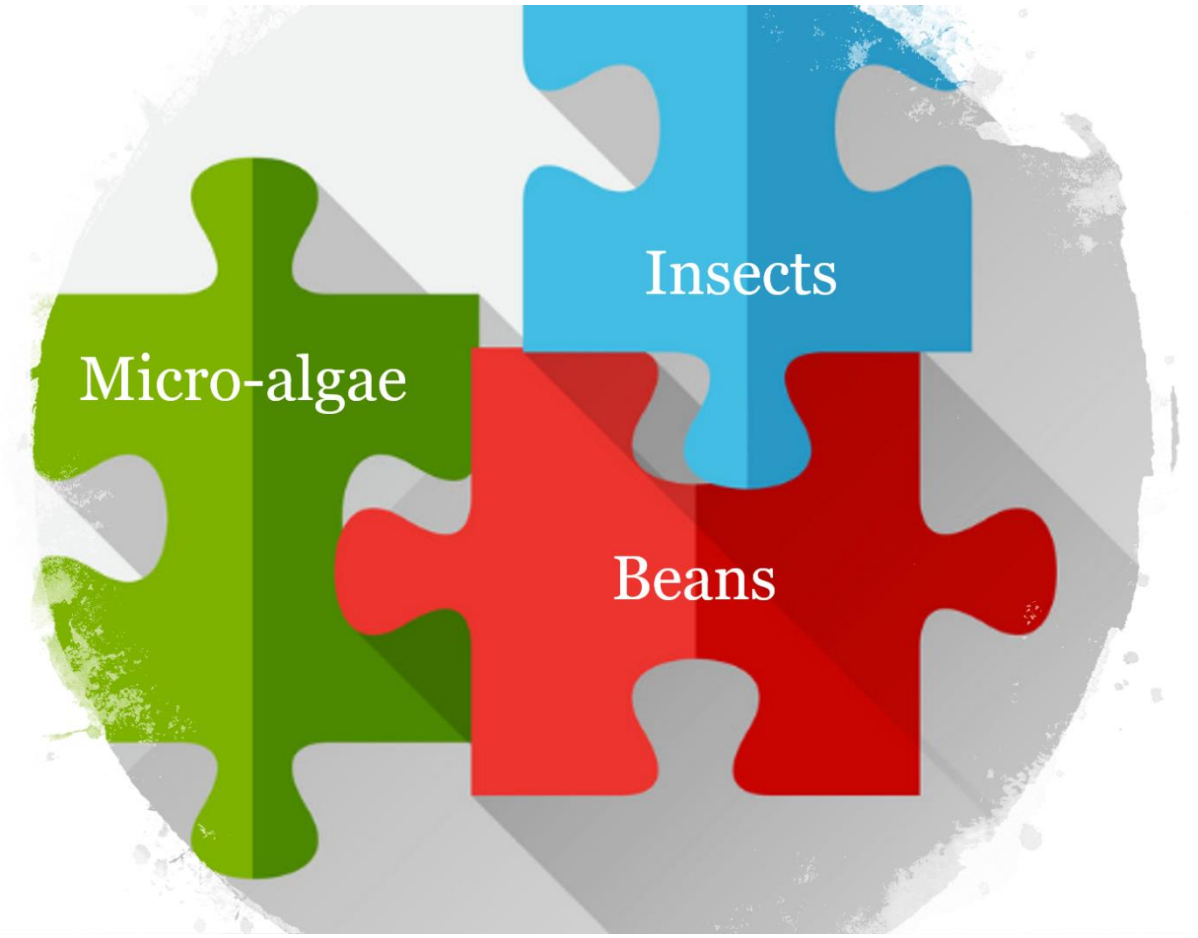
Wageningen University - Social Sciences
Knowledge Technology and Innovation (KTI) group

The Protein Puzzle

Investigating the transition pathways of the Dutch alternative proteins



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Preface

I am currently a student of Wageningen University and Research, pursuing the master's degree Development and Rural Innovation and the track of Technology. As part of my studies, I am also undertaking the "MSc Track Entrepreneurship", in order to cater my interest in learning more about sustainable Entrepreneurship and Intrapreneurship in the food sector. My previous degree is an integrated BSc and MSc in Agriculture with a specialization in Food Science and Technology from Aristotle University of Thessaloniki, in Greece. Moreover, I have so far founded two start-ups, one related to smart city projects and a second one related to alternative proteins. Simultaneously, my passion for entrepreneurship and innovation is fired u by self-studying the ways in which start-ups become successful. In general, my overarching interest in conducting research lies in understanding how innovative technologies, and specifically sustainable technologies, are developed, and how technology and society interact and shape each other.

I am particularly interested in exploring the alternative protein socio-technical niches and the way interactions at niche-levels influence the emerging transition pathways. My academic background and experiences provide me with an overview of the technological and social impact alternative protein sources can have. I am optimistic about the future of alternative proteins and has motivated me to work on this thesis topic for the past months, as part of my MDR studies.

Abstract

The ways in which the transition pathways of sustainable niche-innovations are influenced face a significant scientific knowledge gap. Previous research has shown that sociotechnical regime/niche-innovation interactions and interactions among different niches can influence the transition pathways of sustainable niche-innovations. This study aims to develop scientific knowledge on the type and typologies of niche-level interactions that impact the transition pathways of niche-innovations. Building on existing work on Technological Innovation Systems and Initiative-Based Learning, intra-niche and cross-niche interactions are studied to understand their impact on the transition pathways of insects, beans and micro-algae, in the case-study of the Dutch alternative protein transition. In this context, intra-niche interactions are defined as the socio-technical interactions within one niche-innovation and cross-niche interactions as ones among multiple niche-innovations. Based on a customized framework of Pel's (2013) nested-case methodology and Sanden and Hillman's (2011) typology of interactions and dimensions, semi-structured interviews together with content research were primarily used to study key stakeholders of the Dutch alternative protein transition. Analysis of the generated results demonstrated that the transition pathways of the three protein niche-innovations are influenced by both intra-niche and cross-niche interactions.

Studying the niche-innovations internally showed that insect niche actors are competing for access to networks and knowledge but help each other in achieving regulatory changes and promote insects as a protein source. Micro-algae actors are very fragmented and work together only to achieve regulatory changes and promote micro-algae as a protein source. Beans actors are competing for access to resources and knowledge, trying to gain a competitive edge against each and only work together in promoting their niche as a protein source, while carefully safeguarding their competitive advantages.

The impact of niche-innovations to one another's transition pathway in terms of expectations, knowledge, regulations, resources, and networks, is currently not significant. Nevertheless, the niche-innovations pathways of the insects, beans and micro-algae compete for the concepts of sustainability and nutritional value. In the future it is suggested that the niches studied will develop a diverse range of interactions that potentially influencing the transition pathways of one another in unexpected ways.

The results indicate that in both types of niche-level interactions, impact the transition pathway of a niche-innovations, with intra-niche interactions being more influential in the earlier stages of the transition and with cross-niche interactions gaining importance over time. On the basis of the findings, an adaptation on the widely accepted MLP model is suggested, in order to include cross-niche and intra-niche interactions as factors defining the transition pathway of sustainable niche-innovations. Further longitudinal research is needed to better define the exact ways in which intra-niche and cross-niche interactions, evolving over the long transition periods, impact the transition pathways of the alternative protein niche-innovations.

Chapter 1: Introduction

Climate change is a constantly growing threat the world faces, potentially negatively affecting many aspects of human activity, like the economy and economic growth (Fankhauser and S.J. Tol, 2005), nature biodiversity (Gimmi et al., 2010) and food security (Connolly-Boutin and Smit, 2015). Among the largest contributors to the phenomenon of climate change is the livestock production, due to its high emission of Greenhouse Gases, which in turn are responsible for climate change (McMichael et al., 2007). Reducing meat consumption would possibly have a positive environmental impact, due to fewer Greenhouse Gases emissions, however, potential side-effects like macro-nutrient and micro-nutrient deficiencies could arise (Joe Millward and Garnett, 2009). Since climate change can be characterized as a "super wicked problem" (Levin et al., 2012), it is evident that multiple solutions are required. The need for solutions becomes much more urgent, considering the simultaneous expected global population growth (Lutz and Qiang, 2002) and the rise of emerging economies' middle classes, since it would create demand for developed world products (Bussolo et al., 2010), like meat or dairy products. As a consequence, the future global demand for protein is expected to rise. To satisfy that demand, new technologies and protein sources are required, since the currently established technologies and sources of protein are mainly animal-based and have been proven to be unsustainable and harmful for the environment.

The rising concerns on the sustainability of livestock production and consumption, due to Greenhouse Gases emissions, coupled with the concerns on animal cruelty and human well-being, make the established protein regime to lose its stability. Using the terminology of the Strategic Niche Management (SNM) model (Geels & Schot, 2007), the socio-technical landscape, is applying pressure to the established protein socio-technical regime. This pressure has created a loss of stability and several alternative protein niche-innovations are starting to gain momentum, causing a system transition. A plethora of scientific literature is used to study system transitions in several domains. The scientific literature consists of cases studies mostly regarding transitions related to energy (Sanden & Hillman 2011), automobile industries (Magnusson & Berggen 2017) and urban planning systems (Farla et al. 2012). The scientific literature regarding the protein transition is limited and mostly focuses on the technological feasibility and production costs, sustainability gains, effects on societal organisation and market power, economic viability or resonance with cultural and behavioural patterns of consumption (Weele et al. 2019). Seeing this gap, Weele et al. (2019) provide an integrated assessment of meat alternatives, considering a wide range of implications, by examining every alternative in isolation. As the protein transition is currently taking place, the different niche-innovations that emerge, in the form of alternative proteins, aim to alter the established socio-technical regime, of farm-animals' protein, and this creates uncertainty for all the actors involved in the system.

Combining the previous information, on the one hand SNM theory (Geels & Schot, 2007) focuses on the interactions between the socio-technical regime and the niche-innovations and on the other, Weele et al. (2019) analyse the alternative protein niches on an individual level. A thorough review of literature revealed that there is a gap of knowledge regarding the co-evolution process happening among the alternative protein technological niches. Moreover, there is no literature describing the internal interactions of the alternative protein niches, as models as SNM seem to disregard their influence on the transition process. Therefore, this research aims to reduce the uncertainty revolving around the protein transition and to eliminate the scientific knowledge gap on a) the co-evolution processes of socio-technical protein niche-innovations, and b) the impact of internal niche interactions on the transition pathways of the protein niche-innovations.

In chapter 2, the different theoretical approaches will be discussed and their fitness on the purpose of the research will be explored. In chapter 3, the methodologies and methods used during the research are

presented, followed by the two results' chapters on cross-niche interactions (chapter 4) and intra-niche interactions (chapter 5). In the end, chapter 6 includes the discussion and conclusion of the research and the references and appendixes are given in chapters 7 and 8 accordingly.

Chapter 2: Theories

2.1. Introduction

In this chapter, the theoretical part of the research is presented. Initially, in section 2.2 the different theoretical approaches on the subject are compared. Afterwards, on 2.3 the theoretical framework used for this research is the following. In section 2.4 the research questions are given, together with a short terminology on the researched topic. In section 2.5 the operationalization of the research questions is provided and on section 2.6 analytical choices made as part of the research are illustrated and lastly, this chapter ends with a conclusion on the theories part (Section 2.7).

