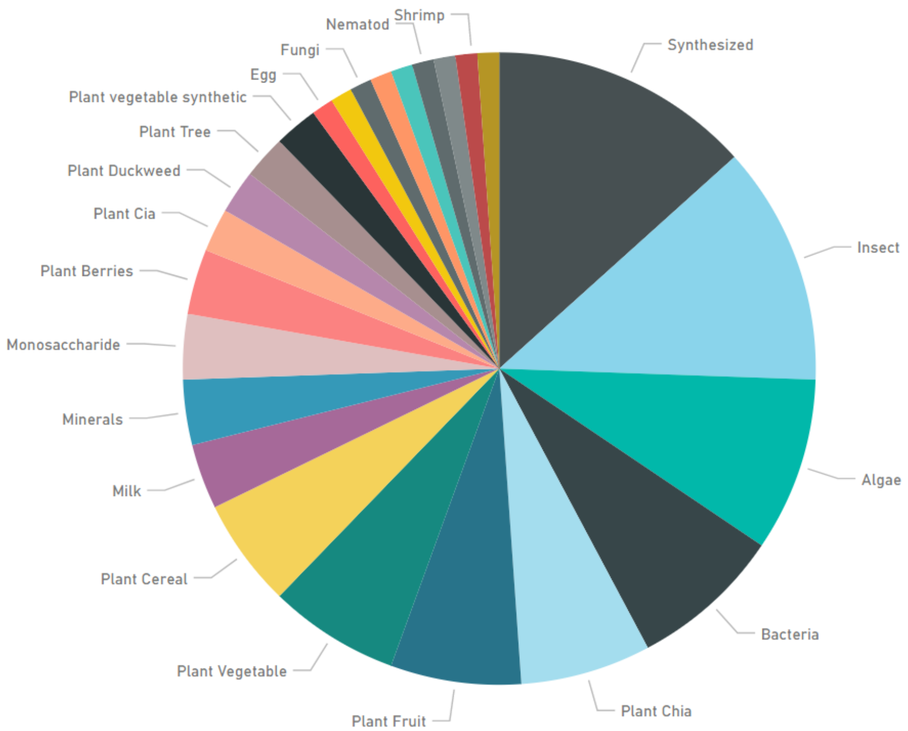
Circles illustrating the number of new novel food applications after 2018. About 40% of the applications have sought data protection – as shown in red.



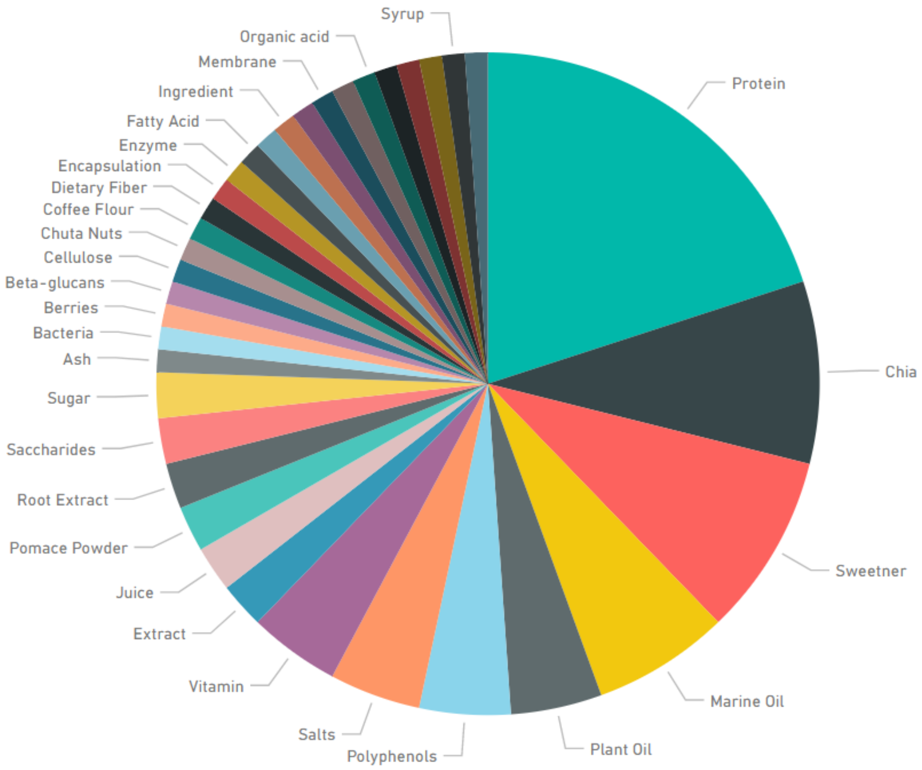
New novel food products and their applications. Those in red have protected data sources.



Countries of new novel food origin regarding applications during the first 18 months under the new regulations.



Sources of novel food in new EU novel food applications for the first 18 months under new regulations.



Ingredients in new EU novel food applications for the first 18 months under new regulations.

