Innovation in the valorisation of by-products: A comparative analysis of the absorptive capacity of food processing firms

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Abstract

The sustainability transition towards bioeconomy concerns how firms innovate, especially in the matter of the utilisation of bio-based resources. The food industry is often criticized for wasting raw materials along the value chain. Those resources can be used in variety of applications and products that confer much higher economic value. Nevertheless, food waste and by-product valorisation has been under-explored in innovation studies. In view of this, the paper aims to study how incumbent firms in a low-tech industry like food make use of technological developments to create higher value-added for their by-products – examining the utilisation of enzymatic hydrolysis technology by using a comparative analysis of a meat and a dairy firm in the Norwegian food industry. The theoretical approach draws on the absorptive capacity of organizational learning literature and innovation systems of transition studies. The study finds that firms in the same industry with quite similar structures (i.e. the form of ownership) can nevertheless have divergent strategies – knowledge development, entrepreneurial experimentation and resource mobilisation, as regards developing innovations for by-product utilisation. The study notes the role of firms' absorptive capacity in acquiring external knowledge and mobilising necessary resources to adopt and develop technological innovations during the transition process.

Keywords: absorptive capacity, incumbents, by-products, enzymatic hydrolysis, innovation systems, sustainability transitions

1. Introduction

How do incumbent firms innovate in the face of (radical) technological innovations, especially in the context of sustainability transitions towards bioeconomy? This question pertains to an ongoing debate on how firms utilise their bio-based resources (Bugge et al. 2016, De Besi and McCormick 2015). Criticisms often direct at the food industry for wasting raw materials along the food value chain (European Commission 2014); especially when those resources confer much higher economic value in variety of applications and products though bioprocessing technologies (Henchion et al. 2016, Lynch et al. 2017, Toldra et al. 2016). Yet, there is no one formula for the valorisation of organic waste and by-products since different technologies are used for different types of by-products (Demirbas 2011). Thus the choice of technology depends on the type, quality and amount of the materials, and on the local conditions where the raw materials are generated (Demirbas 2011). Nonetheless, the value chain of food waste and by-product valorisation (from by-product sources and input to potentially commercial products) are under-addressed in innovation studies (Reardon et al. 2017).

Regardless of increasing researches in the field of sustainability transitions, our understanding of the dynamic role of actors involved in innovation and transition processes is limited (Farla et al. 2012). More specifically, there is a paucity of studies looking into how strategies, resources, and capabilities of firms and organizations impact and trigger the transformation processes (Farla et al. 2012). Transition studies have not given much attention to layer of complexity inside firms (Geels 2014). Thus, more micro-level studies on 'what strategies … actors adopt to shape sustainability transitions and what resources … they mobilise and deploy in the realization of these strategies' (Farla et al. 2012, 992) are needed to untwist some of the complexities of transitions unfolding at the system level.

To understand firms' strategies and motivation in developing innovations, strategic management literature emphasizes the role of knowledge development and transfer within and across firms (Grant 1996, Leonard-Barton 1995, Nonaka 1994, Pisano 1994, Roy and Sarkar 2016, Spender and Grant 1996, Tsai 2001). Absorptive capacity is one of the key management concepts that seeks to understand how firms acquire and utilise external knowledge to generate innovations (Cohen and Levinthal 1990, Easterby-Smith et al. 2008, Lane et al. 2006, Murovec and Prodan 2009, Todorova and Durisin 2007, van den Bosch et al. 2003, Zahra and George 2002). Despite being one of the most frequently cited concepts, absorptive capacity as a process or capability (Edmondson and McManus 2007) has limited empirical evidence with unverified assumptions (Patterson and Ambrosini 2015). Further, few studies on absorptive capacity have attempted to operationalize and test 'the assimilation or application of external knowledge' in an empirical context (Lane et al. 2006, 852). Consequently, this calls for qualitative work (Easterby-Smith et al. 2008, Volberda et al. 2010) to expound the underlying process structures of dynamic nature of absorptive capacity (Jiménez-Barrionuevo et al. 2011). Although few transition researches have benefited from the strategic management literature to investigate organizations' strategies towards technological innovations during the transition process (for example, Hansen and Coenen 2017), our understanding of incumbent firms in the face of technological changes remains limited.

In view of this, the paper strives to fill in such gaps by tackling the following research question: *What is the role of absorptive capacity in incumbent firms' adoption and development of technological innovations*? The study aims to explore how incumbent firms make use of technological developments to further develop innovations within the firms during the transition towards a sustainable bioeconomy. I seek a better understanding of the interrelation between incumbents' absorptive capacity and the way they build up their knowledge base of technological innovation systems to create higher value for their by-product and side stream resources. In particular, the paper carries out a comparative analysis of two empirical case studies – examining the utilisation of enzymatic hydrolysis of protein technology[1] in a meat and a dairy firm in the Norwegian food processing industry.

The theoretical approach of this paper draws on the absorptive capacity of management literature and innovation systems of transition studies to understand incumbent firms' strategies during technological changes. The paper does not examine the enzymatic hydrolysis of protein technological system per se but rather focuses on studying its agents – the firms' strategies as regards adopting and making use of the technological development. With understanding gleaned from the absorptive capacity literature, the paper delves into the firms' ability to capture external knowledge about the enzymatic hydrolysis technology and investigates how they go about transforming the acquired knowledge into innovation (i.e. new products and applications). Firms are seen as one of the key structural components of an innovation system. In order to understand how the dairy and meat firm develop the enzymatic hydrolysis innovation system, the paper explores the incumbents' learning process – exploratory, transformative and exploitative, in relation to such strategies as knowledge development, entrepreneurial experimentation and resource mobilisation. By using the absorptive capacity literature, the paper strives to contribute a better understanding of how actors at the micro-level – the two food processing firms in this study – utilise technological innovations in the context of

[1] Enzymatic hydrolysis is a process in which enzymes are used to enhance the bond cleavage in molecules with the addition of the elements of water. Enzymatic hydrolysis of protein is a process using enzymes to facilitate the cleavage of peptide bonds for the development of protein hydrolysates (Tavano 2013)

sustainability transitions. The study attempts to inform policy-makers of the relevant policy aspects of the bio-based economy.

To explore latent processes of absorptive capacity inside the firms, the paper employs a qualitative research design with open-ended and semi-structured interviews. The method is chosen in order to enable an in-depth analysis of the actors (the firms) with regard to dairy and animal by-product and side stream valorisation. By undertaking a comparative analysis, the paper seeks to understand how firms in the same industry with quite similar structures (i.e. the form of ownership) can nevertheless have different strategies and motivations in respect of developing innovations for by-product utilisation.

The choice of the case study – the food industry stands for several reasons. First, the rapid growth of the world's population entails an increased demand for food and food ingredients, which, in turn, requires a resource efficient delivery and a better utilisation of raw materials in the food industry (European Commission 2014). This appertains to the bio-resource vision of bioeconomy (Bugge et al. 2016) that promotes innovative, sustainable solutions for all bio-based resources. Second, the significant volume of food wastes, by-products and side streams generated and the potential of those resources for high value-added products and applications in various fields such as medicine, pharmaceutics, cosmetics and foodstuff is large thanks to heterogeneous bioconversion technologies (Lin et al. 2013, Mullen et al. 2017, Prazeres et al. 2012). This challenges the food industry to re-examine all processing streams to increase value. However, despite those rationales, research on the link between food system transformation to a more sustainable mode and technology adoption and innovation is not received a sufficient attention (Reardon et al. 2017). The majority of researches on food manufacturing wastes and by-products have been merely done on restricted research examples, experiments, or pilot cases, not at an industrial scale as indicated by Mirabella et al. (2014) in an extensive literature review of 111 papers. There is a lack of empirical research on specific types of food wastes and by-products, quantity, geographical location and commercial feasibility for outcome products (Demirbas 2011) and how industrial firms in the food industry innovate from this aspect (Reardon et al. 2017). Therefore, this paper aims to gain more empirical knowledge by looking into the Norwegian food processing industry and add to the restricted portfolio of empirical research on incumbent firms in a low-tech industry like food.

The paper is structured as follows. Section 2 describes the theoretical framework. Section 3 introduces the methods and data and the case study – the Norwegian food processing industry and the two incumbent firms. Section 4 presents the results while Section 5 turns to the discussion of the analysis. Section 6 notes the conclusion and outlines the policy implications and potential for further research in this field.

