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Document Version
Final published version

Published in:
Proceedings of the 56th Hawaii International Conference on System Sciences

DOI:
10125/103182

Publication date:
2023

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Citation for published version (APA):
Schröder, A., Andersson, F., & Heiberg, K. (2023). M_LK 2.0: Leveraging Digital Technologies for Planternative Ecosystems. In T. X. Bui (Ed.), *Proceedings of the 56th Hawaii International Conference on System Sciences* (pp. 4525-4534). Hawaii International Conference on System Sciences (HICSS). https://doi.org/10125/103182

M_LK 2.0: Leveraging Digital Technologies for Planternative Ecosystems

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Abstract

The agri-food industry is one of the largest contributors to our climate crisis by emitting one third of the world's greenhouse gases. However, the industry also brings great potential to reverse climate change. For example, a plant-based diet might be the single most efficient action to combat climate change. This paper explores the plant-based dairy industry and the utilization of digital technologies. We analyze how the plant-based industry is leveraging digital technologies to revolutionize traditional market configurations. The findings show that digital technologies enable systemic change and facilitate the emergence of digital ecosystems. In particular, Artificial Intelligence (AI) technology can be seen as a digital disruptor. For example, in the plant based dairy industry, AI calculates combinations for plant-based products that mimic the flavor and texture of animal products.

Keywords: plant-based food industry, green transformation, digital technologies, digital ecosystems

1. Introduction

"One coffee with milk, please"
"Oat, almond, soy or cow milk?"
There has been a rise in plant-based alternatives for animal products. In one respect, consumers demand alternatives and plant-based milk options are a must in every coffee shop (at least in the USA and Northern Europe). The other reason for the rise of Planternatives is the need for more environmentally friendly products.

Actually, 82 % of the carbon footprint in the EU comes from animal-based products such as meat or dairy (European Court of Auditors, 2021). Switching to a plant-based diet might be the single most efficient action to combat climate change (Willett et al., 2019). Thus, there has been an increase in funding from governments and private institutions to foster the green transformation of the food industry. In particular 'Planternatives' are on the rise -– market leaders including Oatly, Naturli, Beyond Meat and Impossible Foods are adding to the momentum, as new and traditional companies push for innovation and customer acceptance. 'Planternatives' are plant-based alternatives for animal-based products such as milk, meat, eggs and fish. In 2020 alone, the Planternatives industry received 2 billion dollars in funding and their market is expected to grow rapidly from 29.4 billion dollars to 162 billion dollars within one decade (Statista, n.d.). Even though there was previous resistance within the traditional dairy industry as one dairy expert revealed: *"So ten years ago, I was in a meeting with [an industry consortium] and we had a joint meeting with all the big dairy companies, all of them said: 'plant-based [companies], they are our enemies. We need to fight them like hell. We're going to war, we're going to lobby against them'. By now,* big companies like Arla, are investing heavily in Planternatives. For example, the meat giant Danish Crown, that refused to have plant-based meat on its agenda five years ago, is now ramping up production of plant-based meat, as part of its goal to halve their carbon emissions by 2030 (Berlingske, 2021). "*Ten years later, everybody has plant-based products in their portfolio today. They are moving in different speeds, of course, but they all have a dairy product or non-dairy product in their portfolio."* There has also been an increased research interest and multiple funds investigating Planternatives and the green transition of the food industry.

With the increased focus on these Planternatives we saw a need to study the plant-based industry as they face a series of challenges compared to the traditional industry. The plant-based dairy supply chain is more complex and knowledge intense than the traditional dairy chain. The plant-based industry faces the challenge of mimicking the animal protein for taste, texture, looks and nutritional value. Consequently, a lot of innovation capabilities are needed, and digital

URI: https://hdl.handle.net/10125/103182
978-0-9981331-6-4

technologies are heavily utilized. Thus, our research question is as follows:

How do digital technologies impact the market configuration of the plant-based dairy industry?