2.2. Theoretical comparison

There are different strains of literature trying to describe the sustainability transition pathways, all of which come with different methodological advantages and drawbacks and trade-offs. Using Turnheim et al. (2015) classification, there are three main strains of literature, Quantitative systems modelling, Socio-technical analysis and Initiative-based learning, all of which could potentially be used for researching the protein transition.

Firstly, the Quantitative systems modelling approach is a deterministic attempt to project how policies can be used to achieve desired futures (Turnheim et al., 2015). An example of this strain of literature is the work of Li and Strachan (2019), who used quantitative modelling to analyse the behaviour of actors concerning socio-technological transition pathways to understand sustainability transitions. The Quantitative Systems Approach is a good tool for projecting how sustainability transitions are expected to unravel, however its deterministic nature oversimplifies the individual actions of actors. To use such a model to study the ongoing protein transition, previous research should exist that would provide the researcher with rich transition-specific context. This context would then help create valid quantitative means of extracting information from the actors involved and accurately designing experiments. However, it has already been mentioned that such literature does not exist and therefore the methodological lens provided by this strain of literature was judged unfit to research the protein transition.

The second strain of literature is Socio-technical analysis. This batch of scientific literature approaches focuses on the historical analysis of system transitions, trying to identify patterns on the transition process. One prominent theory of this strain is the Strategic Niche Management (SNM), used to describe sustainability socio-technological transitions, explaining how niche-innovations interact with established socio-technical regimes (Geels & Schot 2007; Kemp, Schot & Hoogma 2007). Another theory is the Multi-Level Perspective (MLP) as described in the article of Geels and Schot (2007), which provides a typology of four transition pathways and describing the way niche-innovations form new socio-technical regimes. A third approach is the Technological Innovation System (TIS), (Magnusson & Berggen 2017; Musiolik, Makard & Hekkert 2012; Sanden & Hillman 2011). SNM, MLP and TIS are all macroscopic approaches, applied on case studies of sustainable technological transitions that are unfolding over decades, in retrospect. To best utilize these approaches, the socio-technical protein regime transition should finish and reach a new point of stability. Moreover, SNM and MLP are focusing on the relations between the socio-technical regime and the niche-innovations. The protein transition is a relatively new transition, which has not yet settled and where many interactions take place, more than just the regime/niche ones. Therefore, even if the theories of this strain can provide good context specificity, they are rather unfit for analysing the protein system transition and have a more macroscopic perspective than the one needed for this research.

The third strain of literature is the Initiative-Based Learning (IBL) approach. This approach is rather heterogenous in terms of studies that classify under it, yet part of the transitions in the making literature is included in it (Turnheim et al., 2015). This approach has a short time-frame of study, it emphasizes on actors' strategies and interactions, is locally-focused and aims to give a local-understanding of the actors and networks within the system it studies, without losing vision of the transition goal (Turnheim et al., 2015). Pel's (2013) nested-case methodology, pinpointing the intersections between different systems in the transition process of the Dutch traffic system management is a study under this approach. IBL provides a lens that is judged to be useful for researching the protein transition since; a) it is appropriate to study ongoing transitions, like the protein transition, b) it focuses on interactions, therefore enabling the study of alternative protein technologies co-evolution and c) it provides local explanations, which is useful for the protein transition, as food is a cultural element.

2.3 Theoretical framework

As discussed previously in the theories part of the introduction (chapter 1), there are three strains of literature, out of which initiative-based learning is judged as the most suitable one to help understand both the co-evolution processes and the internal interactions of the alternative proteins as niche-innovations. In specific, considering the system level interactions that are involved in the protein transition, there is a need for a customized theoretical framework to be used, to successfully measure the underlying complexity. The customized framework created to cater the needs of this research, uses Pel's (2013) nested case framework as its conceptual core. Then, it is complimented by Sanden & Hillman's (2011) a) breaking down of the protein transition in its underlying aspects and b) typology on the modes of interaction that can emerge in this transition. The elements of the customized framework are described further on.

The framework initially involves a definition of the different dimensions underlying in the protein system. The protein system is defined as a socio-technical system, and thus it comprises of the material dimension, the organizational and the conceptual dimensions (Sanden & Hillman 2011).

(1) The material dimension of the sociotechnical system is constituted by physical artefacts and two systems overlap in this dimension when they use the same physical artefact (Sanden & Hillman 2011).
(2) The organizational dimension of the sociotechnical system is constituted by actors and two systems overlap when one actor interacts with more than one technology (Sanden & Hillman 2011).
(3) Conceptual dimension of the sociotechnical system is constituted by schemata, which define what actors are able or are ought to do and what not. Schemata can be embedded in actors or artefacts, or they can exist separately. Two systems overlap in the conceptual dimension when schemata are transferred between two systems (Sanden & Hillman 2011).

Linking the three dimensions that the protein system is comprised of (Sanden & Hillman, 2011) to the short time frame of a 6-month thesis, it is important to emphasize on only two dimensions. Looking closely to the work of van der Weele et al. (2019), it is evident that institutional change, and especially the perceptions about alternative proteins, is an important driver of the protein transition. Since this research focuses on the co-evolution processes and the internal interactions of niche-innovations based on different technological domains, studying the material dimension would make no sense. Therefore, the organizational and conceptual dimensions of the protein transition were chosen, in order to gain insights on the co-evolution and internal interactions happening in the protein transition.

The next element of the customized framework is inevitably the definition of the research objects. Considering that a) there is no previous research on the co-evolution of protein niche-technologies and that b) the organizational and conceptual dimensions are going to be studied, there is need for gaining local explanations on the unravelling protein transition. Pel's (2013) nested case framework, analyses the system co-evolution of Dutch traffic lights by researching local actors involved in the transition process perceptions. The cornerstones of Pel's (2013) nested case framework are the terms "situated complexity", "arena of development", "system intersections" and "interpretative complexity". Pel (2013) use Byrne's definition on "situated complexity" as 'allowing for local explanations regarding patented systems' and Jorgensen's definition on "arenas of development" as 'different configurations of temporary socio-material configurations, the overlap of which is open for conflicts and possible reconfigurations'. "System intersections" are then, using Jorgensen's terms, 'the network nodes where arenas of development become intertwined' (Pel 2013) or in general the interactions between systems. Lastly, "interpretative complexity" stands for the 'heterogeneity of actors and initiatives, eliciting the politics and ambiguities of transition in the making' (Pel 2013).

The terminology of Pel (2013) provides a solid foundation for studying the co-evolution of different technologies in the protein system transition. Applying those terms to the protein transition, there is a 'situated complexity' across the niche-innovations, with multiple possible local explanations. Actors involved in the protein transition, also have multiple local explanations related to their perceptions and interactions with alternative protein niche-innovations. These perceptions and interactions are positioned in the 'arenas of development' which in this case are the three dimensions provided by Sanden and Hillman (2011). Moreover, the actors' explanations and interpretations are constantly changing with the emergence and interaction with those of other protein system actors, in the so-called 'system intersections'. Lastly, the perceptions and actions of actors, who act based on their motives and expectations on the protein transition, lead to the emergence of ambiguities and politics within and between niche-innovations, fostering 'interpretative complexity'.

The last part of the customized framework used in this research, is the typology of the possible modes of interaction both intra-niche (within one niche-innovation) and cross-niche (between different niche-innovations). The typology framework used in this research is the one proposed by Sanden & Hillman (2011), where the following six modes of interactions are possible:

(1) Competition: Both technologies/actors inhibit against each other
(2) Symbiosis: Both technologies/actors benefit each other
(3) Neutralism: Neither technology/actor affects each other
(4) Parasitism (predation): One technology/actor benefits, while the other is inhibited
(5) Amensalism: One technology/actor is inhibited, while the other is not affected
(6) Commensalism: One technology/actor benefits, while the other is not affected

2.4 Research Questions

In the previous sections of the report, both on chapter 1 and chapter 2 (2.1-2.3) the problem statement and the theories relevant to investigate it were elaborated. These chapters operated as the basis for developing the research's General Research Question (GRQ) and the sub-set of Specific Research Questions (SRQs). The GRQ is what this report aims to eventually answer regarding the topic researched and it is formulated below:

GRQ: How do the Dutch alternative protein niche-innovations (beans, algae and insects) interactions influence the transition pathways?

The GRQ is quite abstract and it needs to be broken down on analogous questions that can be answered with a clear way. For this GRQ, the two SRQs that comprise it are stated below:

SRQ1: How do the Dutch alternative protein niches (beans, micro-algae and insects) innovation pathways interact with each other?

SRQ2: How do the Dutch alternative protein niches (beans, micro-algae and insects) innovation pathways interact internally?

As it is obvious, the SRQs are analogous to each other, breaking down the GRQ to cross-niche and intra-niche interactions. With these SRQs it is hypothesized that the interactions influencing the transition pathways of niche-innovations, on a niche level, are intra-niche and cross-niche interactions. The basis of this hypothesis is that studying the protein transition at a micro-level we expect internal interactions within the niches and interactions across the different niches. The regime/niche-innovations interactions are already heavily focused in literature and are deliberately kept out o the framework, as it is hypothesized that the microscopic lens of this research is not the proper one to capture those and that these interactions would be better studied by relevant macroscopic-level literature as indicated in section 2.2.

2.5 Operationalization

Starting with SRQ1, the "cross-niche" socio-technical interactions among the three innovation-niches are specified. Cross-niche interactions is a term referring to the "socio-technical interactions between two different innovation-niches". The "cross-niche" interactions are an abstract concept in need of further elaboration. As it can be seen under the Theoretical framework part of this chapter, the niche-innovations are composed of three different socio-technical dimensions (Sanden and Hillman, 2011). It is already made clear that two of the three dimensions will be studied as part of this research, the "organizational dimension" and the "conceptual dimension".

Starting with the "organizational dimension", it defined as the "actors' interactions with more than one technology, when two systems overlap" (Sanden & Hillman 2011). In order to make this dimension measurable for the purpose of this research, "organizational dimension" is broken down to its aspects. Since Sanden and Hillman (2011) do not provide the information to break down this dimension into its aspect, an alternative approach is taken. The organizational dimension is broken down into its aspects using a customized value chain-inspired framework. Trienekens (2011) uses a network value chain composed of suppliers, traders, processors and retail. Foodvalley uses a 6-element framework to describe the value chain of Dutch alternative Proteins consisting of growers, food product producers, consumers, communication organizations, education and research (Appendix I). Adjusting the previous frameworks into the needs of this research to investigate the resources interactions between different niches, a 6 aspects are suggested to comprise the organizational dimension value chain; supply, food product creation, market, consumers, research and finances, as depicted in figure 1.

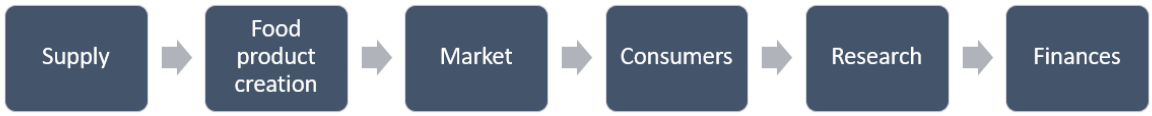

Figure 1: Operationalization of organizational dimension

Moving on to the "conceptual dimension", the definition used is 'the actors' transferring of notions on what they are able or are ought to do and what not'. To make this dimension less abstract and measurable, it is broken down to "positive schemata", "normative schemata" and "concepts" (Sanden and Hillman, 2011). The aspects that were measured for this dimension are presented in figure 2.