2. Setting the theoretical framework

2.1 Incumbent firms and (radical) technological innovations

The emergence of new technologies and socio-technical transformation affect the positions and strategic interests of incumbents and newcomers to a great extent (Grin 2010). Nevertheless, being one of the key structural components of a technological system, the *agency of actors* has not been paid sufficient attention (Farla et al. 2012, Kern 2015, Markard et al. 2015, Smith et al. 2005). Despite the role of firms and other actors as 'the essential driver behind the generation, diffusion, and the utilisation of technological innovation' (Markard et al. 2012, 959), we lack an understanding of why and how some incumbent firms embark on transitions as well as the underlying processes and the mechanisms that drive firms' motivation and strategies to engage in technological innovation developments during the transition process (Safarzyńska et al. 2012). One central critique is that transition studies on the meso level frameworks are descriptive and structural, which give little weight to the importance of agency in this respect. Thus, Markard and Truffer (2008) put forward an '*actor-oriented*' approach to better understand the micro-level foundation of innovation systems. This approach devotes to systematically explore the gap between innovation strategies and resources at the micro-level with system characteristics at the meso level (Markard and Truffer 2008). It is in line with the '*agency of actors*' argument that has been propounded by Smith et al. (2005).

The debate on incumbent firms in the face of (radical) technological innovation commonly discusses the firms' failure in embracing new technologies (see among others, Ansari and Krop 2012, Bergek et al. 2013, Chandy and Tellis 2000, Dewald and Achternbosch 2015, Hill and Rothaermel 2003). The explanation for this failure are forces of inertia within the firms, the embeddedness in an established system (infrastructure and industry networks) and economic incentives, which make the incumbents not initially value the new technology (Hill and Rothaermel 2003). Nevertheless, incumbents have also advantage over new entrants or challengers in terms of better access to complementary assets, which can 'buffer incumbents from competition and enable them to profit from the innovation' (Ansari and Krop 2012, 1365). Ehrnberg and Jacobsson (1997) discuss three main components that a firm must change when responding to a technological discontinuity: (i) to realize that a new product has the potential to substitute for the 'old' product, (ii) to get access to the new technology, and hence change its technology base, and (iii) to change the way in which things are done – its organizational routines.

In order to comprehend the underlying dynamics of actors in respect of technological innovation adoption, development and diffusion, transition scholars have benefited, among others, from concepts in the strategic management literature (Markard et al. 2015) by directing attention to various micro-level processes underlying a technological innovation formation, including network building and formation of coalitions, shaping expectations, or market creation (Dewald and Truffer 2011, Musiolik and Markard 2011, Musiolik et al. 2012). From a conceptual point of view, this approach has the potential to explore the boundary area, where the two strands of literature might be 'fruitfully related to each other' (Markard and Truffer 2008, 444)

There are few studies that seek to understand the link of the micro-meso level interaction (Markard and Truffer 2008). For instance, the micro-level study of firms in the biomedical clusters in Ohio and Sweden by Cetindamar and Laage-Hellman (2002) notes the importance of firms' competence in production and technology competencies, technology transfer capabilities, and commercialization strength during technological transformations. Markard and Truffer (2008) signify the link of innovation strategies and resource endowments to system performance and dynamics in the case of stationary fuel cells. Smith et al. (2005) explore the degree to which resource interdependencies (factor endowments, capabilities and knowledge) required for effective regime transformations. These studies place emphasis on the role of resources and capabilities to firms' innovation strategies. To better understand the underlying dynamics of incumbent firms, the next section discusses the absorptive capacity.

2.2 Absorptive capacity and organizational learning

Knowledge represents a vital resource for firms to create value, to develop innovations and to sustain competitive advantages, especially in a dynamic and turbulent environment (Teece et al. 1997). Outside sources of knowledge are often crucial to the innovation process, thus 'the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends is critical to its innovative capabilities' (Cohen and Levinthal 1990, 128). The absorptive capacity (hereafter ACAP) is a seminal concept originally developed by Cohen and Levinthal (1989), in which the authors stress the ability to first acquire external knowledge, assimilate it and later exploit it is a critical component of innovative capabilities for firms. Hence, the process for absorbing external knowledge becomes a pivotal factor for firms' innovation and adaption to changes in a competitive environment (Camisón and Forés 2010). This process is referred to the recursive relationship of ACAP and organizational learning, in which increased learning in a particular area enhances the organization's knowledge base in that area (Lane et al. 2006). Consequently, developing and maintaining ACAP is crucial to firms' enduring survival and success because ACAP can reinforce and complement, or even re-focus the firm's knowledge base (Lane et al. 2006).

However, the process nature of the relationship between ACAP and organizational learning, i.e. how does ACAP affect knowledge creation within an organization, and help assimilate and integrate external knowledge with existing knowledge in the firm, has not been studied extensively in management literature (Lane et al. 2006). To develop further the ACAP constructs in relation with organizational learning, Lane et al. (2006) expound a three-stage sequential process: *exploratory learning, transformative learning and exploitative learning*. The exploratory learning is the ability of recognizing and understanding potentially valuable new knowledge outside the firm. The transformative learning is the ability of assimilating valuable newly explored knowledge. Lastly, the exploitative learning refers to the ability of applying the assimilated knowledge to create new knowledge and commercial outputs. In addition, learning allows firms to identify new production opportunities (Levitt and March 1988).

The main resulting question regarding the organizational learning of firms is *what do firms learn*? Through an extensive literature review of ACAP, Lane et al. (2006) summarize three major external knowledge characteristics organizations acquire: knowledge content, knowledge tacitness and knowledge complexity. Knowledge content or know-what refers to a specific type of knowledge such as new technologies, customers, markets and common skills (Bierly and Chakrabarti 1999, Lane and Lubatkin 1998). Similar culture and cognitive structures are likely to enhance knowledge absorption and assimilation (Bhagat et al. 2002, Simonin 1999). Knowledge tacitness or know-how refers to the extent to which the knowledge consists of implicit, ambiguous and noncodifiable skills (Kogut and Zander 1992, Lam 1997, Nonaka 1994). This type of knowledge embeds in complex processes, interactions and routines within the firm, it is thus difficult to transfer and absorb (Saviotti 1998, Simonin 1999, Szulanski 1996), which consequently can create barriers to innovations (Reed and DeFillippi 1990, Simonin 1999). Knowledge complexity refers to a variety of interdependent technologies, routines, individuals, and resources associated with a particular knowledge or asset (Simonin 1999). The complexity lies in the interlinkages between different knowledge content areas (Garud and Nayyar 1994). The more complex the knowledge is, the harder it is for organizations to understand and absorb. Additionally, the complexity of knowledge increases sharply in dynamic environments (Lane et al. 2006). Thus, firms in such an environment need to exercise other organizational policies, such as utilising research partnerships, to increase their ACAP (Goes and Park 1997, Powell et al. 1996, Steensma and Corley 2000).

In regard to radical technological innovations, all three dimensions of knowledge are likely to present. Some scholars have suggested that radical innovations involve novel combination of existing technologies and know-how (Kogut and Zander 1992, van den Bosch et al. 1999). However, the underlying process that specifies explicit mechanisms for integration and exploiting such loosely related domains, has relatively been examined (Lane et al. 2006). In other words, there has been little attempt to study the relationship between ACAP and radical innovation (Lane et al. 2006). Since the majority of ACAP researches has focused on R&D and IPR contexts (see among others, Cohen and Levinthal 1990, Meeus et al. 2001, Mowery et al. 1996), this leads to an over-emphasis on being able to understand the technological or scientific knowledge (i.e. the knowledge content) the firm needs to acquire at the expense of the *process knowledge* needed to assimilate and apply it (Lane et al. 2006, Patterson and Ambrosini 2015). This points out the importance of future empirical studies for a deeper analysis on intra- and inter-organizational aspects of ACAP at the micro-level (Volberda et al. 2010) to better understand such process and to fully understand firms' innovation strategies. Moreover, as ACAP strengthens the role of outside knowledge to firms' innovation, it should not only be studied by R&D spend or patents (Patterson and Ambrosini 2015). ACAP – as a dynamic capability, is pertinent to any other external strategic factors, such as potential market, customer or technical knowledge (Volberda et al. 2010) that can be assimilated and applied to commercial ends. This invites further empirical research on ACAP in 'non-R&D contexts' (Lane et al. 2006, 858).

By doing an empirical case study, the paper strives to understand what are incumbent firms' motivation and strategies for such a potential technology as the enzymatic hydrolysis of protein. With insights of ACAP and through the lens of incumbent firms, the paper endeavours to explore what are critical factors for their involvement in such a technological innovation. In other words, the papers seeks to examine the ACAP process of exploratory, transformative and exploitative learning in relation to firms' knowledge development, entrepreneurial experimentation and resource mobilisation. The study focuses on those organizational units that are involved in the utilisation, diffusion and generation of the innovation under study. By zooming in micro-level factors at the firm level and analysing the ACAP constructs, this study attempts to comprehend firms' strategic decisions in the face of (radical) technological innovations and to contribute to a better understanding of innovation system dynamics at the meso level (Markard and Truffer 2008).