In this paper, we investigate the role and importance of digital technologies within the plant-based dairy supply chain. We focus on how value is created as a result of stakeholder interactions.

In the following, we first describe the empirical background of the dairy and plant-based dairy supply chain. Second, we give theoretical background on supply chain vs. (digital) ecosystem theory. Third, we describe in detail the methods of our explorative study. Fourth, we present our findings about the impact that digital technology has on the plant-based industry and the potential of new market configurations. Fifth, we discuss whether digital technology can facilitate an innovation that changes the market dynamics so that ecosystems might emerge. Lastly, we state the implications for the industry and end with a conclusion.

2. Empirical Background

The traditional dairy supply chain has a legacy of basic activities, actors, positions and links. A dairy farmer produces milk and sells the milk to the dairy producer. The dairy producer then processes the milk and manufactures an end-consumer product. Through a distributor, e.g., supermarkets, a dairy product is available to end-consumers. These are linear relationships, and a new dairy product will be produced in similar manner and follows the traditional stream. Multiple actors are included in the stream, but the relationship between them can be treated in isolation from the rest. Besides the line of production, there are actors around the value chain like educational institutions and technology firms. Educational institutions would provide knowledge to the system. Technology firms support manufacturers by tracking their production efficiency and product quality.

In the plant-based dairy supply chain, a farmer grows crops (e.g., oat, almond, peas) that are sold to an ingredient manufacturer. The ingredient manufacturer processes the crop into syrup or isolate and sells it to the food manufacturer that produces an end-consumer product like non-dairy milk. The first steps of the plant-based dairy value chain are quite similar to the traditional grain value chain but differs quite significantly in later steps. As soon as the crop reaches the manufacturer additional knowledge and expertise is required. The additional complexity in mimicking e.g., the texture, taste and flavor of milk cannot be solved by a sole traditional manufacturing firm. To convince end-customers of the product, the right product features are required. These features take knowledge and skill to develop. Thus, the complexity, in the plant-based dairy supply chain increases due to extra steps in the production, complexity of value creation like mimicking animal protein. As a result, traditional dyadic supplier-buyer relationships need to be extended to a system structure that integrates multiple actors in the process. The relationships are needed to combine resources and knowledge that meet the demands and requirements of producing a plant-based alternative.

Subsequently, we analyze the market configuration of the plant-based dairy chain further in section 5.

3. Theoretical Background

In this section, we give an overview of the supply chain and ecosystem logics and explain the concept ecosystem-as-a-structure.

3.1. Supply Chains vs. Ecosystems

The food supply chain is a rather complex network of heterogeneous entities upstream and a market power consolidation downstream from the middle of the chain (Gereffi & Fernandez-Stark, 2011). Food supply chains are mainly captive supply chains with explicit coordination by focal actors (OEMs and retail) (Gereffi et al., 2005). Supply chain management research typically investigates dyadic relationships from the viewpoint of a focal actor (Prockl et al., 2017). This contrasts with the claimed holistic view of SCM that would, by definition (e.g., Mentzer et al., 2001) require at least three or more units involved. In the real world, supply chains are more complex than dyadic buyer-seller relationships and often resemble multidirectional networks (Harland, 1996), devolved, collaborative supply chain clusters (Johnsen & Stevens, 2016) or ecosystems (Prockl et al., 2017). A supply chain network set up acknowledges that in a non-linear network suppliers and customers have the network visibility to uncover potential risk, establish relationships with second and third tier relationship and manage indirect relationships of the network (Choi and Hong, 2002; Choi and Wu, 2009). Within the devolved, collaborative supply chain cluster set up contains a series of self-governing clusters. A supplier network by type, product structure or flow is comprised in a cluster. A firm's focus is to retain the core in-house and outsource non-core activities across a range of clusters. The firm forms collaborative partnerships with each cluster based on a goal consensus (Sheffi, 2012; Johnsen & Stevens, 2016).