Paper 1

I

Paper 2

II

Paper 3

III

The manuscript for paper 3 entitled "European novel food, patents and brokers of knowledge" was submitted to the British Food Journal 21.01.2021. Paper 3 is considered for publication in the special issue named "Open Innovation in the Food Industry: What we know, What we don't know, What we need to know". Manuscript ID number is BFJ-01-2021-0078. Author: Sveinung Grimsby, Nofima AS, Ås, Norway.

European novel food, patents and brokers of knowledge

Abstract

Design/methodology/approach – A multiphase mixed-methods design was used to combine data as follows: Worldwide patents originating from Norwegian novel food (NF) pioneers 2004 – 2019, downloaded through EPO's database. NF application data and interviews were combined with 88 patents with titles, numbers, dates, inventors, nations, owners, applicants, classifications, and citations.

Purpose – The purpose of this paper was to study how open public policy regulation promote or hinder openness in the food industry. How European novel food (NF) regulation have affected external ties among novel food pioneers in terms patents and its inventors have been studied.

Findings –A relationship between patenting, guarding unintended spill over and external collaboration posts an intellectual property rights strategy exists. Further, patents with its inventors and owners prove a pattern of selective partnership with R&D providers.

Practical implications – Food industry actors will gain new insight into collaboration and openness and learn how these can be combined with various appropriability regimes. R&D providers should consider the food industry's flag-planting strategies by integrating these into contractual regulations.

Originality/value – There is little knowledge about how the NF pioneers collaborate with suppliers, research actors, governmental actors, distributors, and customers regarding new product development.

Keywords: Novel food, Open innovation, Intellectual property rights, Appropriability, Patents

Paper type Research paper

1. Introduction

Companies who open up their ideas during new product development towards actors outside their organizations, are claimed to be more innovative as collaboration may foster better innovation. However, when companies open up to outsiders, they might weaken their power to capture returns from their innovative ideas. These conflicting views with organizational openness and spillover prevention may be seen as the paradox of openness (Laursen and Salter, 2014, Arora et al., 2016). During introduction of NF, pioneers in the food industry, have been forced to balance these strategies in new ways.

Pioneers within the food industry has been filing NF dossiers the last 22 years and learning the instrument in order to get radical food products approved (Hermann, 2009, Hyde et al., 2017, Holle, 2018, Ververis et al., 2020). These regulations have forced actors in a traditional mature and old rooted industry to work differently during radical new product development with openness positively impacting innovation radicalness. Open interactions with R&D suppliers involving IPR strategies during novel food development appears to be common, making future studies of NF patents and litigations useful for understanding novel food innovation (Grimsby, 2020). Further it is found that the NF regulation, with its open governance, has affected collaboration among these pioneer companies due to absent appropriability regimes and absent protection mechanisms (Holle, 2018). These regulations has given less incentives for food companies to innovate and develop new products, while imitators have been more or less free to commercialize ideas (Holle, 2018). This is in line with challenges described in the early days of developing the OI framework (Teece, 1986, West, 2006, Chesbrough and Crowther, 2006).

The EC published a critical impact assessment for the old NF regulation (EC, 1997) replacing the first 20 years of NF regulations with a new centralized regulation aiming at more speed to marked and better protection for applicants (SANCO, 2008). 523 competitors applied for permission to sell copies of NF approvals, named substantial equivalent product by the EC, during the first 20 years of NF in Europe. This was a result of the first 125 approved NF products. Since 2018 all approved NF products until then was put up on a Union list of NF. All authorisations until then were made generic and the Union list now serves as a reference for economic operators who wish to place NF on the marked. The NF Union list gives imitators the exact same rights to commercialize products as NF pioneers.

With the background and research gap from above, clarification on how NF regulations have affected collaboration among NF pioneers in terms of appropriability is being searched for. Patents, trademarks and approved health claims are combined with NF dossiers, and it is wondered how these NF pioneers balance policy instruments, with an open governance, while developing new food products interacting and collaborating with various actors.

The remainder of this paper is organized as follows: Section 2 presents OI theory and collaboration patterns used to understand new product development of European NF. The OI paradigm combined with regimes of protection will be clarified in this section; Section 3 will present the background of European NF regulation and previous studies of the NF as a phenomenon will be given; Section 4 describes the use of mixed method where combinations of various data from 22 years of quantitative EU NF approvals are combined with qualitative data from 13 interviews leading to further mapping of 58 patents owned by 7 NF pioneers. Findings are finally presented in section 5 followed by policy implications with discussion, conclusions and by posing further research questions in part 6.

2. Innovation theory

This section will clarify how the paradigm of openness can explain various forms of collaboration for research intensive companies while developing radically new food products. How sharing towards trusted partners may be organised and how patents can be tools for openness. In order to benefit from openness companies need specific expertise and skills, where legal skills are one of these. However, introducing lawyers into business meetings may be coupled with tension and mistrust, where nondisclosure agreements are being presented. The involvement of legal experts in OI processes can potentially be functional as well as dysfunctional (Post and Post, 2018). Various stages of new product development may compose collaboration differently as forms of openness will vary, and it is seen that combining protective strategies with absorptive capacity are of companies interest for capturing returns from innovative ideas (Laursen and Salter, 2014). Further, managerial attitudes to openness and appropriability are very closely connected (Dahlander and Gann, 2010, Laursen and Salter, 2014). The relationship between OI and IPR has received much of attention since the development of the OI paradigm and patent data has been used in various ways in order to understand technological knowledge flow and patterns of OI within companies R&D departments (Suh and Jeon, 2019, Comai, 2019, Linares et al., 2019).