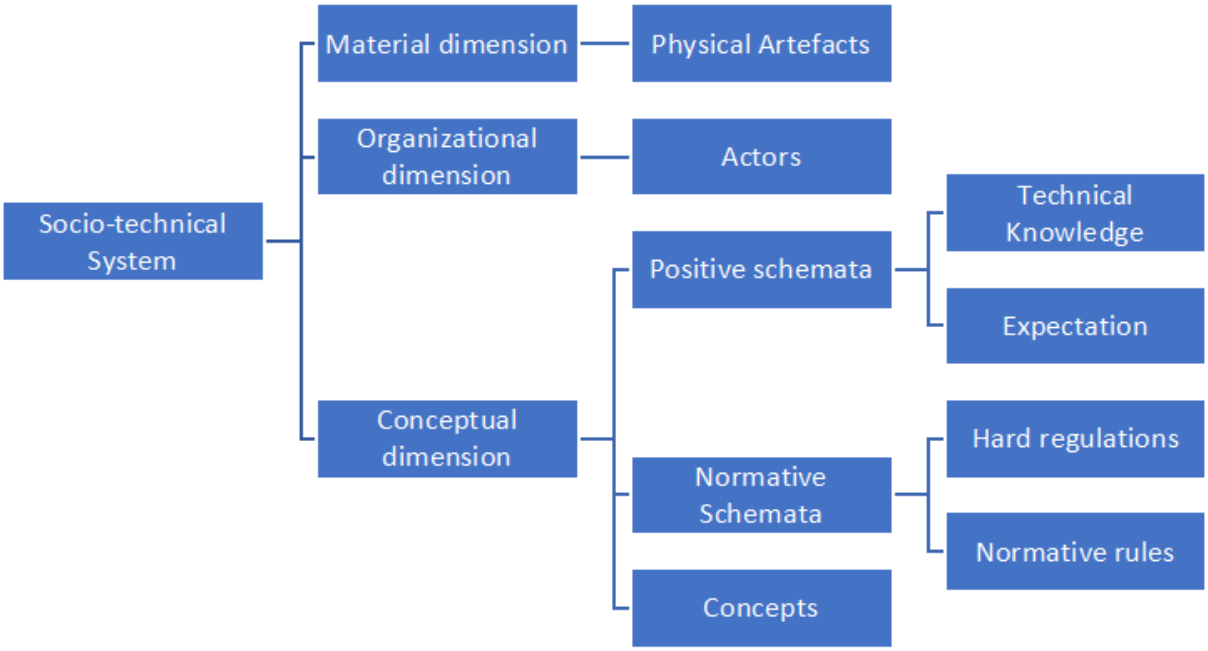

Figure 2: Operationalization of conceptual dimension

Moving to SRQ2, the "intra-niche" socio-technical interactions are defined as the "socio-technical interactions between actors of the same niche-innovation". The "intra-niche" interactions are an abstract concept in need of further elaboration. Considering that there is limited knowledge on "intra-niche" interactions, this research assumes that "intra-niche" interactions consist of the same aspects as the "cross-niche" ones, meaning the only difference between the two. This means that "intra-niche" interactions consist of "material", "organizational" and "conceptual" dimensions. Again, the same two dimensions will be researched; the "organizational" and the "conceptual" dimensions. Therefore, figure 1 depicts the operationalization for the "intra-niche" "organizational dimension" and figure 2 also depicts the operationalization for the "intra-niche" "conceptual dimension".

2.6 Analytical Framework

In In this part, the analytical choices made in the research questions are further justified, defining the boundaries of the research.

Initially, the place that the research takes place is in the Netherlands. The primary reason behind this choice is convenience, as the Netherlands is the place where the researcher lives in. This provides the possibility to conduct in-person interviews, and participate in local events relevant to the research topic. Moreover, the Netherlands government (Government.nl, 2020) promotes sustainable agriculture and multiple alternative proteins, indicating that the protein transition is already ongoing. These two factors make the Netherlands the best option for this research to take place on.

The second analytical choice concerns the selection of the protein niche-innovations that are suitable for this research. Considering the existence of multiple niche-innovations in the Netherlands, as

described by van der Weele et al. (2019), three are chosen; beans, micro-algae and insects as food. This selection is a necessary step in conducting the research, as the time frame of 6 months does not allow for more niches to be studied. Three niche-innovations are chosen to increase the research validity, compared to the minimum required among two for finding cross-niche interactions, without compromising the quality of the results due to time restrictions. The three niche-innovations are deliberately chosen based on the following criteria. First, considering that the organizational and conceptual dimensions are studied in this research, niche-innovations requiring varied levels of technological and institutional change are chosen (Weele et al., 2019). Then, the three niche-innovations chosen represent different organisms, one being animal-based (insects), one being plant-based (beans) and one being microorganism-based (micro-algae). In this way, all different organisms used as protein sources are included to eliminate the research bias for one type of protein sources. Lastly, since the research is mainly qualitative and the researcher is also the measuring instrument (Bernard, 2006) the third choice was to include niche-innovations that the researcher is both familiar with and interested in researching.

A last analytical choice made in this research was to not include consumers as part of the research sample. Including consumers would drastically increase the workload and resources requirements of the research and would make the research impossible to complete in the six months that an MSc thesis is expected to last. Nevertheless, the interviewees were asked questions about consumers and consumer perceptions, to minimize the impact that this choice has on the validity of the research.

2.7 Conclusion

At this point, the theories chapter wraps up. Initially, the theoretical approaches of established literature strains were clustered and compared and a customized theoretical framework to conduct this research was introduced. Afterwards, the research questions and the operationalization of it were elaborated. Lastly, the analytical choices made as part of this study were also mentioned. In the next chapter (chapter 3), the methodologies and methods used to conduct the research are analysed.

Chapter 3: Research methods

3.1 Introduction

In this chapter, the exact research methods used as part of the research are presented. In 3.2, the methodology of the research is provided, followed by the methods used to conduct the research (section 3.3). Lastly, the data analysis methods are presented in section 3.4 and eventually the chapter's conclusion is given in section 3.5.

3.2 Methodology

As mentioned in chapter 2, there is a need to conduct research on the interactions between and within niche innovations. This kind of research aims to both shed light in the modes of interactions and to provide new scientific knowledge using the case of the Dutch protein transition. Several actors are involved in the protein niche-innovations and both their perceptions and way of organizing into networks and moving resources will be studied. In order to conduct this research, the customized framework previously described in this chapter is used. In order to achieve these research goals and understand the transition pathways, qualitative research is used. It is believed to be much better at providing the proper lens to both conduct the research and analyse its results. The main reasons for this choice were:

a) Its ability to provide rich context and new insights on a relatively unexplored topic, as is the case for the protein niche-level interactions.
b) It eliminates cognitive bias based on the researcher's preferences to a specific protein niche-innovation.
c) It enables for the recording of the expectations and motives behind actors' behaviours.

The choice to conduct qualitative research in order to answer the research questions, involves the researcher to also be part of the measurement instruments and this brings certain implications. The researcher's pre-existing knowledge on the topic, in the forms of having an academic background on food technology and of developing insect-based food products, can enable constant reflection on the research and provide the ability for an iteration of the research design in the case it is needed.

3.3 Methods

The first part of the research, involves finding prominent Dutch stakeholders across all three niche-innovations. In order to find these actors, a combination of two methods were used. Initially, a desk research was conducted on the internet, in order to map out all the relevant stakeholders in the three niche-innovations. The second input of data came from participating in the Foodvalley Protein Summit, where almost all the alternative protein actors of the Netherlands were present. Starting with the desk research, Google was used as the search engine to explore the existing stakeholders. Google search provided multiple results on actors of the protein niche-innovations, ranging from producers, investors, ingredient companies, researchers, consumer organizations etc. Moreover, the websites of important networks such as TheProteinCluster (TPC) provided the researcher with multiple websites and actors active in the niches studied. The desk research did not aim for listing every existing actor, but rather identifying the prominent ones. This meant that the actors that appeared first on the search engine organic results or that were repeatedly listed on websites of third-parties as relevant, were classified as the prominent ones.

Secondly, participating in the Foodvalley Protein Summit, allowed the researcher to confirm that the actor results generated during the desk research were accurate. This meant that actors that were found as prominent ones in the search engine and were actively participating in the Summit, were confirmed to be important actors for the Dutch protein transition. The complete list of prominent actors for the three niche-innovations can be found in Appendix II, organized per role and niche technology.

Moving on, the research methods adopted to answer SRQ1 and SRQ2 questions are similar. Based on the generated list of prominent actors, the researcher approached them using e-mail, in order to schedule the interviews. In total sixteen (16) e-mails were sent and thirteen (13) of the recipients agreed to participate in the research, by being interviewed. The list of the thirteen (13) interviewees together with a description of their role is provided in Appendix III. The semi-structured interviews were conducted either in-person or through video-calls, depending on the preference and availability of the interviewee. In specific, out of the total interviews, three (3) interviews per niche-innovation were conducted, each with an actor specialized in only one niche-innovation, and four (4) interviews were conducted with common actors, meaning actors involved in all three niche-innovations. All the interviewees were motivated to participate in the research and most of them suggested to reach out to them with the research results, or in case I needed further help.

Every semi-structured interview started with the researcher introducing himself, the purpose of the research and asking for permission to record the interview and to use their answers for the research. On average, the interviews lasted fifty (50) minutes. The interview rubric and the interview questionnaire are provided in Appendix IV and Appendix V, respectively. Every part of the rubric was answered before finishing all the interviews and whenever it was found relevant, the researcher proceeded to ask follow-up questions, or questions that emerged as relevant to the interviewee answers. In the end of the interview, all interviewees were given the opportunity to ask any questions of their own or to state anything they considered relevant to the research or the researcher.

A second research method used in order to enrich, cross-check, and verify the information gathered from the interviews, was content research. The aim of using a second source of data is to increase the research internal validity by triangulating for research methods (De Vaus, 2001). In specific, content research was conducted on the websites of relevant key actors, who are also listed in Appendix II. The content research aimed to gather information from text, or media that the actors themselves use in order to describe their partnerships, networks, products, values etc.

Lastly, a third research method used to further increase the research internal validity, were the researcher's observations gathered from attending alternative protein themed events. In specific, the researcher attended two major events: the Foodvalley Summit and the WUR community protein day. Both of these events were organized in Wageningen, Netherlands. The Foodvalley Summit, organized by the Foodvalley network, was an industry event where companies, investors, network representatives etc. from all niche technologies were gathered together to network and exchange ideas. The WUR community day, organized by WUR, was an event for researchers and academics of WUR related to alternative protein technologies, with the aim to create connections across different researchers and to exchange knowledge on the protein transition topic. During these events, the researcher was actively participating, observing and interacting with fellow participants. Field notes, observations and the researcher's interpretation and reflection upon what happened in the events are used as a third source of data.