Unlike in supply relationships, in ecosystems firms retain their autonomy in choosing what to produce, how, and at which price level, as a function of the choice of a

final user. Ecosystems don't fit into the classical firm-supplier relationship instead they encourage alignment through informal rules of engagement, standards, and codified interfaces which differs from other market-based relations like formal contracts etc. (Adner, 2017; Jacobides et al. 2018). Ecosystems are new structures of economic relationships that help coordinate interrelated organizations despite their individual autonomy. They offer a distinctive way of organizing economic activity compared to market-based and hierarchy-based value systems (Jacobides et al., 2018). Coupled with digitization, they offer the potential to transform entire sectors (Constantiou et al., 2017). Often the objective is to coalesce with other firms promoting a new core technology and new value proposition in securing more final users and customers for the whole group. Firms focus on how to maximize joint benefits by being part of a group of firms with complementary roles, competing as a collective against alternative value system configurations (Cennamo, 2021).

However, how value is created as a result of stakeholder interactions remains unclear and specific practices to create value remain underspecified (Suseno et al., 2018, Lepak et al., 2007; Tantalo and Priem, 2016) Even though, actors are in need of each other to realize their value propostions (Shipilov & Gawer, 2020). Thus, value creation and capture are from importance within ecosystem literature, however value creation and value capture have not gotten an equal amount of much research attention. According to Teece (2017), both mechanisms are equally important.

Within literature, ecosystems can be categorized in business ecosystems (e.g., Teece, 2007), innovation, ecosystems (e.g., Adner 2017), knowledge ecosystems (e.g. Järvi et al., 2108) and platform ecosystems (e.g. Jacobides et al., 2018).

Studies about business ecosystems mostly focus on the ties and linkages from and to a focal firm and how those influence the ecosystem activities (e.g., Teece 2007). The literature examines how ecosystem actors capture value – often called business model innovation (e.g. Kapoor & Argwal,2009; Tellier, 2017)

Innovation ecosystems studies focus on innovation creation and how different players can complement each other's offerings. In that literature, collaboration plays a key role in terms of interdependencies or multi-actor collaborations (e.g., Adner & Kapoor, 2010, Dedehayir, Mäkinen & Ortt, 2018). This literature centers around value the realization of shared value proposition (Jacobides et al. 2018)

Knowledge ecosystems focus on mechanisms for knowledge exchange and creation, boundary spanning and business models (Järvi et al., 2108; Jacobides et al., 2018).

Digital platform ecosystems are new digital business and innovation models creating value and making profit as a value network and affect the nature and scope of traditional interdependencies (Subramaniam et al. 2019; Jacobides et al., 2018) The literature examines how value is created and captured through the exchange of services or information in a multi-sided market (transaction platforms) and by opening up to third-party platform complementors (innovation platforms) (Cusumano et al., 2019).

3.2. Ecosystem-as-a-Structure

Adner (2017) defines ecosystems as "*the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize".* The formation of multilateral links on the input-, activity- or output side are not attributed to the sum of reciprocal associations between the participating actors. In Adner's view ecosystem as more than the relationships between two actors, but rather the combination of multiple actors in different ways. According to Adner (2017), there exists two types of ecosystems views, (1) ecosystems-as-affiliation, which sees ecosystems as communities of associated actors defined by their networks and platform affiliations, and (2) ecosystems-as-structure, which views ecosystems as configurations of activity defined by a value proposition (Adner, 2017). The two ecosystem-structures have different starting points, the ecosystem-as-affiliation is focused on actors. Whereas the ecosystem-as-structure is focused on activities, the perspectives in the ecosystem structures differ in their understanding of the elements.

Adner (2017) focuses on the importance of a **joint value proposition** for the ecosystem to exist: *"a value proposition is defined by the benefit that the end consumer is supposed to receive from your efforts"* (Adner, 2017).

Activities are defined as something which specify the discrete actions to be undertaken for the value proposition to materialize. Despite these activities having value, not all of them contribute to the goal of delivering on the value proposition. For these activities to be undertaken, a series of actors need to be included. **Actors** are the entities that undertake the activities. **Positions** are specified based on where actors are located in the ecosystem based and who they interact with. The positions follow a critical path based on the activity flow in the supply chain The **links** between the actors specify the transfer of e.g., material, influence, and funds across actors.