2.1. The OI perspective

Diversity of OI research concepts has been evolving over time and we have a dispersion of OI concepts connecting various perspectives. OI, absorptive capacity and R&D co-operation are often closely related followed by resource-based view and network with alliances (Randhawa et al., 2016). Historically innovation researchers were initially mainly interested in the industrial R&D approach and views of innovation as closed processes with little interaction where new technology required was developed internally (Mowery, 1983). According to the OI perspective, organizational boundaries are permeable rather than closed, and innovation is moved from location to a relational system with external partners (Bogers and Jensen, 2017). It is found that OI is in use in a wide range of industries and even traditional and mature industries, as the food industry, would agree on the following statement: "*not all good ideas will come from inside the organization and not all good ideas created within the organization can be successfully marketed internally"* (Chesbrough and Crowther, 2006). The food industry are categorized as a mature industry with low profit margins and with a high R&D failure rate (Tsimiklis and Makatsoris, 2015), and it is believed that OI approval processes will benefit from outsourcing of R&D activities. Food research has been focusing on clusters, networks and innovation brokers as facilitators of innovation activity. In addition the importance of outsourcing R&D and establishment of alliances for food industry partners has been frequent explored (Procopio Schoen, 2017, Randhawa et al., 2016, Chesbrough, 2003). However, during the polarised innovation management debate some scholars rather use other terms of collaboration concepts for explaining the same (Trott and Hartmann, 2009).

2.2. Appropriability

Appropriation refers to capturing innovation rents to fully benefit from innovation (Teece, 1986, Levin et al., 1987). How companies manage the tension between appropriation and R&D collaboration has received attention by many scholars and triggered numbers of important insights. Companies' ability to capture and protect value creation from competitors is seen as a fundamental element of their innovation strategy (Cohen and Levinthal, 1990).

There are tension challenges when companies combine openness, IPR rights and technological growth (Stefan and Bengtsson, 2017) and balancing this can be demanding. In addition, there is a tension between value co-creation and value capture resulting in either solutions or pitfalls. Sources of tensions between collaboration partners may be due to uncertainty, asymmetry, lack of resources, different cultures or appropriability limitations (Stefan, 2018). For development of NF, asymmetry is one obvious collaboration challenge. These processes are often hosted by dissimilar partners having contrasting organizational culture and interests. In cases of R&D collaboration scientists are motivated by publication while commercial companies are motivated by profit. Further limitations for appropriability regimes will be the complexity of patents and the high cost of defending patents years ahead.

There seems to be a pattern with geographical dimensions of companies' collaboration. National collaboration are successfully under semi-formal and informal IPR regimes with contract's, while formal regimes, as patents, explains international collaborations (Stefan and Bengtsson, 2016). Semi-formal regimes in this setting may be trade secrets and nondisclosure contracts associated with collaboration within R&D academic partners and companies. Stefan and Bengtsson (2017) discovered semi-formal regimes as nondisclosure agreements being positive in the idea phase while patents at this early stage was negatively associated with performance. Further, it was found that openness depth in terms of collaboration with R&D suppliers contributed more to innovation novelty than to innovation efficiency during these early phases of new product development. Informal collaboration with R&D suppliers during following engineering phases was found to be positive. However, at these engineering stages informal collaboration with suppliers are associated with less novelty (Stefan and Bengtsson, 2017). These findings from manufacturing companies are of great value for interpreting findings from the European NF case.

IPR generally work well when law mechanisms control R&D cooperation against imitation preventing products from being copied. This will apply for some of the products being exposed for copies in the NF regulations. On the other side contracts do not work sufficiently against imitation during R&D collaboration outside academia (Veer et al., 2016). In contradiction to common OI success stories, it is found indications of companies increased engagement in R&D cooperation being negative for new knowledge production (Veer et al., 2016). Non patenting companies, exposed of being copied, reacts with less R&D collaboration (Lorenz and Veer, 2017). However, companies with patents exposed for being infringed, in the meaning of being misappropriated as intruded, react by collaborating more with R&D suppliers in following years (Lorenz and Veer, 2017). Further it is found that patent infringement triggers cross-licensing agreements, since cross-licensing agreements open the way for following R&D collaboration (Hagedoorn, 1993), in this way being infringed may give more R&D collaboration. This collaboration does not have to be with the infringer in order to bargain on IPR licensing, a collaboration with any party in the field is likely to happen (Hagedoorn, 1993).