3. Methods, data and the case

3.1 Methods and data

This paper applied a qualitative research design and a comparative case study (George and Bennett 2005, Yin 2014). The main data input was interview data derived from 13 interviews in the period of 2016–2018 with the two food processing companies, i.e. the dairy and the meat firm, and other stakeholders involved including research institutes, policymakers, rendering companies, experts, industry federation and government officials from Norwegian ministries. The choice of qualitative research design with semi-structured and open-ended interview method aimed at achieving an in-depth and thorough understanding of the firms' motivation and strategies in respect of developing innovations for their dairy and animal by-product and side stream valorisation. Further, one central point for this chosen approach was to respond specifically to the call of qualitative data to study firms' absorptive capacity by Patterson and Ambrosini (2015). The primary benefit of qualitative data is that rich, qualitative data can help 'expose evidence for the ACAP constructs in a way that "black box" quantitative approaches cannot' (Patterson and Ambrosini 2015, 80). The designed interview questions were based on the food value chain on various stages from raw materials input, processing, transportation and distribution, to retail.

One important secondary source of data for this study was project data gathered from the project bank of the Research Council of Norway. This quantitative data gave an overview of the research projects that the two companies were involved, which was important in mapping the types of knowledge and information the firms wanted to acquire. To supplement the analysis, other sources of data were assembled including reports, artefacts and documents.

Based on the collected data, I carried out a comparative case study of the two firms. By undertaking a comparative analysis, I sought to understand how firms in the same industry with quite similar structures (i.e. the form of ownership) can nonetheless have divergent strategies and motivations in respect of developing innovations for by-product utilisation.

3.2 Case: the Norwegian food industry

The Norwegian food industry plays a key role in the country's economy as it is the largest mainland manufacturing industry in Norway by turnover, value creation and number of employees (Prestegard et al. 2017). The industry has 2 175 companies with total 50 650 employees and a turnover of USD 30.84 billion (2016 statistics in Prestegard et al. (2017)). The Norwegian food industry is organized by a few big companies that account for about half of the turnover and by SMEs (Small and mediumsized enterprises)[2] (Prestegard et al. 2017). The meat processing sector is the biggest sector by employment (25%) and second largest sector by revenue (21%), while the dairy sector is the fourth largest sector by revenue (11%) and employment (12%) in the Norwegian food industry (2016 statistics presented in Prestegard et al. (2017)).

The dairy firm is a big dairy firm, cooperatively owned by farmers in Norway with a turnover of USD 2 910 million and USD 221 million[3] in operating profit, 5 418 employees, which produces various dairy products for the Norwegian and international market. The firm's organic by-products and residues include cheese whey, buttermilk, cheese dust, wasted milk and disqualified cheese products[4]. There are two types of whey generated at the firm, i.e. sweet whey and acid whey, which are in high volume in tons each year. Sweet whey comes from white hard cheese production with a volume of 25 000 tons a year whilst acid whey are by-products of cottage cheese production for Greek yoghurt with a volume of 1 000 tons a year (but increasing rapidly due to the demand for Greek yoghurt products).

The meat firm is a large meat and egg firm, cooperatively owned by farmers in Norway with a turnover of USD 3 036 million[5] and a number of 5 000 employees, which provides meat and egg products for the Norwegian market. Animal by-products generated at the firm are hides and skins, feather, organs, fats, bones, blood, intestines, internal parts etc. The volume of by-products generated by the firm's slaughterhouses is hundred and fifty thousand tons a year, accounting for 35% of the total raw materials at the whole firm.

Both dairy and meat by-products and side streams are great sources for potential bioconversions (Lin et al. 2013). Bioconversion technologies are varied from conventional techniques such as anaerobic digestion and composting to more advanced, combined technologies, which can be used to produce biofuels, biochemicals and various high value-added products in medicine and pharmaceutical industry (Lin et al. 2013). Cheese whey is one typical by-product in the dairy sector that is a valuable source for value-added products (Mirabella et al. 2014). Cheese whey is rich of compounds such as lactic acid, carbon, peptides and proteins, which can, for instance, be derived to produce supplements in diet food, aroma stabilizers, sweetener and confectionary products (Galanakis 2012, 2015). Meat by-products' compounds such as protein, gelatine, fat, phosphates and collagen can be

[2] SMEs are firms with less than 100 employees - a definition by Confederation of Norwegian Enterprise NHO (Prestegard and Sørbye 2016).
[3] From the firm's annual report 2016
[4]These resources are organic by-products or residues left from the major dairy production (e.g., cheese, milk, yoghurt etc.), in other words, they are the remains from the traditional dairy production process.
[5] The firm's annual report 2017

extracted through bioprocessing (Mirabella et al. 2014, Mullen et al. 2017). The enzymatic hydrolysis of protein (hereby PEH) is a technology that works well for the dairy and meat by-products since they are both protein-rich (Krasnoshtanova 2010, Morais et al. 2013, Spotti et al. 2017, Tavano 2013). For example, protease enzymes encourage pre-digestion of the protein, allowing for the release of the full content of the essential amino acids for building muscle and improving muscle recovery (Deaton 2018). Protein hydrolysates (or hydrolysed proteins) are the outcome products of this process.

4. Incumbent firms and the process of learning

4.1 Exploratory learning – recognizing and acquiring valuable external knowledge

The exploratory learning phase of ACAP sets out the types of knowledge firms seek and through what channels. As for the two firms under study, the enzymatic hydrolysis of protein was a radical innovation, given that the technology involved methods and materials that were novel to them (Hill and Rothaermel 2003). Thus the first type of knowledge they needed to acquire was technical knowledge – knowledge content. However, by-product valorisation was new business area to the incumbents, where the prior knowledge from the main production did not play a significant role. In this case, utilising research partnerships was the key (Powell et al. 1996). As noted by an interviewee from the meat firm:

> We have to develop knowledge and know what technologies to invest, to seek knowledge outside at research institutes. […] We don't have a very large research department, so we are very dependent on the collaboration with research institutes.

It turned out that collaborating with research institutes and other industries through R&D projects was a crucial factor for the firms to acquire the needed knowledge. Table 1 summarized the meat firm's research projects on the enzymatic hydrolysis technology. The meat firm acknowledged the enzymatic hydrolysis development from the Norwegian fish industry (Liaset and Espe 2008, Liaset et al. 2000). It actively searched[6] for more knowledge in the field by participating in the projects that involved this industry partner. As one employee of the meat firm remarked in one of the projects:

> There is very much expertise, knowledge in this project [III], not least it has been done a lot of good work on fish, which I think we can translate in principle into meat. The meat, as it is known, is very good protein, completely at the height of fish protein.

[6] Active searching means firms know in advance what they look for and try to find it (Patterson and Ambrosini 2015).

The meat firm got in contact with the technology provider who worked with the fish industry and had earlier developed a continuous flow processing technology. This technology had an advantage over the batch processing technology in terms of time, costs and energy saving. Through the collaborative projects, the meat firm investigated different enzymes and how these enzymes functioned. Further, it also learned about various mechanisms of the hydrolysis process and how it worked on different types of rest raw materials as well as desired outcome products. The table 1 showed a continuous, vigorous effort of the meat firm on studying the PEH technology since 2012. In the project IV and VII where the meat firm played the main role as a coordinator, it focused intensively on examining the potential of chicken by-products that were generated at the firm's slaughterhouses in a great volume.

For incumbent firms, developing knowledge about new markets is also crucial (Chang et al. 2012, Roy and Sarkar 2016). However, it was challenging to identify new high value-added niche markets for valorised products since those markets were disparate from the traditional ones, which required consumer awareness and willingness to purchase. Although the meat incumbent acknowledged a great potential of protein hydrolysates for various uses and applications, it had to determine which markets (both demographic and geographical) to enter by seeking insights from those market players, such as marketing and distributing companies. It must study carefully health trends, consumer need and preference. Apart from proteins for the pet food market, the firm found a great potential of protein hydrolysates for human consumption market such as infants and baby food, the elderly, and sports nutrition. The US sports market was one of the targets due to its large market size (Heitner 2016). The incumbent's criteria for choosing a market was a good business case with profitability prospect, specifically:

> We [the firm] can offer a product that is unique and stands out from alternatives, which fulfils a need, and has a long-term competitive advantage. (Interviewee statement)

The dairy firm, whereas, started the process of investigating the enzymatic hydrolysis of protein technology not so long ago in 2017, when it joined the same project with the meat firm (project VIII in the Table 1). The firm acknowledged the potential of protein hydrolysates from whey, however, it did not have an urgent need to examine this earlier as it produced and sold common whey protein (protein concentrates) through drying technology. Like the meat firm, the dairy firm valued the collaboration with the research environment, as one interviewee noted:

> Working with external research institutes/ research partners is very important strategy for us as [the firm] has a need to develop and expand its knowledge base. [The firm] cannot do

> everything on its own as we do not have competences in all fields. By using research projects, [the firm] can access and develop knowledge and insights from our cooperative network.

Research projects were a pivotal channel where the two firms ‘explored’ the knowledge about the PEH and its potential for by-product valorisation. Research institutes and industry played a role as key partners. The exploratory learning of ACAP lays down the importance of collaboration capability in acquiring external knowledge for developing innovations through networks (Blomqvist and Levy 2006).