4. Methodology

We chose the food industry and in particular the plant-based dairy industry as 'revelatory case' (Eisenhardt and Graebner, 2007). The dairy industry is a major contributor to GHG emissions due to the methane of cows, amongst others. However, food cannot be as easily substituted as, for example, switching from a car to a bike. One of our interviewees sums up the challenge in the following statement: "*this is an industry which needs to change. And it's the most important industry because it touches human beings' multiple times a day. So that's why I think today there is a big pressure for a shift driven by ESGs [Environmental Social and Governance criteria], by customers demand and it's something that the industry cannot be replaced."* (Interviewee 1). Additionally, the dairy industry has multiple stakeholders with different interests and recently displays complex interdependencies with digital technologies. All these show an indication that the dairy industry is an ideal "strategic research site" (Merton, 1987) for the purpose of our study.

For the case, we consulted over 67 archival data sources to gather information about value chain architectures. This information includes industry reports, white papers, internal strategic documents, YouTube videos, podcasts, websites, newspaper articles and data repositories like Statista, UNcom, GoodFoodInstitute, Protein Directory. We conducted 15 interviews with stakeholders and experts, software companies and an analytics provider of the dairy and plant-based dairy industry. The semi-structured interview guide contained questions within five distinct categories: Supply Chain Relationship, Collaboration, Innovation, Data, Sustainability. The semi-structured interviews (ranging between 30-60 minutes with a total of 14,5 hours recorded) were conducted from March to May 2022 (see Table 1. Interview Table). Additionally, we did 15 hours of observations and informal interviews. All data was recorded and transcribed.

ID	Type of Organization	Role of Interviewee
1	multinational food processing & commodities trading	Tech & Operation Executive
2	Hardware Company	Director of Engineering
3	Global Food Futurist	Advisor/Consultant
4	Dairy R&D advisory	Dairy Expert
5	Analytics Company	Head of Analytical Models
6	Analytics Company	Senior Scientist Plant-based foods
7	Analytics Company	Global Market Manager Meat
8	Analytics Company	Market Business Development Manager
9	Plant-based Start up	CEO
10	Plant-based Start up	CEO
12	Software Company	Sustainability & Development Manager
13	Software company	Head of Machine Learning & Engineering
14	Plant-based Start up	CEO
15	Ingredient Manufacturer	Tech & R&D Executive

Table 1. Interviewee Table.

The analysis was done with the software program Atlas.ti 22 designed to aid in analyzing qualitative data. Due to the exploratory nature of our research question, the initial round of coding, we analyzed the raw interview data by staying close to the words and phrases of the interviewees. The first analysis of the interviews resulted in 292 descriptive codes. Based on the descriptive codes, 25 theme codes ranging from very general themes such as challenges, collaboration to more concrete themes such as data and knowledge sharing (see Table 2. Coding Example). In order to understand the market configuration of the plant-based dairy chain and the effect that digital technology has on the system, we chose to re-analyze the data through the lens of the ecosystem-as-a-structure theory (Adner, 2017). Through this analysis, ecosystem dynamics. This was done in three iterations, before reaching the final version of the data coding and thus, adding the aggregate dimensions. To cross-check the findings, we used member checking for the respondent validation (Birt et al. 2016).