3.4 Data Analysis

In this part, the ways the data collected were processed and analysed are presented. The first step after completing the data collection phase was to transcribe the interviews conducted. The transcriptions can be obtained using the contact information indicated in *Appendix VI*. The tool used to transcribe the interviews is the oTranscribe application (oTranscribe, 2020).

The second step after transcribing all the interviews was to organize and code the interview data. To do that, Microsoft Excel sheets were used. Specifically, the interview data were separated into eight categories, with the criterion of the aspect they relate to, as described in the *2.5 section* on operationalization. The complete analysis of the transcripts is provided in *Appendix VII*. The information included in the analysis rubric of *Appendix VII* are quotes coming from the semi-structured interviews. This information were then combined with the ones gathered from content research, and participatory observations and the overall results are presented in *chapter 4* and *chapter 5*, regarding the cross-niche and intra-niche interactions, respectively.

3.5 Conclusion

To conclude, in this chapter the various methodological and practical aspects of the research conducted were presented together with the justification behind the underlying choices. In the next sections, the results of the research are provided. Specifically, the next chapter introduces the results on cross niche interactions (chapter 4) and then *chapter 5* focuses on the results regarding intra-niche interactions.

Chapter 4: Cross-Niche Interactions

4.1 Introduction

this chapter, the results on the interactions among the three socio-technical niches are presented. In *chapter 3*, the methods were presented and this chapter showcases the research results, answering the question of how the socio-technical niches interact with each other currently and in the future. In section *4.2,* the results on the "organizational dimension" cross-niche interactions are presented, by analysing all the underlying aspects (4.2.1 – 4.2.5) and by providing a dimension overview (4.2.6). Afterwards, at *4.3*, the results on the "conceptual dimension" cross-niche interactions are presented, by analysing the underlying aspects (4.3.1 – 4.3.3) and by also providing a dimension overview (4.3.4). Lastly, at *4.4* the conclusion of the results is given.

4.2 Organizational Dimension

4.2.1 Supply

The "supply" aspect of the "organizational" dimension includes different activities for each socio-technical niche. Specifically, the three niches have distinctive production methods and consequently involve unique actors in their production processes; Insects are typically reared in food waste and are cultivated in insect farms and under controlled environments by specialized companies and farmers (Protifarm, 2020), micro-algae are cultivated in bioreactors by specialized bio-engineering companies (Duplaco, 2020) and beans are cultivated by typical crop farmers.

This was also confirmed during several interviews. A Wageningen University and Research (WUR) expert in microalgae production systems mentioned that, so far, micro-algae are mostly grown by large bio-engineering companies (A03 interview). An insect as food and feed expert stated that "the technological setups (of the three niches) are completely different and this leads to no (cross-niche) interactions whatsoever" (I02 interview). Thirdly, an employee of a large insect producing company described that all their contacts are strictly within the insect niche (I03 interview). Lastly, a beans-related food entrepreneur mentioned that her company cooperates with beans farmers, but not with any producers from other niches (B01 interview).

The previous data reveal that in terms of "supply", no producers are shared between the three socio-technical niches and therefore the cross-niche interactions are classified as neutralism.

Hypothesizing about the future of "supply" when all niches grow, larger production volumes will be achieved, probably, by utilizing more land and producers. Many agricultural producers are expected to switch their focus and become part of the alternative protein transition (I01, B01 and B02 interviews). In specific, both a project manager of the largest Dutch alternative protein transition network and an insect-food entrepreneur suggested that insect farming will continue to happen by specialized farmers and companies (O01 and I01 interviews). The WUR micro-algae expert interviewed believes that livestock farmers will switch into insect farmers and hinted that "plant farmers are already looking into beans and micro-algae as potential new crops and businesses" (A03 interview). The network project manager interviewed, stated that "growers are positive to shift into pulses" (O01 interview). Finally, all the interviewees described Dutch farmers as business people that would willingly switch to either beans or even micro-algae and insects, if there was good profit to be made.

This means that niche interactions may become different in the future. Firstly, the insects/beans niche relationships may remain neutral, as different types of highly specialized farmers will be attracted to each niche. The insect/micro-algae relationship will also remain neutral for similar reasons as the insects/beans interaction. Lastly, the micro-algae/beans interaction will be competitive, as both niches will try partnering up with a limited number of innovative and business-minded farmers or with farmers that want to co-produce crops together with either micro-algae or beans in their land.

4.2.2 Food product creation

The "food product creation" aspect includes various actors producing many different products. Starting with insects, 'De Krekerij' sells cricket burgers and cricket balls (De Krekerij, 2020), 'Good Bug Food' sells whole insects, insect powder, cricket pasta, insect pancake mix and insect chocolate (Good Bug Food, 2020), 'Kreca Ento-Food' sells whole insects and insect powder (Krecafood, 2020), 'Protifarm' sells insect-based ingredients (Protifarm, 2020), 'Tiny Foods' sells dried and flavoured insects (Tinyfoods, 2020) and several other companies sell insect-based energy bars, pastry and protein drinks. Moving to micro-algae, 'It's Greenish' sells micro-algae -based burgers (It's Greenish, 2020), 'Phycom' sells micro-algae paste, algae pellets, algae flakes and algae powder (Phycom, 2020), 'TheAlgaeFactory' sells micro-algae chocolate (The Algae Factory, 2020) and 'Duplaco' and 'Corbion' offer a variety of micro-algae ingredients used in juices, bakery, meat analogues, bakery and food supplements (Duplaco, 2020; Corbion, 2020). Thirdly, for beans there is 'Meatless' producing various meat alternatives like pate, sausages, chicken nuggets, patties and hamburgers (Meatless, 2020), 'Vegafit' produces meat substitutes like balls, burgers, schnitzels and fish sticks (Vegafit, 2020), 'Willicroft' produces dairy-free cheese and cheese sauces (Willicroft, 2020), 'Ojah' produces pea-based ingredients for multiple applications (Ojah, 2020), 'The Vegetarian Butcher' produces a wide range of meat substitutes from chicken, meatballs, burgers, bacon, croquettes and sausages (The Vegetarian Butcher, 2020) and there are also multiple other companies working on beans-based products.

Simultaneously, many of the actors involved in the three niches are organizing themselves in larger networks like the 'Foodvalley' and the 'TheProteinCluster' (TPC), which are the largest Dutch entities between the supply and consumer sides in the Dutch alternative protein transition. Foodvalley and TPC act as facilitators in organizing and building the value chains, with initiatives like the 'TPC facility map' (O01 interview). This map is an initiative of TPC to promote the sharing of industrial facilities between its members, aiming to accelerate the protein transition by fostering partnerships (Foodvalley, 2020). This initiative is relatively new and the project manager interviewed admitted that in many cases "if the facility users go to work in another company's facilities, they prefer to close themselves in a small space and work from there, to protect their innovation." (interview O01).

Moreover, three "common actors" specifically stated that the beans niche product development is currently more developed than the insects' niche, which is in turn more developed than the micro-algae one (O01, O02 and O03 interviews). These findings align with the analysis of Weele (Weele et al., 2019), presenting the beans' niche as more mature than both the insects and micro-algae ones.

The previous data suggest that the cross-niche interactions for "food product creation" are currently weak, due to both the less developed states of the insect and micro-algae niches and the reluctance of participating actors to disclose too much information on their intellectual properties. Consequently, the current cross-niche interactions for this aspect are neutralism.

To better predict the future of this aspect, it is important to account for the potential growth of all three niches. As the niches will grow, they will inevitably try to attract more actors and resources to better organize across the value chains. Multiple actors stated that they are willing to form partnerships with

other actors that share the same values with them, regardless of the niche they would operate in (interviews B01, B02, I01, I03, A02, O01 and O03). Some actors indicated that they would rather form cross-niche partnerships over internal ones, to keep protecting their intellectual properties and to ensure that their competitive advantages would last more (B01, B02, I01 and O01 interviews). Lastly, it is expected that initiatives like the "facility map" from TPC, together with potential new initiatives with the same outlook, will create more cross-niche bridges.

In conclusion, there is evidence suggesting that the three socio-technical niches might increasingly start working together, in cross-niche settings, for this part of the value chain. Consequently, all three cross-niche interactions on the "food product creation" aspect are expected to be symbiotic.

4.2.3 Market

The next aspect is "market", for which the three niches were found to be different. In section 4.2.2 the main products and product were listed. Based on global market data, bean proteins have by far the largest market among the three niches with a market capitalization of several billion, while insects and micro-algae follow with market capitalizations around a few hundred thousand million (Grandviewresearch, 2020; Grandviewresearch, 2020; McKinsey, 2020).

Zooming in on the insect "market", it was characterized as "underdeveloped" and "immature" (I02, I03 and O03 interviews). Companies like 'Kreca Ento-Foods', 'Good Bug Food', 'Protifarm' and 'Tiny Foods', all sell their products through virtual channels. 'De Krekerij' sells its products directly to restaurants (I01 Interview). In all cases, insect products have a hard time accessing the retail market (I01, I02, O01, O02 & O04 interviews). My personal experience as a regular supermarket customer confirms this finding; during a visit I made at Jumbo, Wageningen, on January 2020, I found some dried insects for sale in the organic-healthy products section, which, after a couple of days, were removed from the supermarket shelves.

Moving to micro-algae "market", the niche was also characterized as "underdeveloped" and "immature" (A02, A03, O02 and O03). There is also a limited number of product applications (A02, A03, O02 and O03 interviews). Looking at the products available, as introduced in section 4.2.2, most of the companies involved in this niche are selling micro-algae ingredients rather than consumer products. Nevertheless, an employee of a major Dutch supermarket chain indicated that they are willing to sell micro-algae products but are hesitant to introduce insects (O04 Interview).

The beans socio-technical niche, on the other hand, is perceived as "better developed" and "more mature" compared to the other two niches (B02 and O03 interviews). During a visit at the Albert Heijn supermarket at Wageningen, in March 2020, I came across dozens of products and brands utilizing beans as a primary protein source, like meat analogues, milk alternatives etc. The affluence of such products was confirmed the individual investor and the supermarket chain representative, who described the multiple beans-based alternatives existing in the market (O02 and O04 interviews).

Lastly, the supermarket chain representative, described that supermarkets are willing to experiment with all kinds of products, yet they eventually only keep selling the products with the most customer traction in the long run (Interview O04).

Combining the previous information, it becomes clear that the "market" aspect of beans is a lot more developed than of the other two niches. This translates into a well-organized network of actors and many established partnerships for beans, which is something the other two niches lack in the "market" aspect. Moreover, retailers, which are common actors for the three niches, are willing to support all

niches, if they provide them with products that have satisfactory traction. Combining the previous information, all the current cross-niche interactions can be characterized as neutralism for the "market" aspect, as the cross-niche interactions are weak or do not favour any specific niche.