Table 1. Overview of the meat firm's research projects on the enzymatic hydrolysis of protein technology[7]

Project number	Time frame	The firm's role in the project	Type of by-products, residues	Current solution(s) and/or market(s)	Knowledge base, Research path(s)	Potential outcome(s)/ product(s) / market(s)
I	**2012–2015**	Partner	By-products derived from animal (e.g. chicken bone) and marine industries	Low value products markets	Increase the knowledge of enzymatic hydrolysis of residues from animal and marine industries through the development of rapid screening techniques for controlling and monitoring of processes Stable quality protein hydrolysates require good control over the raw material variation	Potential markets for industrial utilisation of protein hydrolysates Reduced production wastes and increased the sales value of by-products
II	**2012–2018**	Partner	By-products from meat and marine production and other Norwegian biomass	NA	Develop competitive enzyme technology and identify the right, promising enzymes better suited for industrial use, such as enzymes using bioinformatics, protein engineering and gene shuffling-based directed evolution. Develop high-value hydrolysates from protein-rich by-products through enzymatic conversion technology Screen and character ization of candidate enzymes, enzyme engineering and larger-scale production for industrial trials	Increased value creation in Norwegian bio-based industries A good bio-economy based on sustainable, environmental-friendly and profitable processes Considerable synergies of the blue and green sector
III	**2013–2017**	Partner	Rest raw materials from fish, chicken and vegetables	NA	Develop novel sensor and automation technology, bioprocessing technology Conversion of raw meat materials using enzymes to prepare protein powder and oil	Novel automated quality differentiation and sorting concepts that increase resource utilisation of food loss and reduce wastes Ingredient in various foodstuffs
IV	**2013–2017**	*Coordinator*	Chicken by-products (e.g. chicken bone)	Meat meal production and low-value feed applications	Explore the potential of chicken bones as the base raw material to produce liquid or dried peptide hydrolysate with high quality and high value application Identify, characterize and quantitate processed peptides through the process of enzymatic breakdown of protein	Novel food and feed ingredients as peptides with bioactive properties with potential obesity-reducing effects
V	**2014–2017**	Partner	Low value side-streams, e.g. potato peel starch, chicken feather	NA	Develop a liquid biodegradable mulch films to control weeds in row crop production by using potato starch and hydrolyzed chicken feather	Environmental-friendly substitute for herbicides, as well as for petroleum- based polymer mulch films Enhanced knowledge and competence in development and characterization of films
VI	**2015–2023**	Partner	Biomass unsuitable for direct human consumption, e.g. wood, seaweed and by-products from slaughterhouses	NA	Develop protocols for converting biomass to hydrolysates for use in yeast production by applying enzyme technology Innovative feed processing technology, conversion of national bioresources into feed for farm animals and fish	Production of novel feed ingredients for farm animals and fish Contribution to the growth and value creation in the Norwegian aquaculture and agriculture industries
VII	**2017–2019**	*Coordinator*	12,000 tons of chicken by-products from mechanical deboning process	Low value feed ingredients	Convert low-value plus products into high-value ingredients and foods for higher-paying markets by using enzymatic hydrolysis of protein	Protein hydrolysates for the sport/ fitness market, and the elderly market Development of new ingredients for functional food and innovative food products for consumers
VIII	**2017–2020**	Partner	Chicken carcasses from poultry and whey from dairy processing	NA	Use Fourier-transform infrared (FTIR) spectroscopy based rapid screening with ligand fishing technologies for facilitated discovery of antidiabetic peptides in protein hydrolysates Screen and identify bioactive principles in protein hydrolysates	Efficient and high quality screening program for bioactive constituents in complex food product

[7] Data collected in the period of 2016–2018 from the Research Council of Norway's project bank; NA = no information available

4.2 Transformative learning – assimilating acquired external knowledge

The transformative learning of ACAP enables firms to assimilate and transform valuable newly explored knowledge via experimentation. Firms may be advantaged through early experimentation by being able to undertake interdivisional transfer of technical knowledge (Miller et al. 2007). This phase of ACAP is particularly important in the sense that the focus on R&D and knowledge acquisition overlooks the process needed to *assimilate and apply* the acquired knowledge (Lane et al. 2006). As a participant of the meat firm in the project III (see Table 1) confirmed:

> Useful values are to take the knowledge that exists and the processes that have already been developed in other contexts, transfer them and adapt them to our raw materials.

Through the research projects on PEH on a pilot/ lab scale, the meat firm tested different types of enzymes on various rest raw materials, possible outcome products which respond to different market needs such as baby food, nutrition for the elderly and sports nutrition. These pilot research projects required a lot of testing and documenting to show that the end products worked with good results. As one interviewee explained:

> We have products from test or lab production, and we can show that this is what we are expecting to produce. We analyse […] and find out if the application has effect in the body […] for example, metabolism. […] We [also need] to find add-on value on this product compared to other products in the market.

The transformative learning process of the dairy firm, however, was got under way, considered by the fact that it began to look into the enzymatic hydrolysis not that long ago. Since whey was the most abundant rest raw material of the firm, it was natural that it started experimenting with this by-product in the first research project on enzymatic hydrolysis (project VIII in Table 1). This project was launched in 2017, thus it would take some time before the firm got any pilot results.

4.3 Exploitative learning – applying assimilated external knowledge

The exploitative learning phase emphasizes firms' ability to convert the assimilated knowledge into new products and services (Cohen and Levinthal 1990). To do so, firms must mobilise necessary resources. After the intensive transformative learning process about the enzymatic hydrolysis, the meat firm made an important decision: to invest in this technology to produce protein hydrolysates on an industrial scale. Nevertheless, the mobilisation of financial resources, especially the risk capital, was troublesome. As noted by an interviewee:

> To develop and implement new innovative processes, technologies and applications takes time, […] is risky and requires a lot of resources – it requires 'big muscles'. Even big companies as ours have low margins and limited access to funding for taking the lead on innovations. […] More funding and access to risk capital will contribute to increase innovation.

Furthermore, raising funds for internal R&D projects was difficult as the valorisation department had to compete with others in the same firm to get a funding approval. The decision to invest in an enzymatic hydrolysis plant was only made after the meat firm had received some public funding and successfully invited a partner to share the financial burden and to reduce risks (Strøm-Andersen and Tartiu 2018). The enzymatic hydrolysis project bore a new joint venture firm between the meat firm and its partner. This partner, interestingly, had the same organizational structure (i.e. cooperatively owned) as the meat firm. It was also a large firm selling feed ingredients. The plant was built in 2017 and expected to launch final products on the market early 2019. In addition to the importance of capital resources mobilisation, the meat firm also invested in its human capital by hiring more people for the research team on the by-product valorisation, as it recognized the great potential of this field.

As for the dairy firm, it was still in an early stage of investigating and learning more about the enzymatic hydrolysis. Thus, it decided:

> We [the firm] follow what happens in other countries, what are published and communicated at seminars and conferences and so on. So we follow the development of the field. […] We wait and see. [If] the documentations are better, we should use them. (Interviewee statement)

'Wait and see' did not mean the firm was static. However, it invested in human capital by increasing personnel in the by-product valorisation department in order to be able to examine the potential of this technology in particular and other potential technologies and possibilities for utilising its rich by-product resources.

5. Discussion

5.1 Absorptive capacity and firms' strategies

Through the lens of the 3-stage learning of ACAP process – exploratory, transformative and exploitative learning, the paper discusses three important areas of firms' strategies: knowledge development, entrepreneurial experimentation and resource mobilisation in relation to the two case studies:

Knowledge development. In the modern economy, knowledge is considered as the most fundamental resource and learning is the most important process (Lundvall and Johnson 1994). Knowledge and learning are intertwined where knowledge development involves the learning process. Knowledge development is prerequisite for innovation systems, which is placed at the centre of an innovation system (Bergek et al. 2008). Firms learn and develop knowledge through 'learning by search' (Hekkert et al. 2007, 422). Firms involve in the development or diffusion of new technologies by incorporating novel knowledge into their activities; in order to do so, they must have absorptive capacity (Cohen and Levinthal 1990). Both firms under study built up their knowledge base through an exploratory learning. This absorptive capacity allowed the firms to explore potential knowledge from different learning channels, especially through a research collaboration with research institutes. Further, the knowledge and experience across industries for this specific technology – the enzymatic hydrolysis, i.e. from the Norwegian fish industry, seemed to play a significant role in the knowledge acquisition of the two food firms under study. The meat firm first acknowledged about the enzymatic hydrolysis of protein process from the Norwegian fish industry 20 years ago. But, it only started the exploratory process by involving in an enzymatic hydrolysis research project for the first time in 2012 (project I in Table 1). The firm constantly developed its knowledge base of this technology by actively participating in a number of research projects. The dairy firm, however, started to explore the technology by engaging in a research project in 2017, although it had earlier acknowledged the potential of protein hydrolysates from its Danish partner who produced hydrolysed proteins in a large scale.