2.3. Trust and geographical patterns

In order to access new knowledge and establish and deserve trust, companies will have to pass information both ways as inbound and outbound (Nestle et al., 2018). Unbalanced exchange of information may be described as reduced information asymmetries in clusters (Nestle et al., 2018), and negative for building trust. Increasing involvement by cluster members combined with homogenized perspectives, as found when actors share the same background by training or social capital, provides trust as opinions and behaviour are more homogeneous within than between groups (Burt, 2004). Brokers of knowledge connected across groups are more familiar with alternative ways of thinking and behaving (Burt, 2004). Brokerage across, what can be named as structural holes between groups, provides a vision of options otherwise unseen. These are the mechanism by which brokerage becomes social capital (Rousseau et al., 1998, Burt, 2004). This promotes strong ties on organizational and personal level as building stones of mutual trust. In this case study of NF pioneers, with inventors having deviating background, selected innovators may be seen as brokers of knowledge. The degree of prior trust when trading technology is highly variable for companies, and a high level of trust prior business dealings is found to increase the probability of transaction success especially when patents are absent (Jensen et al., 2015). Further, there seems to be a pattern where companies in high trust countries produce high level of joint output as e.g. co-owned patents (Innocenti et al., 2020). Looking at companies' patents and collaboration patterns there are indications of a north south axis on country level trust in Europe where the Nordic countries have the highest level of trust (Brockman et al., 2018).

2.4. Patents and openness

OI processes may be controlled by appropriation mechanisms as patents, establishing market lead time, keeping key technologies unavailable for competitors while gaining access to complimentary assets (Teece, 1986, Arora et al., 2016). Arguments from Laursen and Salter (2014) suggests that appropriability and openness can be combined, to benefit from innovative ideas. Companies that are overly protective of their knowledge might miss opportunities to exchange knowledge with different actors in the innovation system.

Whether a patent is based on open or closed innovation is under debate. Comai (2019) divides patents into three groups; 1) The intra-firm relationship where only companies employees are inventors, 2) The extra-firm relationship where external individuals are inventors and 3) The inter-firm relationship with co-applicants and more than one company owning patents (Comai, 2019). The two last groups is defined as OI patents and will represent one out of every four patents (Comai, 2019, Walsh et al., 2016). However, Vanhaverbeke et al. (2014) argued that most patents developed by large companies can be linked to R&D projects. Though, it is found that half of companies R&D projects can be categorised as OI projects (Du et al., 2014, Vanhaverbeke et al., 2014). With this background one might classify not only one out of four patents originating from OI projects, but possibly half of all R&D projects having traces of the OI perspective through its process.

The paradox of openness is found when managers make themselves open to external actors while at the same time strive to protect knowledge from being copied (Laursen and Salter, 2014). Though, there are patterns where trade-off between openness and patenting are solved differently by leading companies and followers (Arora et al., 2016). Having two or more external partners, during innovation processes, may divided companies into equal parts of open or closed (Arora et al., 2016). Further, there seems to be an increase in patenting due to openness for leaders compared to followers. Followers, with incremental innovations will benefit little from patenting, and it is believed that followers patent less because it makes them less attractive as an open partners (Arora et al., 2016). How NF regulations with is open governance have affected openness and appropriability mechanisms across stages in the innovation process is of interest in this study. Formal, semiformal and informal IPR mechanisms seem to be balanced by these NF pioneers giving the paradox of disclosure.

3. NF in Europe

Until 1997 the history of safe consumption of foods eaten by other populations where considered as evidence of safe to eat in Europe. This was followed by new rules introduced in 1997, with more sophisticated methods in the assessment of toxicological and microbiological safety (EC, 1997). This triggered additional requirement for imported foods as well as for new food that had not been consumed in the European countries before 15. May 1997 (EC, 2015). These safety standards where the same for all foods on the market, regardless of their origin.

When it comes to introduction of radical new food products most parts of the world have established NF regulations with open governance for food safety authorisation for public interest. The European Unions (EU) policy instrument of NF regulation introduced in 1997 (EC, 1997), with a centralized version implemented in 2018 (EC, 2015), see figure 1. These regulations were designed to protect EU's citizens against possible hazardous effects from unknown food and represents an open governance with transparency and accountability. These governmental instruments has not yet been studied according to patents and their effect on innovation, openness, and collaboration.

Figure 1 illustrates the two main regulations of NF in Europe. During the first 20 years of NF (EC, 1997) each EU member state was involved delaying the approval period giving three years in average time to authorise 128 NF products. Under this first regulation notifications of substantially equivalent product was needed before putting NF approved products on the marked for other companies than the applicant. 523 substantially equivalent products, or NF copies, was approved during this first 20 years. However, under the new regulation from 2018 (EC, 2015) dossiers are sent directly to the EC. In addition, this revised regulation gives a possible data protection with individual authorization for applicant companies for five years, otherwise generic authorization of NF is given. There are no longer need for notifications of substantially equivalent products since approved NF products now are being placed on a union list of NF. All authorisations are generic and the union list serves as a reference for companies who wish to place in the market an authorised NF, unless data protection is requested by the applicant.