To explore the future of this aspect, it is hypothesized that the three socio-technical niches will gradually further develop in the aspect studied. The supermarket chain representative revealed that micro-algae and beans have both good potential in entering the retail market, while insects do not, as their experience with insect products was not good, as customers prefer animal-free products (O04 Interview). Even the insect actors interviewed appeared to be sceptical about whether insects could be a success in the supermarkets (I01, I02 and I03 interviews). Moreover, all niches are expected to initiate partnerships with chefs and restaurants in the future, to attract consumers in their niche-products (I01, B02 and B03 interviews). The WUR micro-algae expert described that "competition for mainstream applications will increase", referring to products that many consumers use, like milk replacers and meat analogues (A03 interview). Imagining a future where product variety will grow for the niches and where all supply chains will be cost-effective, capturing and keeping consumers will become the primary goals for the three niches (I01, A02, B01, B02 and O02 interviews). Provided that consumers segmentation will remain the same, there will be vegetarian, vegan, flexitarian and omnivore consumers, with insects only being an omnivore-only option, micro-algae and beans being mainly vegetarian and vegan options and with all niches trying to attract the flexitarian group (O02, I01, I02, O04 and A03 Interviews). Lastly, it was found that the development of the two radical niches, insects and micro-algae, could switch consumer perspectives on what protein is (A01, A02 and I01 interviews).

Combining the information regarding the future of "market" with the current interaction types, dissimilar types of interactions evolve for the three niches. The data suggest that micro-algae/beans interaction might be competition, with both niches aiming to address vegans, vegetarians and flexitarians. Next, the beans/insects interaction is predicted to also be competition, as they will both aim to address the flexitarian market and to also forge partnerships with chefs and restaurants. Lastly, the future insects/micro-algae interaction cannot be classified with the data collected. In specific, contradictory results were found; on the one hand, the niches will probably compete for flexitarian consumers, while on the other both niches aim to introduce novel ideas requiring actors to change their perspectives, which could benefit both niches, thus showing symbiosis. It is, therefore, impossible to predict the insects/micro-algae interaction and monitoring future "market" aspect developments would help in defining this relationship.

4.2.4 Financial

In this section, the "financial" interactions between the three socio-technical niches are presented. All new technologies need some form of funding to develop and reach their potential. At first, the motives of alternative protein investors in the Netherlands are indicated. SHIFT Invest is a collaboration fund of Banks, Universities, NGOs and investors that supports projects aiming for positive environmental and health impact while having the potential to yield financial returns (Shiftinvest, 2020). SHIFT Invest has so far funded companies related to all three socio-technical niches, namely FUMI ingredients (Fumi Ingredients, 2020), Meatless (Crunchbase, 2020) and Protix (Crunchbase, 2020), working on micro-algae, plant and insect protein technologies respectively. This indicates that SHIFT Invest prioritizes company-specific criteria that are not related to the overall socio-technical niche.

Additionally, StartLife is a Wageningen-based hub that also provides start-ups with soft-loans of up to 100.000 euros (StartLife, 2020). StartLife currently lists companies such as Algreen (Micro-algae), Phycom (Micro-algae), The-Algae-Factory (Micro-algae), GreenFood500 (plant-based) and Rival foods (beans-based) as its members (StartLife, 2020). The StartLife intake criteria are related to social,

environmental or health impact, team formulation and innovativeness of the technology (StartLife, 2020).

Moreover, as part of the research one individual investor was interviewed. He often provides funds to early-stage start-ups and acquires a percentage of company shares in return and has so far invested his own money in companies across different niches; a cultured meat company, a pea-milk company and some plant-based meat companies (O02 Interview). This investor also mentioned that he is not investing in the insect niche based on his values and his preference for vegan products, yet he sees a lot of value for other investors doing so (O02 interview).

After examining three types of Dutch investors operating in the alternative protein niche, it is obvious that the company-specific characteristics like the technology, the founding team and the overall market (interview O02; Shiftinvest, 2020) are more important than the socio-technical niche type in accessing financial resources. What is more, multiple interviewees stated that there are currently a lot of investments happening in the three socio-technical niches (A03, I02, B02 and O03 Interviews). They also mentioned that micro-algae receive relatively fewer funds that the other two niches, but this is the consequence of the micro-algae niche being in an earlier state than the other two niches and they need more time to develop, rather than more money (A03, I02, B02 and O03 Interviews).

All the previous evidence suggests the current cross-niche interactions of the three socio-technical niches for "finances" are classified as neutralism, as the factors influencing access to financial resources are company-specific and not niche-specific.

Hypothesizing on future of this aspect, two key interviewees, the individual investor and the WUR alternative protein research coordinator, indicated that the financial resources that will be invested in alternative protein technologies in the future will come mainly from the yield of the investments made now, e.g. on plant-based meat and milk alternatives (O02 and O03 interviews). So far, there have been several successful investments in plant-based companies, like in the cases of Beyond Meat (Marketwatch, 2020) and Impossible Foods (CNBC, 2020). According to the individual investor, this has so far helped other alternative protein niches to grow, as the previous profits have been re-invested in less developed alternative protein niches (O02 Interview).

Predicting the future of the "financial" aspect is complex and constant research on the future investments that will be made in the three socio-technical niches required. Nevertheless, this research enables some assumptions on the future of this aspect for the three niches. The niches will interact in dissimilar ways; The future beans/insects and beans/micro-algae interactions are classified as commensalism, as the beans niche is more mature and better established than the other two and therefore the micro-algae and insect niches could financially benefit from its success. The future insects/micro-algae interaction is more complicated, as both are radical alternatives and both will need time to develop; therefore, the relationship cannot be accurately characterized by the data collected.

4.2.5 Research

The last aspect of the organizational dimension is "research". Universities were found to be key research partners for many of the interviewees and specifically WUR (O04, I03, I01, A01, A02 and B02 interviews). In specific, WUR researches all three protein alternatives (WUR, 2020) and has also published an e-book report with the title "Chickpeas, Crickets and Chlorella: our future proteins" (WUR, 2019). Furthermore, on the 6th of February 2020 and on the 30th of September 2019, WUR organized the "Protein Transition Community Days" to connect researchers among different disciplines to exchange ideas and speed up the transition (Protein Transition Community Day - WUR, 2020).

I have personally participated in the community day of the 6th of February 2020 and I got to witness the type of interactions occurring in this event. Researchers from different scientific disciplines but all working on the protein transition participated and some participants even presented their work. The presentations were mostly focused on highly technical aspects and consequently, the question rounds were monopolized by individuals working in the same alternative protein niche or discipline as the speaker. Afterwards, several networking activities were planned to create cross-niche connections. During a specific networking activity that tried to map the existing connections in the room, it became obvious that most participants attending the community day had limited connections to their peers that were working on different alternative protein niches. As part of the networking activities, and to encourage cross-niche partnership formation, the organizers hosted a "networking lunch". During the lunchtime, I kept observing the participants' behaviour. I then saw most participants moving into the lunch venue in pre-formed groups, with which they stayed throughout the entire lunchtime. I interpreted this emerging behaviour as if the participants preferred to stay with their colleagues and the people they were already acquainted with. Therefore, even though the organizers planned for cross-niche networking to happen, most participants were reluctant to initiate such connections.

Moreover, during the interview with the WUR coordinator for alternative protein research, she indicated that the three niches have different research needs, except two common needs for making the protein extraction process more efficient and for finding successful consumer product applications (interview O03). Moreover, universities were found to play an invaluable role in creating new knowledge mainly on production systems, which is to a large extent niche-specific and for which there is almost no value in exchanging across niches (A02, I03 and B02 interviews).

Researchers do not currently exchange knowledge with their peers from other niches, as they are researching highly niche-specific topics, e.g. production systems. Consequently, the current cross-niche interactions for the "research" aspect are all classified as neutralism.

For the future of this aspect, it is firstly important to predict future research needs for the alternative protein niches. As mentioned, current research revolves mostly around production systems and technical aspects. However, hypothesizing that the three niches will gradually become more developed, research on commercial applications aspects, like consumer and retail perceptions, marketing, sales etc. would essential. This kind of research would probably be conducted by similar actors for all the three niches. Based on these hypotheses, the predictions for the future of this aspect are split into two types of research: commercial and technical.

In terms of technical research, several interviewees believe that no converging is expected to happen. The insect expert described that the technical setups in place are fundamentally different (O02 Interview). The same notion was communicated by the micro-algae expert, who stated that technical aspects cannot be combined or researched together and described how a project initiative aiming to bring insects and microalgae technical innovation together eventually ended up leaving insects out, due to the technologies not being comparable (A03 Interview).

Hypothesizing on commercial research needs, the three niches might end up having similar research needs. There is a shared need for the three niches to "conduct research on product development and consumers/marketing" (O03, O01, I03, B03, A02 interviews). Lastly, the micro-algae expert mentioned that she is convinced that in the future "the three niches will compete for mainstream applications, which will inevitably lead to more competition (to develop them)" (A03 interview).

Connecting the data regarding future developments on "research", the cross-niche interactions will be heterogeneous. For technical research, the three niches interactions will be neutralism, due to the

fundamentally different technical setups. However, for consumer and product development research, the cross-niche interactions will be competition, as the three niches will increasingly research that they will try to keep for themselves, to create competitive advantages against the others. It is, therefore, not possible to classify the future "research" aspect of the transition entirely using the typology developed.

4.2.6 Overview on Organizational Dimension

At this point, an overview of the interactions found in the entire "organizational dimension" is presented. All the results for the interactions on this dimension can be seen in figure 3. The results on the current state of the "organizational" dimension, as seen in figure 3, show that all the interactions across all five aspects are classified as neutralism. This result was unexpected and contradictory to my initial hypothesis, as I had initially expected to find a variety of interaction modes. The reasoning behind this unexpected emergent commonality is provided in the following bullet points:

- The "supply", "food product creation" and "market" aspects for micro-algae and insects were found to be underdeveloped. This translates into weak external interactions for the insects and micro-algae niches with the other niches and makes them unable to influence other niches' development pathways.
- For the "research" the mode of interactions is also neutralism across niches, but for different reasons. It was found that, currently, the micro-algae and insects niches' "research", aims at creating more efficient production systems. Therefore, since the technological domains involved in the production phase of each niche are fundamentally different, the three niches actors' do not interact with each other and their development pathways are not interacting.
- The "finances" aspect is, again, neutralism for all three socio-technical niche interactions. This is supported by the fact that investors prioritize the technological innovativeness and the team when making investment decisions, rather than the socio-technical niche the project is developed in.

Furthermore, the socio-technical niche interactions of the "organizational dimension", could potentially change in the future. This was finding was expected as the existing literature, as seen in *chapter 2*, already describes transitions as dynamic processes changing over time. Before analysing the results for the future of this dimension, it is important to indicate that the mode of interactions found is mere suggestions on the potential interactions' pathways, and not solid predictions, as this would be beyond the scope of this research.

The first important conclusion derived from the results, as shown in ***figure 3***, is that the three interactions are heterogeneous in terms of their underlying aspects. Specifically:

- The expected future micro-algae/insects interaction is neutralism for the "supply" aspect, symbiosis for the "product creation aspect" and a heterogeneous mixture of competition and neutralism for the technical and consumer parts of the "research" aspect. The data for the other two aspects were insufficient and no assessment could accurately be made.
- The future suggested for the micro-algae/beans interaction is competition for the "supply" and "market" aspects, a symbiosis for the "food product" creation aspect, commensalism for the "finances" aspect and a heterogeneous mix of competition and neutralism for the technical and consumer sides of the "research" aspect.
- Lastly, for the insects/beans interaction, the "supply" aspect was classified as neutralism, the "food product creation" as symbiosis, the "market" one as competition, the "finances" one as commensalism and the "research" aspect was a mixture of competition and neutralism for the technical and consumers parts.