Entrepreneurial experimentation. Knowledge needs to be tested and turned into concrete actions via entrepreneurial experimentation. Entrepreneurial experimentation is 'the main source of uncertainty[8] reduction' (Bergek et al. 2008, 415), which suggests possible results coming from trials and failures. Entrepreneurs are not only new entrants but also incumbent companies who diversify their business strategy to take advantage of new developments (Hekkert et al. 2007), which is the case of the firms under study. Experimentation in the form of learning by doing and learning by using is vital for innovation to thrive (Carlsson and Stankiewicz 1991, Dosi 1988). The transformative learning of ACAP allowed the meat firm to experiment on the technology by testing different enzymes with different by-product types. Good results from the pilot projects provided the meat firm with solid foundation for further developing the enzymatic hydrolysis of protein technology. The dairy firm, nonetheless, was

[8] This uncertainty is a fundamental feature of technological and industrial development (Hekkert et al. 2007)

still in an early phase of knowledge development of the technology, thus it did not come far in experimenting the technology.

Resource mobilisation. For a specific technology, the allocation of sufficient resources is indispensable to make knowledge exploitation possible (Hekkert et al. 2007). Resources are human, financial capital and complementary assets such as complementary services, products and network infrastructure (Bergek et al. 2008). Among them, financial commitment is one of the most important resources, acting as a necessary condition of innovative enterprises (Lazonick and Prencipe 2005). Resources are important input for the knowledge development (about a specific technology) and entrepreneurial experimentation to allow testing of new technologies in niche experiments (Hekkert et al. 2007). The exploitative learning of ACAP required the firms' dedication to turn the transformed external knowledge into commercial outputs by mobilising necessary resources. Resources are needed in any phase of the ACAP process; however, it is more decisive at the exploitative phase, especially the financial capital, as shown in the case of the meat firm. The firm needed a large amount of money to realize the enzymatic hydrolysis of protein project: build a plant and prepare for production in an industrial scale. Mobilising resources from the partner and public funding. The dairy firm devoted its human capital to explore the technology and other technological possibilities in the valorisation field.

The analysis showed that the two firms practised different strategies in regard to the enzymatic hydrolysis of protein technology. The meat firm was ahead and seemed to be more decisive and active in knowledge development (by acquiring needed technical knowledge through a number of collaborative research projects via the exploratory learning), in entrepreneurial experimentation (by doing several pilot projects to transform the acquired knowledge via the transformative learning) and resource mobilisation (by mobilising both financial and human capital to exploit the assimilated and transformed knowledge via the exploitative learning). The dairy firm, however, was in an early stage of exploring the technology and investing in human capital to investigate the potential of the technology. The findings of the paper are illustrated in **Fig**. 1.

A possible explanation for the difference in innovation strategies of the two firms might lie in the by-product characteristics and external factors such as demand, price fluctuations and competitiveness. Animal by-products with inherent properties are more challenging to handle and face stricter regulations of how they should be treated[9]. Furthermore, the meat firm used to sell its rest raw materials to the international market, however; when this market experienced sharp decline and

[9] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009R1069

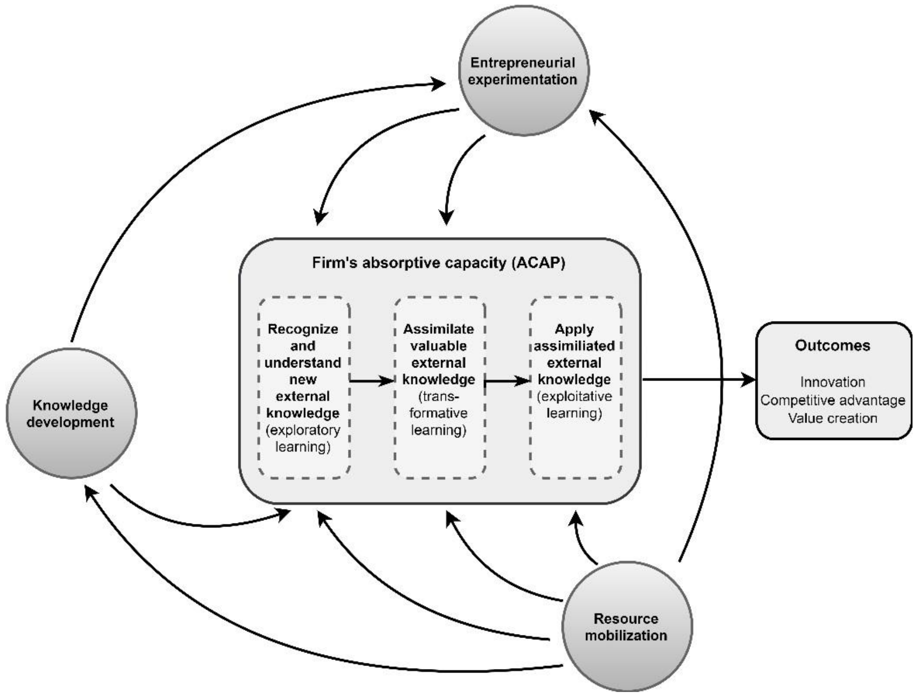
fluctuations (see Strøm-Andersen and Tartiu 2018 for more details), the meat firm must find other solutions. The dairy firm used to sell whey as common whey proteins (whey concentrates), despite the acknowledgement of the potential of whey hydrolysates as higher value-added products. The study showed that the meat firm was more resolute in investing and creating its ACAP than the dairy firm to develop this particular technology. Thus, it created a certain competitive advantage over the dairy firm as a result.

Our understanding of how ACAP exerts its influence on innovation and competitive advantage, and is subsequently transformed in terms of individual action and interaction that is embedded in an organizational context is restricted (Volberda et al. 2010, Watts and Hamilton 2013). The analysis of this paper provided an empirical evidence on this link through the processing of organizational learning, i.e. exploratory, transformative and exploitative, relating to knowledge development, entrepreneurial experimentation and resource mobilisation strategies of the firms. More specifically, the outcome of innovation of the meat firm was product innovation, i.e. protein hydrolysates in various forms. The meat firm expected to launch the products on the market in 2019. The link is presented by continuous arrows in **Fig**. 1. However, the dairy firm was still in an early process of searching and investigating the technology, the direct innovation outcome was not yet visible, which is presented by discontinuous arrows in **Fig**. 1. Thus, the paper sets out the importance of developing absorptive capacity for innovation, value creation and competitive advantage.

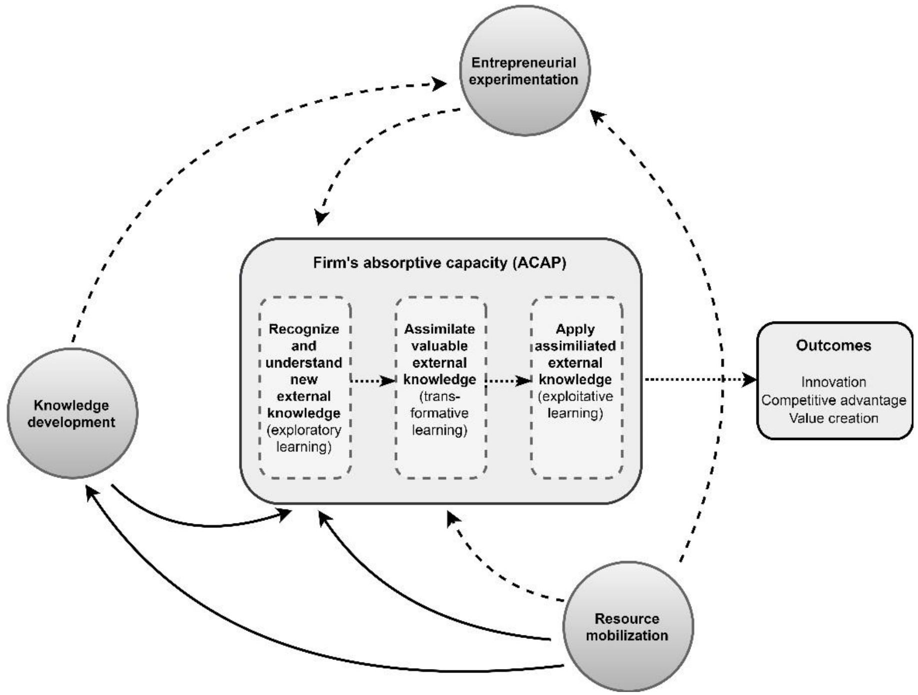
Several researches lay stress on incumbent firms' ability to combine existing, internal knowledge with externally acquired knowledge to create new sources of knowledge or to develop innovations (Bergek et al. 2013, Salvato 2003, Verona and Ravasi 2003, Woiceshyn and Daellenbach 2005). However, given the by-product valorisation was a new business area to the incumbents under study, prior knowledge seems not sufficient. In addition to the novelty of the technical knowledge, the protein ingredient market was absolutely new to them where they could not use the traditional market channels. When a firm wishes to expand into new industry or market in which it already has considerable relevant knowledge, the firm may be able to do so independently (Lane et al. 2006). However, when a firm lacks sufficient relevant prior knowledge and wishes to acquire and use knowledge that is unrelated to its ongoing activity, then the firm must dedicate effort exclusively to creating absorptive capacity (Cohen and Levinthal 1990), which are the case of the firms under study. To meet this challenge, they have to engage in knowledge search and extended experimentation as a basis for building in-house knowledge.