Descriptive Codes	Themes	Dimen-sion
if the customer allows data use, then they use them to generally to develop a more global calibration.	Data sharing	Eco-system Inter-actions
It has to be in the context of an end goal in mind, of trying to share this data and building something on top of that		
APIs enable interoperability when sharing data with partners		
If you don't share the information, there is no way you can collaborate		
That sharing it is a competitive advantage, but it can also be if you look at it in a collaborative mentality	Know-ledge sharing	

Business or cooperation agreements can enable data sharing		
We are in contact with educational entities, such as universities, where they have ongoing projects		
The plant-based [industry] is a very collaborative industry	Collab-oration	
You see a lot more cooperation amongst developing in the plant-based space		
So, if we help them and they help us, we try always to find this win win situation		
Two of our clients, without knowing, are actually connected.		
Data is important when looking on product information for various types of decision-making	Data resource	Enab-ler Data/ Tech
Data is needed in order to develop calibration packages based on mathematical model, so we can analyse.	Data utili-zation	
And then utilizing that data and converting that data into knowledge		
We used consumer data to create new products based on demand		

Table 2. Data Coding Example.

5. Findings

In the following, we display the impact that digital technologies create within the existing supply chain and the potential consequences on the market configuration. The findings are based on our interviews, observations and archival data and aim to understand potential changes of the plant-based industry value chain architecture. Thus, we identified the value proposition and the value delivering activities of the plant based dairy system. Next, we identified the actors and their position in the system. Lastly, we state their relationships within the plant-based industry.

5.1. Challenges and Impact of Digital Technology

The plant-based dairy industry faces a series of challenges that the traditional dairy industry does not encounter. The biggest challenge is to properly mimic animal protein. In the process, emulsifiers or other additives are frequently added, which is disliked by consumers. Also, the nutritional value of plant-based dairy is in most cases inferior to dairy products. Additionally, some dairy products still face problems with texture and taste, like non-dairy cheese.

Unlike with animal-protein, producers are challenged with variation in their product: *„In traditional spaces they never had this variation coming in because a cow was a cow and they knew exactly what the variation was“,* (Scientist, Analytics Firm, ID6). For example, producers trying to mimic the foamability of milk. However, that a batch is foaming is still a gamble: "*sometimes as a barista, the plant-based milk doesn't foam. Yeah. We don't know why we expect it to be like the raw materials coming in with a wrong profile or something.”* The producers are unsure whether the problem lies within raw material or the production process. Thus, they turn to analytics companies for help which are trying to understand what parameters are responsible for that and how they could help the producers *“we have already parameters measured at each point and then just connecting the dots and mapping the influence of variance […] that need be an easy win on getting the basics.”* (Scientist, Analytics Firm, ID6).

We discovered that the use of digital technologies is heavily utilized in the plant-based space. One expert mention that the accelerators in the industry are sensors, AI and quantum computing: *“it is going to make enormous differences in our ability to manage data"* (Planternatives Expert, ID3). In particular, AI might be "*the future of food*" as AI could be used to formulate plant-based products to better mimic the animal-based products.

One of the interviewed software companies is already utilizing machine learning technology that predicts the best compositions of plant-based ingredients to match recipes from animal-based products. By analyzing the structure at the molecular level of animal-based products, it can be replicated by only using plant-based ingredients. By doing so, the company can sell recipes to their customers. The AI program is based on huge datasets from public data like the US Department of Agriculture's (USDA) National Agricultural Library, and vast amount of private data of formulation. The companies' smart use of data has disruptive potential as another industry expert stated that their use of AI to develop products was one of the most significant changes he has seen in the industry. The firm's head of machine learning confirms that the resistance of traditional dairy stakeholders is still prominent: "*With a big change or any disruption in a marketplace, there's always going to be resistance from the established players there and as the company that's doing the disruption - we kind of wear as a badge of honor. We're making an impact and we're able to do that where the dairy industry is going to respond negatively. I mean, we're doing something right. It's almost like a positive signal, if you will.”* The resistance of the traditional players is seen as a positive signal and some big players

are also leaning in and see this development as an opportunity. The Head of machine learning continues: *"we just announced we're doing a joint venture with Kraft Heinz. Kraft Heinz has a whole portfolio of animal-based products, and we have this engine that can help create out a plant-based portfolio and get it out into the market. So, some companies and some industries might resist the movement, but then there's other companies like Kraft Heinz, who say, oh, this is a step in the right direction"*. Not only is it an opportunity for established players to join this partnership, also with this joint venture, the digital company will increase their global market outreach and their environmental impact: "*for [company name] it's a huge win as well, because once again, our mission is to change the way that people eat food, the kinds of foods that they eat, that is produced in a more sustainable manner. So if you have a huge company like Heinz with global distribution – we [are] kind of getting behind that mission. It's a really positive signal and saying hey, there is something systemic here that needed addressing and big companies are aligning with that mission."* Together, they are hoping to systemically change the industry step by step to a more sustainable future.