It is evident that none of the three interactions is homogenous, but rather the aspects studied are classified in different ways. However, looking into the potential future interactions per aspect, as showcased in *figure 3*, some commonalities emerge. Specifically:

- The future "food product creation" aspect is suggested to be symbiosis for all three interactions.
- The future "research" aspect classification is, potentially, also similar for all three interactions, defined as neutralism for technical "research" and competition for consumer "research".
- The future "market" aspect of the beans/micro-algae and the beans/insects interactions is suggested to be competition for both, while the third interaction is unclassified.
- The future "finances" aspect is expected to be commensalism for both the beans/micro-algae and beans/insects interactions, while the third interaction could not be classified.
- Lastly, the "supply" aspect was heterogeneous, as the micro-algae/beans interaction is suggested to be competition, while the remaining two could both be neutralism.

The data reveal that for four out of the five future aspects, the micro-algae/beans and insects/beans interactions are expected to interact in similar ways. This result is justified by the fact that both micro-algae and insects are radical and underdeveloped technological niches. Comparing the future of these niches against beans, which are already an established technology and taking the extreme uncertainty around these radical niches, the expected development pathways are naturally expected to be parallel to each other. This does not mean that the interactions are expected to be identical, but rather that they are expected to develop over time in almost parallel courses. This finding is also supported by the inability to define two of the five future aspects of the insects/micro-algae interaction and also the fact that the three interactions that could be predicted were classified in entirely different ways, as symbiosis, competition and neutralism (figure 3).

Dimension	Aspect	Insects - MicroAlgae	MicroAlgae - Beans	Beans - Insects
Organizational	Supply	**Currently:** Neutralism // **Future:** Neutralism	**Currently:** Neutralism // **Future:** Competition	**Currently:** Neutralism // **Future:** Neutralism
	Food Product Creation	**Currently:** Neutralism // **Future:** Symbiosis	**Currently:** Neutralism // **Future:** Symbsiosis	**Currently:** Neutralism // **Future:** Symbiosis
	Market-Channels	**Currently:** Neutralism // **Future:** Unclear	**Currently:** Neutralism // **Future:** Competition	**Currently:** Neutralism // **Future:** Competition
	Research	**Currently:** Neutralism // **Future:** Neutralism(technical) - Competitive(consumers)	**Currently:** Neutralism // **Future:** Neutralism(technical) - Competitive(consumers)	**Currently:** Neutralism // **Future:** Neutralism(technical) - Competitive(consumers)
	Finances	**Currently:** Neutralism // **Future:** Unclear	**Currently:** Neutralism // **Future:** Commensalism (In favor of Micro-algae)	**Currently:** Neutralism // **Future:** Commensalism (In favor of **Insects**

Figure 3: Organizational dimension overview of results.

4.3 Conceptual Dimension

4.3.1 Descriptive schemata

The first aspect studied as part of the conceptual dimension is "descriptive schemata". It was previously mentioned in 4.2.2, 'TPC' is a network promoting the protein transition through knowledge exchange and partnership building. 'TPC' does this through the facility map and by hosting various events (The Protein Cluster, 2020) for its members, to promote knowledge sharing throughout the network. Furthermore, WUR and specifically the alternative protein research coordinator interviewed, actively encourage peer learning among all three niches with activities like the "Protein Transition Community Days" (WUR, 2020) and the "reThink Protein Challenge" student competition (WUR, 2020).

Moreover, a production system expert and a start-up founder working with micro-algae acknowledged the other two niches as valuable sources of product development knowledge (A02 and A03 interviews). The representative of a large insect production company pointed out that "cross-niche learning in the product-development phase happens" (I03 interview), but not so much for the production setups, as each involves completely different domain-specific knowledge (I02 and I03 interviews). An employee of a company and the founder of a start-up working with beans stated that they are learning from other niches, yet they are reluctant to share too much of their knowledge (B01 and B02 interviews). Lastly, the founder of a beans-related company talked about the shared need to better understand the customer needs and create better products, which can be achieved through niches' knowledge exchange (B03 interview). Lastly, the previous data must be then combined with the fact that the beans niche is more developed compared to the other two, that is only now starting to build their knowledge (O01, O02 and O03 Interviews).

In total, the current "descriptive schemata" interactions are dissimilar. The micro-algae/beans relationship is characterized as neutralism, as micro-algae possess mainly technical knowledge, for which there is no value to exchange with the beans niche. The current insect/beans interactions are characterized as commensalism, as regardless of their different technological setups, insects currently benefit from the product development knowledge created in the beans niche. Lastly, the insects/micro-algae interaction for this aspect is neutralism, as both niches focus mainly on technological aspects, for which knowledge is not shared due to the different technological setups.

Hypothesizing about the future of "descriptive schemata", things are expected to change. In specific, two major trends reoccurred throughout all the interviews: firstly, all actors interviewed expect the pluralism of protein alternatives to help in changing the established regime and secondly, multiple niche actors admitted that they will increasingly share their knowledge with outsiders, but not so much internally. Moreover, in the future, all three niches are predicted to create deeper knowledge in all parts of the value chain.

To conclude, the following cross-niche interactions are suggested for the future; Firstly, the insects/micro-algae and beans/insects future interactions are predicted to be symbiotic, due to the expected increased cross--niche knowledge transfer for product development and marketing disciplines. The future beans/micro-algae future interaction will probably be more complicated; beans are expected to always be ahead of micro-algae. This relationship could take the forms of parasitism, commensalism or even symbiosis, yet the available data are not sufficient to accurately determine it.

4.3.2 Normative schemata

The next aspect to be studied is the "normative schemata". To start with, all Dutch companies producing food products must abide by the food safety laws of the EU and the Netherlands, which are almost the same for the three niches and therefore no further focus is given in this topic. However, the three socio-technical niches deal with the Novel Food Regulations in different ways. "Novel Food is defined as food that had not been consumed to a significant degree by humans in the EU before 15 May 1997, when the first Regulation on novel food came into force. 'Novel Food' can be newly developed, innovative food, food produced using new technologies and production processes, as well as food which is or has been traditionally eaten outside of the EU (European Commission, 2020). Some types of micro-algae, a few types of beans and all insects are affected by these regulations (I01, A03, A01, I03, O01, O03 and B02 Interviews). Describing in detail food safety matters was beyond the scope of this research and emphasis was given to the perceptions of actors of the three niches regarding Novel Food Regulations. All the interview (all interviews) data collected point unanimously in the following findings:

· ‘Novel Food’ regulations are currently a major hurdle for the insect niche, a moderate hurdle for the micro-algae niche and not a hurdle for the beans niche.

· Niche actors deal with regulations and norms internally and they do not see value in peer learning or knowledge transfer.

· Niche actors acknowledge the value of passing through these regulations, yet they believe that the procedure must be faster and less expensive.

All the previous information indicates that currently there are no cross-niche interactions and therefore the current “normative schemata” cross-niche interactions are classified as neutralism. Furthermore, there are no indications that this situation will change in the future, as all interviewees expect it to stay the same and no data point elsewhere. Consequently, all the future cross-niche interactions for this aspect are also predicted to be neutralism.

4.3.3 Concepts

The last aspect of the “conceptual dimension” is “concepts”. To start with, multiple participants of the Foodvalley Summit that I interacted with described that “there is enough space for all protein alternatives” and that their goal is to change the established protein regime. This finding was initially repeated by many actors that I interviewed that characterized themselves as “pro-protein transition” (B02, I01, B03, I02, A01 and A02 interviews). Even though these data initially pointed into one direction, future findings throughout the interviews were contradictory. An example was that during the Summit, a representative of a micro-algae company initially stated that all three niches are valuable to the transition but then proceeded in describing how micro-algae is the only truly “sustainable” alternative and has the largest potential of all niches. The same observation emerged multiple times, with interviewees from all niches providing me with “politically correct” initial answers, but when they talked about which niche is more “sustainable”, has larger “potential”, is a “healthy option” or is better because it is “animal-free”, every interviewee picked the niche she was more involved in (I01, I02, I03, A01, A02, A03, B02 and B03 Interviews).

Moreover, research on the language that different actors use on their websites to characterize their products, technologies and niches overall generated similar findings. A comparison of three company websites, one per niche, was made; Firstly, Phycom, a micro-algae company, uses the terms “animal-free”, “plant-based”, “sustainable”, “efficient”, “healthy” and “nutritious” to describe its products(Phycom - We bridge the food gap, 2020). Secondly, Protifarm (insects), uses the terms “efficient”, “sustainable”, “nutritious” and “healthy” to describe its own (Who we are - Protifarm, 2020). Lastly, Vegetarian Butcher (beans) uses the terms “animal-free”, “sustainable”, “efficient”, “plant-based” and “healthy” (The Vegetarian Butcher - About us, 2020). Therefore, a repetition of the same keywords regarding conceptual characterizations of the niches is evident.

The previous data indicate that all the cross-niche interactions for “concepts” are classified as competition. Specifically, all niches compete against each other for the “sustainable” and “healthy” concepts and insects compete against both micro-algae and beans for the “animal-based” versus “animal-free” characterizations. Lastly, micro-algae and beans compete against each other for acquiring the “vegan” and “animal-free” characterizations.

Hypothesizing about the future of this aspect, all three niches will possibly grow further and consequently more competition for acquiring consumers and partners like growers, retailers and chefs will happen. Moreover, for niches to create partnerships or to acquire customers, they will probably use

these characterizations to benchmark themselves against other niches and competitors, as it is also currently done. Furthermore, no other interview data provided insights that the future of this aspect will change. Therefore, the future of the cross-niche interactions for "concepts" is hypothesized to also be "competition".

4.3.4 Overview on Conceptual Dimension

After analysing the three aspects of the "conceptual dimension", an overview is provided. The results concerning both the current and future of this dimension can be seen in ***figure 4***. Starting with the current interactions, it was found that the underlying aspects for all three interactions were heterogeneous to each other, for both the current state of the interactions and their expected future states. This was again an unexpected finding, as mentioned in section *4.2.6* of this chapter. The initial hypothesis was that the three interactions would be homogenous for their "conceptual dimensions", yet it was disproved. The major reason contributing to this is that the "concepts" aspect is competition for all three interactions, while "descriptive schemata" and "normative schemata" were both neutralism for both insects/micro-algae and micro-algae/beans. Meanwhile, beans-insects was completely heterogeneous, with each aspects being classified as commensalism, neutralism and competition for the "descriptive schemata", "normative schemata" and "concepts" aspects respectively. Overall, this indicates that the interaction of two niches for the "conceptual dimension" is not cohesive, but rather a bundle of various underlying dynamics, as measured by the aspects.

Furthermore, looking at the results presented in ***figure 4*** with an aspect focus, some commonalities emerged:

- The current "concepts" aspect is classified as competition for all three interactions. This has to do with the fact that the three niches were found to compete for several conceptual labels, having to do with the benefits they provide. These labels are used by all niches actors to benchmark the one niche against the other for concepts like sustainability, efficiency, health benefits etc.
- For the "normative schemata" aspect, all the current interactions are neutralism. This finding is justified by the niches' handling legislative issues only internally, without other niches interfering.
- The third aspect is different for the beans/insects interaction and the other two interactions. Currently, insects are in the process of starting to develop products and are using some of the knowledge that has already been created by the beans niche, making the interaction commensalism. On the other hand, the other two interactions are neutralism, as the micro-algae niche is still in an underdeveloped phase, and creates its knowledge internally.