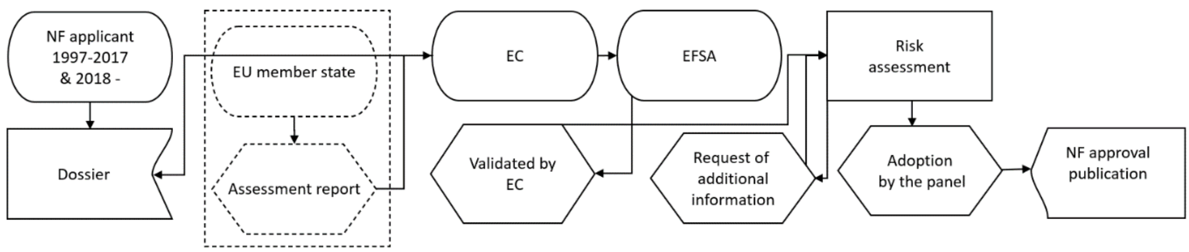


Figure 1: European NF regulation illustrated in a fleet diagram. After 2018 NF dossiers are sent directly to the EC and not passed through EU member states like during the first 20 years of NF regulation in EU. The box with the stippled line was included in the first 20 years of NF regulation.

There are conflicting views on EU NF regulation, and it may be named an regulatory failure (de-Magistris et al., 2015). These regulatory failure has been exemplified by the case of insect-based products where it has slowed down introduction of new protein sources (Marberg et al., 2017, de-Magistris et al., 2015). In addition, EU food safety law has been considered as a negative integration instrument hindering free movement of goods since the requirement of scientific risk assessment for food safety sets limits for national legislators (Hermann, 2009). Production process are rarely approved as a novel process, but the final food product will have to be. This can be exemplified with multiple cases of UV treated foods where it is the vitamin D- enriched food component and not the process which has been regarded as novel. This is also the case of supercritical carbon dioxide for pasteurisation in liquids and solids (Smigic et al., 2019), with the result of multiple applications with costly toxicology data of each product.

NF may also be associated with health claims. The European commission authorises these health claims based on scientific evidence translated into labels possible to understand by consumers The European

Food Safety Authority (EFSA) is responsible for evaluating the scientific evidence supporting health claims. The term EFSA approved health claims is being used and the food industry put considerable effort in order to meet this claims during new product development (Kinner et al., 2011, Amanor-Boadu, 2004).

4. Methodology

A multiphase mixed method was chosen to follow up data from NF in Europe combined with patent search and interviews. Transferability of results has been in focus and for this pragmatism in mixed methods can revise previous disciplinary theories. A pragmatism approach with both subjectivity of own reflections and objectivity in data collection and analysis is practically oriented and offers a strong focus on the research question and meaning making (Shannon-Baker, 2016, Creswell, 2013). Patents and forms of collaboration within selected actors among selected NF applicants has been mapped to understand innovation processes. Previously investigation of these paradoxes of openness, has mostly been conducted on firm levels (Arora et al., 2016) suggestions it should be tested on project level data like the NF cases.

Quantitative data from NF approvals from 1997 throughout 2017 including description of NF, initial assessment company, dates, company names, addresses and status of the NF application was mapped. This NF data was re-organized and processed in the database program Power BI, leading to the final research question and builing a unique background designing qualitative data collection. Further, interviews with selected Norwegian NF cases was conducted. Norway had 7 out of 128 NF approvals and 6 of these companies where interviewed. This was completed with interviews of 7 NF experts, giving 13 interviews in total. Database visualisation and patterns from NF dossiers and notifications was presented during interviews for framing the case of NF. To follow up interview findings where patents were mentioned by all NF pioneers, the EPO's database of European patents was used for downloading worldwide patents originating from the Norwegian NF companies from 2004 - 2019. These patents were organized from database documents to spreadsheets and processed in the program Power BI. 249 lines with patent information including titles, numbers, dates, inventors, nations, owners, applicants, classifications and citations for the 88 patents was processed and re-written for sorting.

Parts of the first sets of data in this study resulted in a paper revealing new novel food policy after centralised regulation in 2018 and collaboration for innovation (Grimsby, 2020). Although, this paper shares some initial data it is original and unique on key food policy IPR implications with its systematic patent search. By mixing sets of data in the study, new insights from NF collaboration, openness during new radical product development and appropriability regimes in the food industry appeared. Understanding the industry, access to data and interview objects were prerequisites for the correct interpretation of the interview subjects in their settings. A background from food research, combined with extensive work experience in adjacent industries, has been crucial for both access and for interpretation of interview objects. Notwithstanding, cognitive blind spots and biased interpretation could result from being too close to the material. A positive confirmation bias towards the favourable effects of collaboration patterns can be expected from OI researchers. From food research actors a slightly negativity bias towards bureaucratic centralized regulations, put up in order to protect EU citizens can also be expected. However, companies within the food industry applying for NF approvals are rare and little is known about these actors, which is positive for an impartial interpretation. Whenever possible, a third-party adviser has been consulted during interpretation of data. In addition to this the four sets of data triangulates findings by using three method to collect data on the same topic. This way of involving various types of data has verified and validated findings.

5. Results

Interviews with actors in selected cases has reveal mechanisms of how open public policy regulations and IPR instruments has affected external ties for innovation in the European food sector. All actors had patents and trademarks registered, and the companies revealed clear appropriability strategies for protecting themselves for being copied by followers.

The most surprising findings from interviews was how actors focused on their patents and how patents seemed to be planned strategies in combination with NF approvals. The second most frequently used code from interviews, after R&D collaboration, included IPR, and how this protection mechanisms were combined with various forms of collaboration with providers of R&D. *"Behind this growth is our first patent, synthetic patent. In addition, we have the NF approval from 2012. These are the two most important things for our business in Europe"* (NF pioneer).