The analysis notes the importance of intra-organizational aspects, i.e. firms' motivation and ability to acquire external knowledge and transform it into innovations by mobilising necessary resources. Roy and Sarkar (2016) posit that technological knowledge is likely to be more beneficial than market knowledge for responding to radical technological changes. However, this study finds that both sources of knowledge are equally important. The study supports the findings of Hansen and Coenen (2017) that learning about new markets for new bioproducts is vital, but not enough to ensure resource mobilisation. To unlock investment capital, firms must secure demand. By establishing a joint venture, the meat firm was assured by suppling protein feed ingredients to its partner.

Intra- and inter-organizational aspects cannot be separated (Volberda et al. 2010). This study shows such a close interlink through the analysis of ACAP in relation to firms' knowledge development, entrepreneurial experimentation and resource mobilisation. The ACAP model is not an inward looking process; rather, it should be connected to external organizations (Patterson and Ambrosini 2015). This argument notes the significance of utilising research collaboration (Goes and Park 1997, Steensma and Corley 2000), especially in the process of knowledge development and entrepreneurial experimentation, where both firms acknowledged. Research collaboration is particularly important in the context of dynamic environments where the expansion and complexity of knowledge increase rapidly, making it more difficult for a single firm to capture and capitalize on all relevant knowledge (Lane et al. 2006).



The case of the meat firm



The case of the dairy firm

Fig 1. The scheme of analysis of the two case studies, author's representation based on Cohen and Levinthal (1990) and Lane et al. (2006). The continuous arrow represents a direct link; the dashed line arrow represents an indirect link.

5.2 The role of public policy

Apart from a common intention to analyse the underlying processes of technology development, a major motivation of technological innovation studies is to inform policymaking (Markard et al. 2015, Markard and Truffer 2008). There are several issues the paper draws attention of policymakers through the actor-oriented analysis of the incumbent firms in the Norwegian food industry.

Despite the environmental and economic potential of organic by-product valorisation, it is a new business area where the incumbents have a little prior knowledge (in comparison to the mainstream production), which results in firms' hesitance to invest. In addition, costly investment in new technologies and machineries as well as challenges in building new knowledge base can be barriers. Most importantly, the lack of funding creates a chasm between research and industrialisation. As noted by one interviewee of the meat firm:

> More funding and access to risk capital will contribute to increase innovation. We need more funding to reduce the gap between science and industry so that science creates new industry, for example, good funding to develop a pilot to industrial scale.

Besides the lack of funding to scale up pilot researches, the meat firm faced a challenge of finding technology vendor who could provide needed equipment and machineries to an industrial scale:

> It is a challenge that in the research project you don't have the one [technology vendor] actually can be able to develop it from the pilot to the industrial scale. […] maybe have to bring more of the industries' innovation networks or something. (Interviewee statement)

Unlike well-established businesses, the infrastructures and networks of the valorisation area has not yet developed. This results in more challenges for firms to develop innovations.

Lastly, since the valorisation was a new field, the firms needed regulative and legislative guidance, especially about animal by-products. To enter a new market, the firms had to prepare numerous documentation to meet the approval:

> The regulation can be immature or not yet developed on new areas when it comes to new bioprocesses and new ingredients. It is difficult to get clarifications and help from Mattilsynet (Norwegian Food Safety Authority). […] We also need someone to advise us when it comes to legislation and approvals when entering new international markets with new products. (Interviewee statement)

Since there are strict regulations concerning animal by-products, the meat firm needs to seek for support in guidance of, e.g. how the by-products can be used in new applications, what is allowed and what is not. However, it takes time to develop legislation, which sometimes slows down the business development process. By responding to the firm' needs, i.e. providing good and timely support and sufficient policies, the authority can help firms cope with such challenges and might push the transition process faster forward.

Further, these issues necessitate an attention of public policies in strengthening some of the system's weaknesses, especially the resource mobilisation. In addition, networks may fail to aid new technology simply because of poor connectivity between actors (Bergek et al. 2008).

6. Conclusions and implications

The promotion of bioeconomy sets out the significance of utilising all bio-based resources(Bugge et al. 2016)(Bugge et al. 2016), which requires an involvement of all actors throughout the economy in order to transform our world for sustainable development (United Nations 2015). In this sense, this study points out to the active engagement of Norwegian food processing firms in valorising their by-product resources. In view of this, the contribution of the paper is twofold:

In regard to the transition studies, the paper contributes to the understudied topic of the role of incumbents in transition processes (Geels 2014), especially firms in a low-tech sector like the food industry. Despite the fact that actors are given the key role in innovation system, empirical findings have made little effort to investigate the influence of strategic decisions of particular actors on system transformations (Markard and Truffer 2008). This paper sheds light on how the incumbent firms (with the same organizational structure) exercised different strategies for the by-product valorisation, and how this helps to move forward the development of this particular technology and its innovation system dynamics. Moreover, the paper highlights some of the system's weaknesses in resources mobilisation and networks that might hamper the technology development.

In respect of the management literature, the study notes the link of two intra-organizational aspects: organizational strategies and organizational learning, and how the relationship affect the outcome of innovation and competitive advantage. Additionally, the paper provides an empirical evidence of the interaction of intra- and inter-organizational aspects (Volberda et al. 2010) in a non R&D context, in which the firms interact with its network to develop the knowledge base through an organizational learning process. Further, the study sheds light on firms' decision processes on investing in absorptive capacity (Cohen and Levinthal 1990) and presents evidence that investment is responsive to the need to develop this capability.

The study draws attention of policymakers to incumbent firms in the transition towards a sustainable bioeconomy on three aspects: (i) support public funding to reduce the gap between R&D and commercialisation, (ii) create a common platform and network to connect actors, and (iii) provide timely new policies, new supportive guidance and regulations. These issues are particularly important especially in the early phase of the transition process, given the fact that the valorisation is a new business area to the firms.

This study zooms in examining actors – two incumbent firms in the Norwegian food industry in respect of the enzymatic hydrolysis of protein. Transition studies might benefit of future researches looking into others structural components of the technology, i.e. networks and institutions to have a better, overall understanding of this particular technological innovation system. Further, more qualitative research studies needed to uncover various underlying processes of technological developments towards sustainable innovations in the context of bioeconomy. Such analyses will provide a means to more informed, deliberate and effective processes of system and regime transformation.

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Reference:

Ansari, S. S., and Krop, P. 2012. "Incumbent performance in the face of a radical innovation: Towards a framework for incumbent challenger dynamics." *Research Policy* 41 (8):1357–1374.

Bergek, A., Berggren, C., Magnusson, T., and Hobday, M. 2013. "Technological discontinuities and the challenge for incumbent firms: Destruction, disruption or creative accumulation?" *Research Policy* 42 (6):1210–1224.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., and Rickne, A. 2008. "Analyzing the functional dynamics of technological innovation systems: A scheme of analysis." *Research Policy* 37 (3):407–429. doi: 10.1016/j.respol.2007.12.003.

Bhagat, R. S., Kedia, B. L., Harveston, P. D., and Triandis, H. C. 2002. "Cultural variations in the cross-border transfer of organizational knowledge: An integrative framework." *Academy of Management Review* 27 (2):204–221.

Bierly, P., and Chakrabarti, A. 1999. "Generic knowledge strategies in the US pharmaceutical industry." In *Knowledge and Strategy*, edited by Zack, M. H., 231–250. Elsevier.

Blomqvist, K., and Levy, J. 2006. "Collaboration capability a focal concept in knowledge creation and collaborative innovation in networks." *International Journal of Management Concepts and Philosophy* 2 (1):31. doi: 10.1504/ijmcp.2006.009645.

Bugge, M. M., Hansen, T., and Klitkou, A. 2016. "What is the bioeconomy? A review of the literature." *Sustainability* 8 (691):1–22.

Camisón, C., and Forés, B. 2010. "Knowledge absorptive capacity: New insights for its conceptualization and measurement." *Journal of Business Research* 63 (7):707–715.

Carlsson, B., and Stankiewicz, R. 1991. "On the nature, function and composition of technological systems." *Journal of Evolutionary Economics* 1 (2):93–118.