Looking at the commonalities formed in examining the current interactions per aspect, the first outcome is that insects-micro-algae and micro-algae beans "conceptual dimension" interactions are analogous, meaning that the same modes of interaction were found per aspect. Moreover, the beans-insects interaction is also similar to the other two for the "normative schemata" and "concepts" aspects. The results, therefore, indicate that a commonality of neutralism interactions for "descriptive schemata" and "normative schemata" and competition for "concepts" is formed for all interactions of this dimension. The only exception is the commensalism mode of interaction between beans and insects, which is explained by the insects' niche currently benefiting from the beans niche product development knowledge.

Assuming about the future of this dimension, the future "normative schemata" aspect will remain neutralism and the future "concepts" aspect will remain "competition". On the contrary, the "descriptive

schemata" aspect is expected to be different. For both beans/insects and insects/micro-algae "descriptive schemata" interactions, the expected future is a symbiosis, while for the micro-algae/beans not sufficient data were collected and the interaction cannot be determined. It is again impossible to classify the entire future interactions for the "conceptual dimension", even though an almost identical typology of symbiosis for "descriptive schemata", neutralism for "normative schemata" and competition for "concepts" emerges.

The expected shift on the mode of interaction on the "descriptive schemata" aspect, while "normative schemata" and "concepts" are expected to stay the same, has to do with the fact that the latter aspects have already found an equilibrium point, as legislation and conceptual labels were developed first. Meanwhile, knowledge and expectation, covered by the "descriptive schemata" aspect, are constantly shifting over time and are points of interaction that are just now starting to occur.

Dimension	Aspect	Insects - MicroAlgae	MicroAlgae - Beans	Beans - Insects
Conceptual	Descriptive Schemata	**Currently:** Neutralism // **Future:** Symbiosis	**Curently:** Neutralism // **Future:** Unclear	**Curently:** Commensalism (in favor of insects) // **Future:** Symbiosis
	Normative Schemata	**Currently:** Neutralism // **Future:** Neutralism	**Curently:** Neutralism // **Future:** Neutralism	**Curently:** Neutralism // **Future:** Neutralism
	Concepts	**Currently:** Competition // **Future:** Competition	**Curently:** Competition // **Future:** Competition	**Curently:** Competition // **Future:** Competition

Figure 4: Conceptual dimension overview of results.

4.4 Conclusion

To conclude, in this chapter, the results regarding the cross-niche interactions of the three socio-technical niches are presented. In this section, the results will be summarized and some conclusions will be made.

In terms of the "organizational dimension", all the current cross-niche interactions were classified as neutralism. Gradually, these modes of interactions are expected to change in dissimilar ways, meaning that there will be multiple contradictory interactions within the "organizational dimension" of each interaction. This heterogeneity means that characterizing the interaction between the niches with only one term from the typology suggested by Sanden and Hillman (2011) is impossible. In some cases, it was even hard to classify the interaction within one underlying aspect, as with the case of the expected future interactions on the "research" aspect. Moreover, the results on the "organizational dimension" of the niche interactions studied showed that even if the interactions between the niches are expected to be heterogeneous, the underlying aspects of the three niches are expected to be mostly homogeneous for all interactions. For example, for all three interactions, the "food product creation" aspect was found to be symbiosis. The homogeneity on the cross-niche interaction aspects for the "organizational dimension" relates to the actors' perceptions on the expected futures of the transition, meaning that they can expect the socio-technical niches to work together, compete and copy each other's techniques in creating networks and moving resources, or to even be neutral in other aspects. This heterogeneity also relates to the level of maturity and technological readiness of the niches, which is why in the case of the two radical technologies, micro-algae and insects, it was hard to find and interpret the given data to classify the expected future interactions.

In terms of the "conceptual dimension", the current interactions between the niches were classified in different ways. This heterogeneity connects mainly to the different elements included in the "conceptual dimension", indicating that, again, the typology framework of Sanden and Hillman (2011) cannot be applied at a dimension-level. This typology worked well in defining the underlying aspects within the

dimensions though. Therefore, comparing the three interactions classifications per aspect forged some similarities for the most part on both current and expected future modes of interactions. This relates to the fact that in terms of each aspect, niche actors seemed to hold really strong opinions and to have already figured out how they perceive and are perceived by other niches. The best confirmation of that is that in most cases, as seen in the "concepts" and "normative schemata" aspects, the cross-niche modes of interaction types will remain the same the interactions are also expected to become stronger than they currently are.

Comparing the two dimensions, some overall conclusions can be made. Firstly, in terms of the two dimensions, it became obvious that the "conceptual dimension" is better developed than the "organizational" one. It can be logically assumed that newly-formed socio-technical niches, like insects and micro-algae, do not interact intensely with other niches. Based on the results, it is suggested that the "conceptual dimension", meaning the perceptions, expectations, regulations concepts etc., is formed earlier than the "organizational" one. This assumption also explains why this study that focused on two newly-developed niches, found the cross-niche interactions for the "organizational dimension" as neutralism with a heterogenous expected future and the "conceptual dimension" as heterogenous that will only grow stronger in the future.

Secondly, the typology provided by Sanden and Hillman (2011) is a good analytical tool for classifying interactions at an aspect-level, but not at a dimension-level. This can be justified by the fact that TIS literature studies interactions in a long period and usually after the equilibrium points of the transition have been found. Conversely, this research studies a transition in the making, between novel socio-technical niches that in the cases of insects and micro-algae have still significantly underdeveloped aspects. This closer look into the cross-niche interactions of the three niches hence reveals micro-interactions and dynamics that are missed by the macroscopic approaches like TIS, SNM and MLP.

Lastly, the findings of this chapter revealed that the three socio-technical niches studied have strong intra-niche interactions that, even if they were not anticipated in the original research plan, were also studied. The results for the intra-niche interactions are presented in the next chapter (chapter 5). Lastly, applying this framework for studying cross-niche interactions in an ongoing transition, generated insights into the theories used. These insights will be further elaborated in the "Conclusion and discussion" part (chapter 6).

Chapter 5: Intra-Niche Interactions

5.1 Introduction

In this chapter, the research findings on the intra-niche interactions of the three socio-technical niches are presented. In specific, the intra-niche interactions of the insects are presented first at 5.*2*. In 5.*3*, the intra-niche interactions of micro-algae are presented. The beans internal interactions results are provided in *5.4* accordingly. Lastly, in *5.5*, the conclusion of *chapter 5* relates the results of the three niches against each other and provides an overview of intra-niche interactions.

5.2 Insects

In this section, the intra-niche interactions of the insect niche are analysed, starting from the "organizational dimension" of insects and then focusing "conceptual dimension".

Regarding "supply", an insect expert illustrated a competitive internal relationship between small-scale and large-scale insect farmers (I02 Interview). In specific, he explained that "small-scale farmers are not receiving any help to set their insect rearing businesses" and "large farmers do not want to help them as they perceive them as competitors and would rather make these small-scale farmers their employees". Concerning "supply" and "food product creation", there are some networks in which actors participate in, like the 'Foodvalley', that was extensively analysed in *chapter 4, section 4.2.2*. There are more insect-specific network initiatives, like the Insector and the Dutch association of insect rearers called 'VENIK' (I01 and A01 interviews). The Insector exists to bring together actors from across the value chain and of facilitating knowledge exchange and partnerships creation, while 'VENIK' focuses on efficient farming practices (I01 interview; Venik, 2020). Nevertheless, in these networks, "supply" actors were found to not collaborate, but rather with actors from other parts of the value chain, as found by analysing the partners listed on two prominent "supply" actors websites; Protifarm lists networks ('ipiff', 'VENIK' and 'Foodvalley'), research institutes ('Danish Technological Institute', 'Eurofins', 'DIL', 'WUR', 'Utrecht university', 'has Hogenschool' and 'Maastricht University') and FAO as its partners (Protifarm, 2020). Protix lists financial support institutes ('Europees Innovatieprogramma' and 'WWW.ec.europa.eu/ agriculture'), technology companies ('Buhler', 'Hendrix Genetics'), food companies ('Fair Insects') and research institutes ('WUR', 'Norwegian University of Life Sciences', 'Deutsches Institut für Lebensmitteltechnik' and 'Università Di Pisa') as its partners (Protix - Partners Archive, 2020). In both cases, there was no reference to partnerships with other producers. Overall, the competitive spirit between large and smaller-scale farmers and the lack of collaboration between large companies or with smaller producers suggest this aspect to be competition.

The next aspect is "food product creation". An insect start-up entrepreneur described that "Two years ago, people were asking 180 euros per kilo of raw insects and now it is around 15 euros and that "The cost price is not even one-tenth of that and it will change more in the next years" (O01 interview). This shows that insect products will potentially have lower costs of production and eventually lower end-product prices. Additionally, as indicated in section in *4.2.2*, after content analysis of the products that food companies produce, it was found that the companies currently offering insect products, like dried insects, protein powder, insect flour and protein bars, have almost identical products with each other. Based on previous research in the Dutch insect industry, it was found that food companies aim to create successful product applications and provide products at the lowest prices possible, to succeed in the market (House, 2018). The results regarding this aspect, show no cooperation between actors and suggest a potential competition between actors to create new and cheaper products. Therefore, in terms of the "food product creation" aspect, internal competition is suggested.

In terms of the "market" aspects, several interviewees operating in the insect niche, as well as the supermarket chain representative, said that insect products do not have good access in supermarkets (I03, I02 and O04 interviews). Moreover, the insect expert mentioned that this forces companies to sell their products in alternative channels, like the internet (I02 interview). The supermarket chain representative also mentioned that their customer base prefers animal-free products and thus they do not see any insect products viable options for their stores (O04 Interview). The previous data suggest limited access of insect products to retail channels. In addition to that, the "market" part of the value chain, was found to be currently underdeveloped, with too few actor interactions existing at this level (interviews O01, O03, I01, I02 and I03). This creates a situation, where the insect products do not access retail channels and not many consumers purchase them. This aspect is suggested to still be underdeveloped and companies try to create novel products to better develop their "market" part (interviews O01 and I03). Overall, this aspect seems to still be underdeveloped and it is suggested that actors work independently in developing in terms of the "market". Therefore, this aspect is suggested to be neutralism.

The fourth aspect of the organizational dimension is "finances", yet not any relevant data were found for this aspect and it is impossible to define this aspect without more research.

The last aspect of the "organizational dimension" is "research". Previously in this section, it was mentioned that both Protix and Protifarm cooperate with universities or research institutes to carry out research projects. Various interviewees, both ones operating on the insect socio-technical niche and other 'common actors' for all three niches, stated that universities have a crucial role in creating knowledge that benefits the entire niche, by researching topics that are too big for one actor to research by himself (I02, I03, O01 and O03 interviews). A primary example of this relationship is the annual "Summer School – Insects as Food and Feed", an educational event targeted to insect industry professionals hosted by WUR, in which multiple industry actors, even competitors, participate (Summer School Insects as Food & Feed - WUR, 2020). Consequently, the results gathered for this aspect, suggest a symbiosis interaction concerning the insect niche internal interactions for the "research" aspect.