The arrangement from the first 20 years of NF in Europe (EC, 1997), where notification applications where needed for second to market approaches, companies used patents as obstacles protection as well as for monitoring competing products entering the same market. "*So, we have our product patented, and if other companies file a substantial equivalent application, I would like to know about it. I don't think so, if so, someone has stolen our technology"* (NF pioneer). The new NF regulation from 2018 (EC, 2015) introduced a possibility of data protection used by close to half of all new applicants. This protection will stop these new NF approved products to enter the union list of NF and serve as an appropriation regime for 5 years. NF pioneers knew of this arrangement which was suggested by scholars a decade earlier (SANCO, 2008). Although, the data protection possibility has less protection than patents, since it relies on data being secret.

5.1. Blends of formal and informal regimes

Blends of IPR strategies for these NF pioneers includes NF approval, EFSA approved health claims, patents, trademarks and scientific publications. In addition to protection, these IPR measures were used intentional for marketing strategies for sales. The NF approval, the patents, trademarks and EFSA approved health claims were all major selling points towards business customers, next to being part of the companies appropriability regimes. These NF pioneers are all high on R&D and patterns of deep external search activity and R&D innovation collaboration are presented. Companies have long-term relationship and early collaboration with universities or research institutes that may have introduced the NF idea at start. In line with Stefan and Bengtsson (Stefan and Bengtsson, 2017) academic R&D alliances was found important during early phases on new product development. "*The university here has been very important for us, off-course for the whole enterprise. This company is originating from the university campus, but also in relation to some early phase research and such things. We have done lots and lots with several Phd's in collaboration with the university. We even facilitated an industry financed PhD together"* (NF pioneer).

5.2. Network of patents

The number of patents hold by these six companies, plus the one firm not willing to be interviewed, was 88 patents in total. Publication date on these patents spanned from 2004 till 2019, with 65 inventors originating from 13 countries. How to protect knowledge and hinder copied products from only competing on price was in focus by companies interviewed.

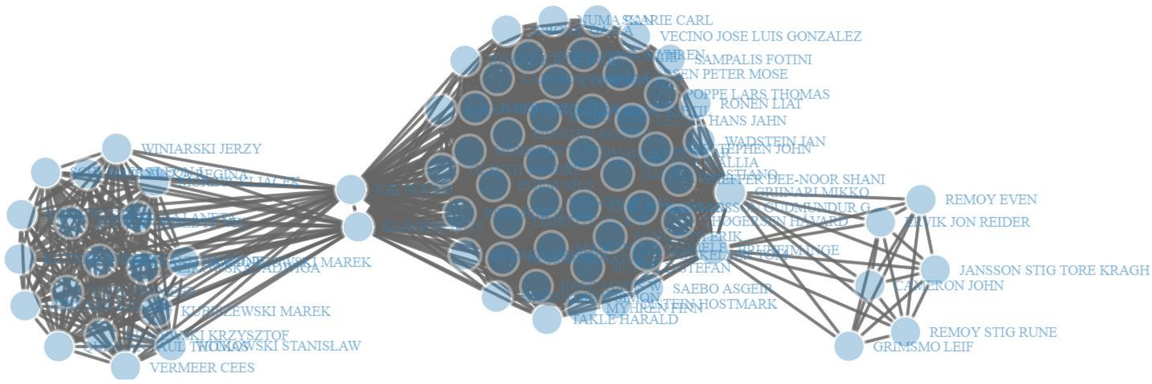


Figure 2: NF inventors. Network of patents clustered by inventors. Inventors of patents are shaping three companies. Four inventors are engaged in patents in more than one cluster/company.

Powerful brokers of knowledge are illustrated in figure 2, as a social networks selection, where inventors are engaged in patents owned by more than one company. Inventors forms companies in this plot. The appendix illustrates the same phenomenon with companies in the hub and inventors as plots on spokes. Four inventors have their names on competing companies' patents. Unlike tangible assets, knowledge is naturally mobile in the heads of individuals (Liebeskind, 1996). A flow of knowledge within strict appropriability regimes is found.

Social network analyses on patents, their inventors, and applicants' owners, proves connection between most of the Norwegian NF actors. Background of the NF pioneering companies' inventors, with their patent collaboration, points out three research institutes and three universities with central roles for these co-creation R&D partners. Partnerships and openness in this NF case seems to foster innovation as scientist and NF employees possess knowledge. Companies and organizations ensure knowledge is bound together and provides a framework for knowledge to result in innovations. This tie other vice clusters of often rough competitors together. *"…we have focused on regulatory expertise and we have focused on patents and gradually… those patents have covered production … meaning we have no patents on machines, but we have on process and we have on use."* (NF pioneer).

There seems to be some exchange of employees in between the NF companies, which also can be seen on the patents having inventors now working for the competitors. Figure 2 illustrates this spillover and flow of knowledge with three competitors in the industry sharing four inventors. This finding from seven selected companies who at the starting point only had two things in common; having filed an NF dossier during the first 20 years of NF regulation in Europe and originating from Norway, was a surprise. However, this can illustrate the unintended flow of knowledge embedded in the heads of employees.