5.2. Value proposition and Activities

The plant-based dairy industry builds on a *joint value proposition*. This value proposition is defined by the promised benefit to the discovered two end-customer segments, (1) Vegans and Vegetarians, and (2) Flexitarians, and follows as: *To deliver good quality green alternatives fitting for different situations*. The industry will create value for its customers when it delivers environmentally friendly quality products that have good taste, texture and nutritional value to its end-consumers.

We identified that the plant-based industry revolves around a series of *activities* that provide value for the supply chain actors, and to deliver on the value proposition. These activities ranged from firm specific activities, to innovation, to product-specific activities.

Some activities were found to be of greater importance for the industry. For instance, product-specific activities of quality control have been identified in all actors as fundamental to follow regulations regarding e.g., food safety.

The core business activities resemble in many ways the traditional dairy supply chain with the aim of making and distributing products, however the innovation activities within the plant-based industry had a more prominent focus. Innovation such as mimicking animal-based products is a new process. These new activities include a greater focus on ingredients manufacturing and food manufacturing. Innovation was found to affect the market dynamics. Innovation as an activity is a collective concept of new initiatives made for the industry to meet the value proposition. Here, the activity of innovation can be divided into two main parts: Agricultural and digital innovation. Agricultural innovation includes technology advances and new ways of facilitating production with the use of hardware technology, e.g., vertical farming, algae farming, and new ways of producing in an environmentally friendly manner. The activity of digital innovation was found mostly within software firms using digital technologies like AI or Blockchain. The activity of digital innovation focused mostly on sustainability and an understanding of the line of production. Sustainable solutions like carbon footprint tracking or using AI for food formulation that mimic animal protein.

5.3. Actors and Position

Multiple *actors* exist in the plant-based industry, whereas the 'core' set of actors in the supply chain are: *Farmers, Ingredient manufacturers, Food Manufacturers, Distributors.* The various complementary actors such as educational institutions, software, hardware and analytics companies make the industry more efficient and targeted towards the value proposition (depicted in Figure 1). We identify that two actors (hardware and software companies), in particular, undertake the activity of innovation in the plant-based industry.

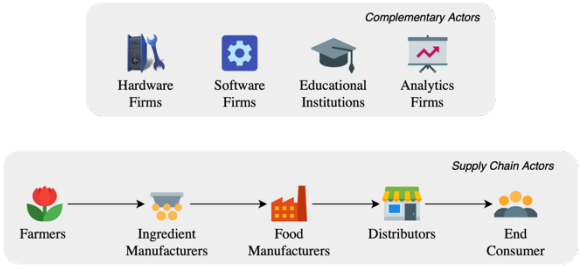

Figure 1. Plant-based dairy supply chain.

The *position*, in which the actors deliver on their activities, followed the traditional linear production line stream. Within the 'core' set of actors, buyer and supplier relationships are clearly defined, however outside the core alignment is needed. Educational institutions, hardware firms, analytics firms and software firms were positioned outside the core as they are not part of the production line directly but provide means to optimize the production of products. The findings suggest that the significance of the actors has shifted, and that technological players have a more

prominent role in the functionality of the system, especially software firms.

5.3. Linkages

Links between the actors specify the transfer of goods, influence and funding between the actors. This case builds on a traditional supply chain: there are four actors (Farmers, Ingredient Manufacturers, Food Manufacturers, Distributors) that are the *line of production* where they produce part of the product that is made available for the End-Consumers. The line of production links is reciprocal.