Cetindamar, D., and Laage-Hellman, J. 2002. "Micro-level analysis of firms in the biomedical clusters in Ohio and Sweden." In *Technological Systems in the Bio Industries: An International Study*, edited by Carlsson, B., 81–122. Springer.

Chandy, R. K., and Tellis, G. J. 2000. "The incumbent's curse? Incumbency, size, and radical product innovation." *Journal of Marketing* 64 (3):1–17.

Chang, Y.-C., Chang, H.-T., Chi, H.-R., Chen, M.-H., and Deng, L.-L. 2012. "How do established firms improve radical innovation performance? The organizational capabilities view." *Technovation* 32 (7-8):441–451. doi: 10.1016/j.technovation.2012.03.001.

Cohen, W. M., and Levinthal, D. A. 1989. "Innovation and learning: the two faces of R & D." *The Economic Journal* 99 (397):569–596.

Cohen, W. M., and Levinthal, D. A. 1990. "Absorptive capacity: A new perspective on learning and innovation." *Administrative Science Quarterly*:128–152.

De Besi, M., and McCormick, K. 2015. "Towards a bioeconomy in Europe: National, regional and industrial strategies." *Sustainability* 7 (8):10461–10478.

Deaton, J. 2018. "Protease enzymes make a better whey." accessed 03.04.2018. https://www.arlafoodsingredients.com/the-whey-and-protein-blog/manufacturing/protease-enzymes-make-a-better-whey/.

Demirbas, A. 2011. "Waste management, waste resource facilities and waste conversion processes." *Energy Conversion and Management* 52 (2):1280–1287.

Dewald, U., and Achternbosch, M. 2015. "Why did more sustainable cements failed so far? Disruptive innovations and their barriers in a basic industry." *Environmental Innovation and Societal Transitions*. doi: 10.1016/j.eist.2015.10.001.

Dewald, U., and Truffer, B. 2011. "Market formation in technological innovation systems—diffusion of photovoltaic applications in Germany." *Industry and Innovation* 18 (03):285–300.

Dosi, G. 1988. "The nature of the innovative process." In *Technical Change and Economic Theory*, edited by Dosi, G., et al., 221–238. London: Pinter.

Easterby-Smith, M., Graca, M., Antonacopoulou, E., and Ferdinand, J. 2008. "Absorptive capacity: A process perspective." *Management Learning* 39 (5):483–501.

Edmondson, A. C., and McManus, S. E. 2007. "Methodological fit in management field research." *Academy of Management Review* 32 (4):1246–1264.

Ehrnberg, E., and Jacobsson, S. 1997. "Technological discontinuities and incumbents' performance: an analytical framework." In *Systems of Innovation: Technologies, Institutions, and Organizations*, edited by Edquist, C., 318–341.

European Commission. 2014. "Towards a Circular Economy: A Zero Waste Programme for Europe." accessed 14.02.2017. http://eur-lex.europa.eu/resource.html?uri=cellar:50edd1fd-01ec-11e4-831f-01aa75ed71a1.0001.01/DOC_1&format=PDF.

Farla, J., Markard, J., Raven, R., and Coenen, L. 2012. "Sustainability transitions in the making: A closer look at actors, strategies and resources." *Technological Forecasting and Social Change* 79 (6):991–998.

Galanakis, C. M. 2012. "Recovery of high added-value components from food wastes: Conventional, emerging technologies and commercialized applications." *Trends in Food Science & Technology* 26 (2):68–87.

Galanakis, C. M. 2015. *Food Waste Recovery: Processing Technologies and Industrial Techniques*: Academic Press.

Garud, R., and Nayyar, P. R. 1994. "Transformative capacity: Continual structuring by intertemporal technology transfer." *Strategic Management Journal* 15 (5):365–385.

Geels, F. W. 2014. "Reconceptualising the co-evolution of firms-in-industries and their environments: Developing an inter-disciplinary Triple Embeddedness Framework." *Research Policy* 43 (2):261–277. doi: 10.1016/j.respol.2013.10.006.

George, A. L., and Bennett, A. 2005. *Case Studies and Theory Development in the Social Sciences*: Mit Press.

Goes, J. B., and Park, S. H. 1997. "Interorganizational links and innovation: The case of hospital services." *Academy of Management Journal* 40 (3):673–696.

Grant, R. M. 1996. "Toward a knowledge-based theory of the firm." *Strategic Management Journal* 17 (S2):109–122.

Grin, J. 2010. "Understanding transitions from a governance perspective." In *Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change*, edited by Grin, J., et al., 221–319. New York: Routledge.

Hansen, T., and Coenen, L. 2017. "Unpacking resource mobilisation by incumbents for biorefineries: the role of micro-level factors for technological innovation system weaknesses." *Technology Analysis & Strategic Management* 29 (5):500–513.

Heitner, D. 2016. "North American Sports Market At $75.7 Billion By 2020, Led By Media Rights." Forbes, accessed 11.04.2018. https://www.forbes.com/sites/darrenheitner/2016/10/10/north-american-sports-market-to-reach-75-7-billion-by-2020/#3100fddf217b.

Hekkert, M. P., Suurs, R. A., Negro, S. O., Kuhlmann, S., and Smits, R. E. 2007. "Functions of innovation systems: A new approach for analysing technological change." *Technological Forecasting and Social Change* 74 (4):413–432.

Henchion, M., McCarthy, M., and O'Callaghan, J. 2016. "Transforming Beef By-products into Valuable Ingredients: Which Spell/Recipe to Use?" *Frontiers in Nutritrion* 3 (53):1–8. doi: 10.3389/fnut.2016.00053.

Hill, C. W., and Rothaermel, F. T. 2003. "The performance of incumbent firms in the face of radical technological innovation." *Academy of Management Review* 28 (2):257–274.

Jiménez-Barrionuevo, M. M., García-Morales, V. J., and Molina, L. M. 2011. "Validation of an instrument to measure absorptive capacity." *Technovation* 31 (5-6):190–202.

Kern, F. 2015. "Engaging with the politics, agency and structures in the technological innovation systems approach." *Environmental Innovation and Societal Transitions* 16:67–69.

Kogut, B., and Zander, U. 1992. "Knowledge of the firm, combinative capabilities, and the replication of technology." *Organization Science* 3 (3):383–397.

Krasnoshtanova, A. 2010. "Obtaining enzymatic protein and lipid hydrolysates from byproducts of the meat processing industry." *Catalysis in Industry* 2 (2):173–179.

Lam, A. 1997. "Embedded firms, embedded knowledge: Problems of collaboration and knowledge transfer in global cooperative ventures." *Organization Studies* 18 (6):973–996.

Lane, P. J., Koka, B. R., and Pathak, S. 2006. "The reification of absorptive capacity: A critical review and rejuvenation of the construct." *Academy of Management Review* 31 (4):833–863.

Lane, P. J., and Lubatkin, M. 1998. "Relative absorptive capacity and interorganizational learning." *Strategic Management Journal* 19 (5):461–477.

Lazonick, W., and Prencipe, A. 2005. "Dynamic capabilities and sustained innovation: strategic control and financial commitment at Rolls-Royce plc." *Industrial and Corporate Change* 14 (3):501–542.

Leonard-Barton, D. 1995. *Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation*. Boston, MA: Harvard Business School Press.

Levitt, B., and March, J. G. 1988. "Organizational learning." *Annual Review of Sociology* 14 (1):319–338.

Liaset, B., and Espe, M. 2008. "Nutritional composition of soluble and insoluble fractions obtained by enzymatic hydrolysis of fish-raw materials." *Process Biochemistry* 43 (1):42–48.

Liaset, B., Lied, E., and Espe, M. 2000. "Enzymatic hydrolysis of by-products from the fish-filleting industry; chemical characterisation and nutritional evaluation." *Journal of the Science of Food and Agriculture* 80 (5):581–589.

Lin, C. S. K., Pfaltzgraff, L. A., Herrero-Davila, L., Mubofu, E. B., Abderrahim, S., Clark, J. H., . . . Dickson, F. 2013. "Food waste as a valuable resource for the production of chemicals, materials and fuels. Current situation and global perspective." *Energy & Environmental Science* 6 (2):426–464.

Lundvall, B.-ä., and Johnson, B. 1994. "The learning economy." *Journal of Industry Studies* 1 (2):23–42.

Lynch, S. A., Mullen, A. M., O'Neill, E. E., and García, C. Á. 2017. "Harnessing the Potential of Blood Proteins as Functional Ingredients: A Review of the State of the Art in Blood Processing." *Comprehensive Reviews in Food Science and Food Safety* 16 (2):330–344. doi: 10.1111/1541-4337.12254.

Markard, J., Hekkert, M., and Jacobsson, S. 2015. "The technological innovation systems framework: Response to six criticisms." *Environmental Innovation and Societal Transitions* 16:76–86. doi: 10.1016/j.eist.2015.07.006.

Markard, J., Raven, R., and Truffer, B. 2012. "Sustainability transitions: An emerging field of research and its prospects." *Research Policy* 41 (6):955–967.