5.3. R&D collaboration and patents

Building company value around its patents combined with the NF approval came up as conscious strategies. Further, the protection of data while collaborating with R&D providers seemed to be cases with hesitation. Companies expressed insecurity of IPR ownership during PhD schemes, while others where more comfortable with early and deep R&D collaboration involving universities and educational institutions.

"…we try to protect ourselves with patents and things like that,.. you are in a phase before you can patent things where you want to be sensitive… meaning protect sensitive information, and then you have problems with the universities about such things as ownership and data…" (NF pioneer). This quote

illustrates how NF pioneers feel insecure about universities and other governmental financed R&D providers about patent rights and the urge to publish. This finding is in line with previous findings of openness effect on companies performance across stages in the innovation process (Stefan and Bengtsson, 2017). This explain why companies close up and avoid involvement of R&D providers outside its boundaries during sensitive activities at early phases where patents might be developed.

Other's feel more secure of how patents are regulated and believe their IPR are being protected during co-creation. "*… that IPR you can have, you will have to access it. Then there are at least two owners, he or she, who takes the PhD and you as a business, owner and manager, you will get that knowledge"* (NF expert). The shift towards commercialization and patenting, for academic partners in Europe and Norway (Iversen et al., 2007) can contributes to these conflicts about independence, habitation and mixed roles for universities, research institutes and technology transfer offices. The establishment of third-party technology transfer offices running the patent work for universities and other R&D providers are somehow effecting trust between these NF pioneers and the R&D providers.

5.4. EFSA approved health-claims

In combination with patents, trademarks, published papers and NF approval, EFSA approved health claims came up as of big importance for these NF companies. Half of the companies had EFSA approved health claims and used these deliberately in marketing and sales context. The other half where all working on getting health claims in Europe approved. However, getting new health claims approved appears to be more challenging than NF approval, and these regulations of claims seems to be handed very different in various parts of the world."*…if you don't have protection, and others too have NF, but not the health claim, you end up competing on price only. And, there we have some (companies) that takes the whole burden of building the segment that does not gets paid for it..."* (NF pioneer).

5.5. Scientific publications

"We have a scientific paper. This was written in Canada based on the documentation we made, and it was ready for publication a year ago. But, in fear of jeopardizing this (data) protection from the EU, right, we first seek the EU with five years protection, and then we will get there…" (NF pioneer). This quote illustrates how scientific publication, building up credibility of findings, are being a part of a strategy. There seems to be a considered strategy not to publish scientific papers, or to hold back, in order to keep the results internally or use them purely for approvals. *"If you do not publish, but have the report on your desk, then you can choose to use the claim or case (for yourself) and not give it to anyone else"* (NF pioneer enterprise). Companies who publish scientifically are conscious about timing in order not to reveal information before it is protected in a similar way as they act before a patent application is filed.

5.6. Patents distribution

The lead actor in the marine oil industry control more than half of the Norwegian NF case patents. This actor has bought up and taken over several international competitors. In Norway, two of these actors represent a well-known example of lawsuits caused by patent fights, since two of these actors has met in curt several times from 2017-2019. This proves the same pattern as in literature described as the paradox of openness and patents (Arora et al., 2016) where large enterprises seek patents as an preferred appropriation mechanism. The lead actor seems more engaged in patents than the smaller players, and the lead actor are in many ways trading-off openness. The smaller actors seem more secure of themselves, on what to be open about and collaborate more freely with R&D, ingredient suppliers and users. This counts especially for the actors with long experience in the business.

6. Policy implications

Patents, trademarks, EFSA approved health claims combined with NF approval are being parts of both appropriation regimes for the food industry actors and for building value into their products. Based on selected literature in the direction of appropriation regimes and R&D collaboration, this study clarifies the case of new product development under the NF regulations in Europe with its open governance. The tension between appropriating innovation return, while NF pioneers at the same time engaging in deep R&D collaboration, is less common for actors in the food industry. This empirical setting with unique data from 22 years of costly time consuming European NF dossiers combined with interviews and patent data, illustrate how radical innovation under open governance policy amplifies the paradox of openness (Arora et al., 2016, Laursen and Salter, 2014, Stefan and Bengtsson, 2017). NF pioneers are collaborating, and patterns of openness during radical innovation is present in line with earlier findings and suggestions (Lyu et al., 2020). Although, these companies have conscious strategies on IPR and protection mechanisms in order to protect themselves from unintended spillover under these open policy regulations.

The flow of knowledge, inn figure 2, illustrated through patent inventors moving between R&D providers and competing companies, are important findings, and illustrates both co-creation and unintended spillover. Further, the appendix illustrates all seven Norwegian NF pioneers and their patent network. This knowledge flow, attached to employees' heads, is mostly unintended spillover as employees change work. However, the sharing of patent inventors in between competing companies was surprising. Further, a company cluster due to geographical issues giving competitive advantage through absorptive capacity (Cohen and Levinthal, 1990) seems to exist. Norway has been represented firmly among the NF pioneers with six times more approved NF applications than average in Europe, and this case illustrates how the technological route can be used to understand knowledge flow (Linares et al., 2019). In line with earlier findings (Du et al., 2014, Jensen et al., 2015) the R&D collaboration between companies and academia has been found to give strong trusted ties in combination with formal appropriability regimes as patents. The north south axis of trust (Brockman et al., 2018) explain some of this collaboration pattern in the Nordic countries. However, elements like wealth among the Nordic countries could possibly explain some of the same pattens.