Educational Institutions, hardware, analytics and software firms provide complimentary products to the system and can be seen as complementors of the plant-based dairy supply chain.

Educational Institutions share knowledge, information and create awareness with all actors of the system. In return, they collect data from all stakeholders for e.g., new studies.

Hardware, analytics and software firms with the 'the core' is dependent on information flowing both ways. *Hardware firms* provide machines, tools, and services to the upstream supply chain to make production more efficient. In return, they get feedback on their hardware for improvement.

Analytics firms provide analytics machines for product quality assurance in each step of the supply chain. In return, they utilize the analytics data for calibrations to improve measurements.

Software firms provide different types of software to maximize information and data usage. Software firms facilitate a multilateral exchange of data between the actors in the core supply chain. This data is shared through the system and helps maximize production, both the speed of production, as well as quality of end products.

This exchange of information actively affects the links between the core actors and makes rise to new links. The new links help shorten the production time and delivery time of the industry.

6. Discussion

Within this section, we discuss if there might be a systemic change sparked by digital technology and whether the change triggered a market reconfiguration.

6.1 Disrupted Industry

A digital innovation such as the one we mentioned in our findings - where AI can find ideal matches to mimic animal protein – has far reaching effects on the industry. This digital innovation disrupts, for example, the product development process and thereby shortens the process lead time from years to days; disrupts the business model of the traditional ingredient manufacturers, and will alleviate the challenges about taste, texture, additives and nutritional value. This digital innovation can be seen as a digital disruption. Digital disruption describes environmental turbulences prompted by digital innovation. These digital innovations fundamentally alter established logics for value creation and capture by eroding, recombining or creating links among resources (Karimi & Walter 2015; Weill & Woerner 2015; Rauch et al. 2016; Skog et al. 2018). As an outsider, innovating the product development process might not seem as a systemic change, but as the biggest challenge is to mimic the animal protein it has far reaching impacts.

With this digital innovation the following foundations will be eroded:

The competitive advantage of food manufactures that is based on highly advanced plant-based product and a well working R&D process will be diminished. The higher margins that ingredient manufactures take due to the long development process of patented food formulation might erode.

Additionally, the traditionally dairy industry will be affected quite heavily. The competitive advantage of the dairy industry about their 'superior' taste and higher nutritional value will be decayed. The dairy supply chain is quite cost intense due to involvement of animals. If the animal protein can be completely mimicked this might mean that the traditional dairy industry is insufficient if the same product can be produced by just growing plants. However, the products need to look alike, and consumers need to adopt it.

6.2 The Emergence of Ecosystems

Due to the disruption, the plant-based industry has new core actors and new activities, that impacted positions and links that gave rise to a new set of interactions. Adner (2017) argues that a need for an ecosystem approach arises in the context that requires change in underlying relationships of any of the four elements of structure.

The position of software firms changed and created new links in the value chain that greatly increase value creation for all actors in the system. While powerful firms tend to craft rules and shape the process of ecosystem development, they are only the informal leader and power situations can quickly change (Adner, 2017). The importance of the actors has shifted, so that technological players have a bigger role in the functionality of the system. Software firms not only hold

the role of complementor (providing complimentary products to the system), but with their digital innovation they also have the functionality as a potential 'hub' of the system. Actors like software firms who are changing roles within ecosystems and associated shifting patterns of collaboration and competition, are an important feature of an ecosystem (Iansiti and Levien, 2004). Arguably, the software firms are not the largest or most resource-rich in the system, but they possess intellectual property rights and have key tools (e.g., AI) thus they can be seen as an actor that uses "*smart power*" (Williamson & De Meyer, 2012), that stimulate movement in the ecosystem through technological advances and potential disruption.

We could see that in particular two ecosystems are emerging: the *knowledge ecosystem* and the innovation *ecosystem* (see Figure 2. Plant-based dairy ecosystem).