Markard, J., and Truffer, B. 2008. "Actor-oriented analysis of innovation systems: exploring micro–meso level linkages in the case of stationary fuel cells." *Technology Analysis & Strategic Management* 20 (4):443–464.

Meeus, M. T., Oerlemans, L. A., and Hage, J. 2001. "Patterns of interactive learning in a high-tech region." *Organization Studies* 22 (1):145–172.

Miller, D. J., Fern, M. J., and Cardinal, L. B. 2007. "The use of knowledge for technological innovation within diversified firms." *Academy of Management Journal* 50 (2):307–325.

Mirabella, N., Castellani, V., and Sala, S. 2014. "Current options for the valorization of food manufacturing waste: a review." *Journal of Cleaner Production* 65:28–41.

Morais, H. A., Silvestre, M. P. C., Silva, M. R., Silva, V. D. M., Batista, M. A., Simões e Silva, A. C., and Silveira, J. N. 2013. "Enzymatic hydrolysis of whey protein concentrate: effect of enzyme type and enzyme:substrate ratio on peptide profile." *Journal of Food Science and Technology* 52 (1):201–210. doi: 10.1007/s13197-013-1005-z.

Mowery, D. C., Oxley, J. E., and Silverman, B. S. 1996. "Strategic alliances and interfirm knowledge transfer." *Strategic Management Journal* 17 (2):77–91.

Mullen, A. M., Alvarez, C., Zeugolis, D. I., Henchion, M., O'Neill, E., and Drummond, L. 2017. "Alternative uses for co-products: Harnessing the potential of valuable compounds from meat processing chains." *Meat Science* 132:90–98. doi: 10.1016/j.meatsci.2017.04.243.

Murovec, N., and Prodan, I. 2009. "Absorptive capacity, its determinants, and influence on innovation output: Cross-cultural validation of the structural model." *Technovation* 29 (12):859–872.

Musiolik, J., and Markard, J. 2011. "Creating and shaping innovation systems: Formal networks in the innovation system for stationary fuel cells in Germany." *Energy Policy* 39 (4):1909–1922.

Musiolik, J., Markard, J., and Hekkert, M. 2012. "Networks and network resources in technological innovation systems: Towards a conceptual framework for system building." *Technological Forecasting and Social Change* 79 (6):1032–1048.

Nonaka, I. 1994. "A dynamic theory of organizational knowledge creation." *Organization Science* 5 (1):14–37.

Patterson, W., and Ambrosini, V. 2015. "Configuring absorptive capacity as a key process for research intensive firms." *Technovation* 36–37:77-89. doi: 10.1016/j.technovation.2014.10.003.

Pisano, G. P. 1994. "Knowledge, integration, and the locus of learning: An empirical analysis of process development." *Strategic Management Journal* 15 (S1):85–100.

Powell, W. W., Koput, K. W., and Smith-Doerr, L. 1996. "Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology." *Administrative Science Quarterly* 41 (1):116–145.

Prazeres, A. R., Carvalho, F., and Rivas, J. 2012. "Cheese whey management: A review." *Journal of Environmental Management* 110:48–68. doi: https://doi.org/10.1016/j.jenvman.2012.05.018.

Prestegard, S. S., Pettersen, I., Nebell, I., Svennerud, M., and Brattenborg, N. 2017. "Mat og industri 2017: Status og utvikling i norsk matindustri." Norsk institutt for bioøkonomi, NIBIO, accessed 18.03.2018. http://matogindustri.no/matogindustri/dokument/Mat_og_industri_2017_plansjer_for_nedlasting.pdf.

Prestegard, S. S., and Sørbye, S. E. 2016. "Mat og industri 2016: Status og utvikling i norsk matindustri." Norsk institutt for bioøkonomi, NIBIO, accessed 19.02.2017. http://matogindustri.no/matogindustri/dokument/Mat_og_industri_2016.pdf.

Reardon, T., Lu, L., and Zilberman, D. 2017. "Links among innovation, food system transformation, and technology adoption, with implications for food policy: Overview of a special issue." *Food Policy*. doi: 10.1016/j.foodpol.2017.10.003.

Reed, R., and DeFillippi, R. J. 1990. "Causal ambiguity, barriers to imitation, and sustainable competitive advantage." *Academy of Management Review* 15 (1):88–102.

Roy, R., and Sarkar, M. B. 2016. "Knowledge, firm boundaries, and innovation: Mitigating the incumbent's curse during radical technological change." *Strategic Management Journal* 37 (5):835–854. doi: 10.1002/smj.2357.

Safarzyńska, K., Frenken, K., and van den Bergh, J. C. 2012. "Evolutionary theorizing and modeling of sustainability transitions." *Research Policy* 41 (6):1011–1024.

Salvato, C. 2003. "The Role of Micro-Strategies in the Engineering of Firm Evolution." *Journal of Management Studies* 40 (1):83–108.

Saviotti, P. P. 1998. "On the dynamics of appropriability, of tacit and of codified knowledge." *Research Policy* 26 (7-8):843–856.

Simonin, B. L. 1999. "Ambiguity and the process of knowledge transfer in strategic alliances." *Strategic Management Journal* 20 (7):595–623.

Smith, A., Stirling, A., and Berkhout, F. 2005. "The governance of sustainable socio-technical transitions." *Research Policy* 34 (10):1491–1510.

Spender, J. C., and Grant, R. M. 1996. "Knowledge and the firm: overview." *Strategic Management Journal* 17 (S2):5–9.

Spotti, M. J., Tarhan, Ö., Schaffter, S., Corvalan, C., and Campanella, O. H. 2017. "Whey protein gelation induced by enzymatic hydrolysis and heat treatment: Comparison of creep and recovery behavior." *Food Hydrocolloids* 63:696–704. doi: 10.1016/j.foodhyd.2016.10.014.

Steensma, H. K., and Corley, K. G. 2000. "On the performance of technology-sourcing partnerships: The interaction between partner interdependence and technology attributes." *Academy of Management Journal* 43 (6):1045–1067.

Strøm-Andersen, N., and Tartiu, V. E. 2018. "Incumbents in the transition towards bioeconomy: the role of dynamic capabilities and innovative strategies." *Under Review*.

Szulanski, G. 1996. "Exploring internal stickiness: Impediments to the transfer of best practice within the firm." *Strategic Management Journal* 17 (S2):27–43.

Tavano, O. L. 2013. "Protein hydrolysis using proteases: An important tool for food biotechnology." *Journal of Molecular Catalysis B: Enzymatic* 90:1–11. doi: 10.1016/j.molcatb.2013.01.011.

Teece, D. J., Pisano, G., and Shuen, A. 1997. "Dynamic capabilities and strategic management." *Strategic Management Journal* 18 (7):509–533.

Todorova, G., and Durisin, B. 2007. "Absorptive capacity: Valuing a reconceptualization." *Academy of Management Review* 32 (3):774–786.

Toldra, F., Mora, L., and Reig, M. 2016. "New insights into meat by-product utilization." *Meat Science* 120:54–59. doi: 10.1016/j.meatsci.2016.04.021.

Tsai, W. 2001. "Knowledge transfer in intraorganizational networks: Effects of network position and absorptive capacity on business unit innovation and performance." *Academy of Management Journal* 44 (5):996–1004.

United Nations. 2015. "Transforming our world: the 2030 Agenda for Sustainable Development." accessed 19.08.2017. http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.

van den Bosch, F. A., Van Wijk, R., and Volberda, H. W. 2003. "Absorptive capacity: antecedents, models and outcomes." In *Handbook of Organizational Learning and Knowledge Management*, edited by Easterby-Smith, M. and Lyles , M. A.: Wiley.

van den Bosch, F. A., Volberda, H. W., and De Boer, M. 1999. "Coevolution of firm absorptive capacity and knowledge environment: Organizational forms and combinative capabilities." *Organization Science* 10 (5):551–568.

Verona, G., and Ravasi, D. 2003. "Unbundling dynamic capabilities: an exploratory study of continuous product innovation." *Industrial and Corporate Change* 12 (3):577–606.

Volberda, H. W., Foss, N. J., and Lyles, M. A. 2010. "Perspective—Absorbing the concept of absorptive capacity: How to realize its potential in the organization field." *Organization Science* 21 (4):931–951.

Watts, A. D., and Hamilton, R. D. 2013. "Scientific foundation, patents, and new product introductions of biotechnology and pharmaceutical firms." *R&D Management* 43 (5):433–446.

Woiceshyn, J., and Daellenbach, U. 2005. "Integrative capability and technology adoption: evidence from oil firms." *Industrial and Corporate Change* 14 (2):307–342.

Yin, R. K. 2014. *Case Study Research: Design and Methods*. 5th ed. CA: SAGE.

Zahra, S. A., and George, G. 2002. "Absorptive capacity: A review, reconceptualization, and extension." *Academy of Management Review* 27 (2):185–203.