Blends of formal and informal appropriability regimes follow the same patterns as earlier described with contradictory nature of disclosure and appropriation (Stefan, 2018). However, local R&D collaboration with semiformal protection mechanisms as nondisclosure agreements have not been revealed during interviews in same way as informal trust mechanisms. In addition, knowledge sharing and collaboration towards trusted R&D academic partners follow patterns described by scholars (Stefan and Bengtsson, 2017, Lorenz and Veer, 2017, Arora et al., 2016, Laursen and Salter, 2014).

Finally, it was found that NF pioneers are selling their products as tablets and health improving shots, more than typically food products. This may put NF actors into a subgroup of the food industry closer to nutraceuticals and medicine than food. This can explain some of the intensive R&D collaboration and the importance of appropriability protection mechanisms in the same way as for biotechnology and pharmaceutical industries.

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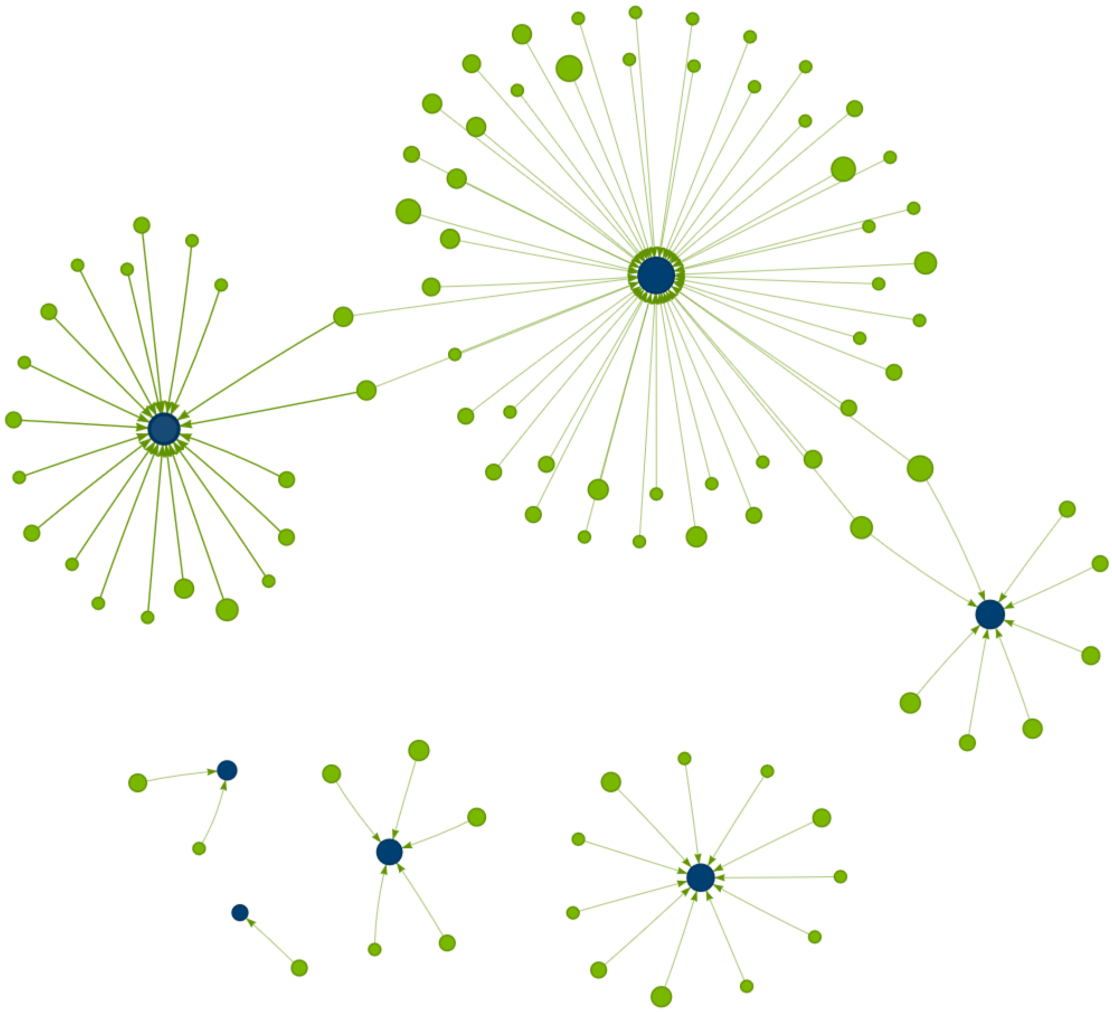
Appendix.



Network of patents clustered by the seven Norwegian NF pioneering companies and their inventors. Structure of co patenting internally and externally. Companies in blue and inventors in green. Number of patents are illustrated as larger blue or green dots. Four inventors engaged in patents owned by more than one firm.