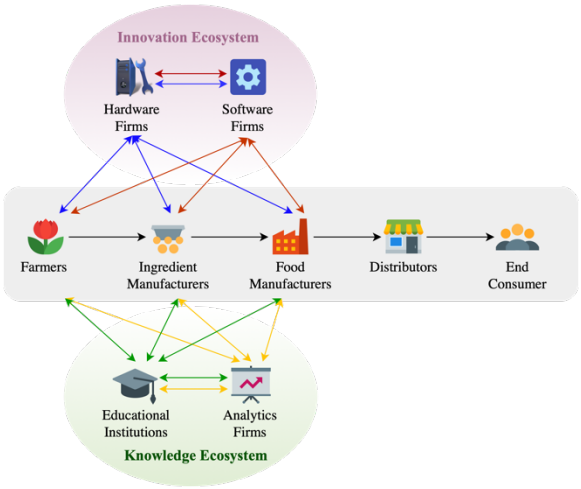

Figure 2. Plant-based dairy ecosystems.

The *knowledge ecosystem* occurs with core supply chain actors and educational institutions and analytics firms. Educational institutions (green arrows) and analytics firms (yellow arrows) actively participate in knowledge creation.

As the plant-based must overcome a series of challenges, and in particular the mimicking of the animal protein, educational institutions are actively involved in research project to create better formulation and find the best resources. There have been huge funding projects for Planternatives within the EU, local governments and private institution. Additionally, analytics firms are taking over the leading role by collaborating with private organizations and educational institutions.

Educational institutions and analytics firms have active research collaborations going on where they integrate plant-based producers as their empirical sample where not only the sampled producers benefit but the whole ecosystem

Additionally, analytical firms collaborate with producers and contribute with their calibration measurements. Producers can then use the measurements to adjust parameters such as the circumstances when plant-based milk foams.

The *innovation ecosystem* occurs between the core supply chain actors and hardware and software companies. As mentioned before the hardware firms rather facilitate agricultural innovation like technology advances with e.g., farming machinery. They actively collaborate with software firms to add e.g., apps like smart field data from satellite images to their farming machinery (e.g., see John Deere). In return, they get ideas, feedback and data from the core actors to advance or invent new machinery or software.

Furthermore, software firms facilitate digital innovation and take over a lead role. The digital innovation ecosystem that occurs is from particular interest as it has severe systemic effects in the industry. When trying to mimic animal protein, digital innovation plays a major role: Technologies like AI can calculate a vast amount of combination of plant-based product that mimic the animal protein and find the ideal matches. This is far more efficient than the previous long trial and error product formulation processes.

7. Conclusion

While Information Systems literature has shed much light on digital technologies like AI, digital innovation and its disruption, there has been less attention on the opportunities that digital disruption can bring to emerging industries (e.g., Sandberg et al., 2014; Roland et al. 2018)

This study aimed at investigating how digital technologies impact the market configuration of the plant-based dairy industry. Whereas supply chain management is typically dominated by a top-down view from the focal firm to its dyadic partners (Prockl et al., 2017), digital technologies are more prone to a bottom-up approach of an ecosystems view. Digital transformation creates areas of tension in supply chains, as the common governance structures of supply chains change, thus there is a natural need for an occurrence of a new market configuration. Our study contributes to IS literature by examining how value is created as a result of stakeholder interactions in a specific market configuration and the role digital technology has within that.

Our research contributes to showing how a linear l supply chain transforms due to technology to an ecosystem and how the constellation of that

environment – here the plant-based industry – changes. The findings of our study show that digital technologies facilitate systemic change towards a novel supply chain set up. In this case, the AI technology can be seen as the digital disruptor as the algorithm learned to combine immense amounts of plant protein data to mimic the flavor and texture of animal products for dairy, meat etc. This disruption triggered a market reconfiguration, and we could see an innovation and knowledge ecosystem emerging.

The nature of case studies restricts the generalization of the results which should be seen as early indications of the impact on the plant-based industry. Further research should make an attempt to investigate the plant-based dairy and traditional dairy industry over an extended time period to understand how the digital disruption will play out over time and how these ecosystems might develop.

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