Moving to the "conceptual dimension" the first aspect is "descriptive schemata". In specific, the insect expert and the network project manager interviewed, mentioned that insect producers use patents to protect the knowledge they create internally from being used by their intra-niche competitors, especially regarding production systems and product creation (interview I02 and O01). This is evident in the case of Protifarm, which is a large insect producer. During the interview with its representative, he specifically stated that some aspects of what they do are protected by patents (Interview I03). The same statement is also made explicitly in the company's website, where it is mentioned that "Our (Protifarm) controlled rearing environment as well as our processing technology platform is covered by a range of patents, granted and pending" (Research & Development - Protifarm, 2020).

Combining the previous information, it is suggested that the insect intra-niche interactions for "descriptive schemata" are competition.

Secondly, in terms of "normative schemata", insects face significant issues regarding 'Novel Food' regulations (O01, O03, I01, I02 and I03 interviews). The process of approval regarding these regulations was characterized as too costly and too slow (I01, I02 and I03 interviews). Nevertheless, actors of the insect niche were found to cooperate, as legislation change is a slow process and a big hurdle for all of them, as none can address them as an individual entity (I01, I02 and I03 interviews). The Internal Platform of Insects as Food and Feed is the major stakeholder representing insect niche actors and

pushing for legislative changes at a European level (IPIFF, 2020). Overall, the intra-niche interactions for "normative schemata" are suggested to be symbiosis.

The last aspect to be analysed as part of the "conceptual dimension" is "concepts". It has been previously described in section *3.3.3*, based on content research of insect actors websites, that the concepts used for the insects' niche are "efficient", "sustainable", "nutritious" and "healthy" (Protifarm, 2020; I01, I02, I03, O01 and O03 Interviews). All insect niche interviewees mentioned the importance of educating consumers on the advantages of insects, which could, in turn, benefit the entire niche (I01, I02 and I03 interviews). Moreover, the websites of Protix, De Krekerij and Protifarm, all indicate the need for insects to become more widespread as a niche-innovation, and not specifically their products (Protix, 2020; De Krekerij, 2020; Protifarm, 2020). Consequently, niche actors have a common incentive to work together for this aspect, to make insects be perceived as a viable protein alternative. The interactions for this aspect are suggested to be symbiotic.

5.3 Micro-algae

In this part, the micro-algae socio-technical niche internal interactions are presented. Starting with the "organizational dimension", a general observation regarding all its aspects, coming from a representative of a major micro-algae platform, was that "the micro-algae supply chain is, currently, fragmented and there is a significant distance between the actors involved" (A01 interview).

Starting with the "supply" aspect, it was characterized as the best-developed one compared to other parts of the value chain for this niche (O03, A01 and A03 interviews). Nevertheless, many critical aspects of the "supply" part of the value chain were still found to not yet be adequately developed; for instance, according to an expert in the micro-algae field, there are still no specialized stakeholders to treat the biomass produced in algae farms (A03 interview). Under the current conditions, there is a significant amount of production companies and micro-algae producers focusing primarily on their technologies aiming to improve the production yields (A02 and A03 interviews). In doing so, the actors seem to work individually. For example, doing content analysis on the website of 'Phycom', a leading Dutch micro-algae producing company, the company lists research institutes (WUR), networks (Micro-algen platform, Feed design lab and Aqua Valley) and the National Sports Centre Papendal as its partners, while no other producing company is listed (Phycom, 2020). Overall, the previous data indicate that even if "supply" actors have a common goal to make production more efficient, they work towards achieving it individually, without interacting. Therefore, this aspect is suggested to be neutralism.

The next aspect is "food product creation". Regarding this aspect, multiple actors described the immature state it currently is in (A01, A02, A03, O01, O03 and O04). A micro-algae production expert specifically mentioned that "micro-algae companies are very secretive (in this aspect), even if the overall niche is very immature, and this makes progress slower" (A03 interview). The founder of a micro-algae production company stated that he works together with other companies creating food products, but that these companies work individually from each other (A02 interview). The company 'it's Greenish', creating meat substitutes made with micro-algae, only lists 'veganisme' as a partner in its website (About us, 2020). Adding all the previous points together, it is suggested that the interactions between the "food product creation" actors are inexistent or weak, making this aspect's internal interaction classify as neutralism.

The third aspect is the "market". This aspect was described as "immature" and "underdeveloped" (A01, A02, A03, O01, and O03 interviews). The micro-algae production expert mentioned that "there is a lot of interest from the vegetarian and vegan community (for micro-algae)" (A03 interview) and the

supermarket-chain representative stated that "we (the supermarket) want to have more micro-algae products" (O04 interview). Moreover, the founder of a micro-algae start-up mentioned that the current price for micro-algae products is quite expensive, with the products having a premium character, which makes market penetration hard (A02 interview). The micro-algae production expert described the supply and demand of micro-algae as a self-feeding cycle; increased demand will also drive production up and prices down and these will eventually create more demand (A03 Interview). Combing the above information, it is suggested that more market demand operates as a pull factor for the entire niche to grow, yet no interactions are in place. Therefore, "market" is suggested to be neutralism.

The following aspect is the "financial" one. Throughout the research, the data collected was not sufficient to explore this aspect and therefore the classification of the intra-niche interactions cannot be made. More research on micro-algae funding is required to better understand this aspect.

The last aspect of the organizational dimension is "research". All the micro-algae actors mentioned universities and specifically WUR a key research partner (A01, A02 and A03 interviews). The micro-algae production expert indicated that in several research projects she has participated, multiple microalgae stakeholders have participated (A03 interviews). The focus of current research is mainly the improvement of production facilities to increase micro-algae yield and this technology is mostly protected via patents (A01, A02 and A03 interviews). The data collected are contradictory and thus no classification can be made accurately, showcasing the need for the collection of more data.

Moving to the "conceptual dimension", the "descriptive schemata" is the first aspect to analyse. As it was briefly touched upon in the "research" aspect analysis of this section, several micro-algae niche actors create their knowledge. Multiple actors that were interviewed stated that this knowledge that actors create, is not shared with other niche actors, even in the cases where actors participate in the same conferences and networks (01, A02, A03, O01, O03). This reluctance to share knowledge is translated as a protection mechanism, where actors try to hold their competitive advantages against each other (A01, A02 and A03 interviews), regardless of whether the niche is too small for the competition to matter (A03 interview). As a participant of the 'Foodvalley Summit', my observations also confirm the previous interview findings. Specifically, when I had a small discussion with a micro-algae producing company representative at the booth they had in the event venue, she was very much willing to discuss the product properties. However, when I asked more questions about the process of productions and what is it that makes their products unique, I was told that many of this information is protected by patents and it is information they cannot share out of the company. Therefore, the actors seem to be protective and competitive with their knowledge and consequently, intra-niche interactions for this aspect are suggested to be competition.

The second aspect presented is "normative schemata". Micro-algae were found to face some issues regarding regulations, as many micro-organisms that are classified as micro-algae have to go through the 'Novel Food' regulations (O03, A01, A02 and 03 interviews). Dealing with 'Novel Food' regulations were characterized to be too expensive and too slow for the individual actors to manage by themselves (A01, A02, A03 and O03 interviews). Therefore, several actors were found to formulate larger entities, such as networks, to collectively surpass this barrier, which in the end would benefit them all (A01, A03 Interviews). Looking at the website of 'Micro-Algen Platform', a micro-algae specific network with a focus to promote the niche's position in the market, it is mentioned that communicating with the government and tackling legal barriers are among its primary roles (Micro-algen platform, 2020). Overall, all the previous data support the notion that niche actors work together for improving the position of the entire niche and therefore the intra-niche interactions for this aspect are classified as symbiosis.

The last aspect of this dimension is "concepts". As mentioned in *chapter 4*, and as indicated by Weele (Weele et al., 2019), the micro-algae niche requires many changes in consumer perceptions regarding what is a protein (A02, A03). Moreover, the concepts "animal-free", "plant-based", "sustainable", "efficient", "healthy" and "nutritious" are used in connection to micro-algae, as mentioned in section *4.3.3*. All the interviewed actors of this niche described that educating consumers and partners on the benefits of micro-algae, is a common goal that would inevitably benefit them all (A01, A02, A03 Interviews). Therefore, micro-algae actors understand the mutual benefit of helping each in terms of "concepts" and the suggested mode of interaction is symbiosis.

5.4 Beans

Lastly, the intra-niche interactions of the beans socio-technical niche are presented, starting with the "organizational dimension" and in specific with the "supply" aspect. This aspect is characterized by two major trends according to two bean-based entrepreneurs; first, the supply of beans is too small to meet the demand from alternative protein buyers and secondly, as a consequence of that, the supply chains are very long, as beans are brought in the developed countries from all over the world (I01 and I02 interviews). At the same time, according to the same entrepreneurs and the supermarket representative, many actors of the beans value chain want to shorten the bean supply chains (interviews I01, I02 and O04). Dutch actors producing beans should therefore not have problems with selling their produce. At the same time, no significant signs of cooperation between "supply" actors were found. The data collected for this aspect are judged as insufficient to classify this aspect, yet they slightly indicate a neutralism type of interaction.

Moving to the "food product creation" aspect, multiple actors interviewed suggested that "good taste" and "low cost" are the most important characteristics for bean-based food products (I01, O02, B02 and B01). Multiple networks are aiming to help actors succeed in creating such products by fostering partnerships and encouraging peer learning, such as 'Foodvalley', 'TPC', 'The Green East' (The Green East, 2020) etc. However, even if "food product creation" actors are part of these networks, they do not work with one another, but rather with supply and market actors (B01, B02 and B03). This is because every actor wants to create a competitive advantage over the other and keep it for as much time as possible (B01 and B02 interviews). Consequently, the interaction for this aspect is competition.

The next aspect analysed is "market". It was found that there is a high need for partnering up with actors operating in this part of the value chain, e.g. for chefs and retailers (B01, B03 and O03). This is because chefs help in developing better products that convince consumers to purchase them (B03 and I01 interviews). On the other hand, according to the supermarket chain representative, retailers want to provide consumers with sufficient options but eventually, consumer traction is the most important metric for keeping products on the selves (O04 interview). After conducting content research on several websites of bean-based food companies, as it can be seen in section *4.2.2*, it is obvious that the products currently in the market are to a large extent similar. Since consumers make their choices having price and taste as their main criteria, companies try to have better and cheaper products to capture more consumers. Consequently, "market" interactions for the beans niche are characterized as competition.

In terms of the fourth aspect, "finances", insufficient data were collected and therefore the classification of this interaction cannot be made.

For the last aspect of organizational dimension, "research", a beans entrepreneur and the coordinator for the alternative protein research projects at WUR both stated that universities are a key resource to all actors involved (B02 and O03 interviews). Specifically, actors participate and invest in networks and work closely with universities to conduct research projects that are too large and too expensive for

any individual actor to do individually. As an example, the 'Pulses for flavour and functionality' call that WUR started on 2020, aiming to work together with pulse producers to improve pulse functionality for use in meat alternatives (WUR, 2020). Overall, the interactions for this aspect are suggested to be symbiosis.

Moving to the "conceptual dimension", the "descriptive schemata" aspect is the first to analyse. Multiple actors revealed that neither themselves nor other companies from the same niche are willing to share any innovative knowledge that was developed internally, to protect their intellectual property and maintain their competitive advantage (B01 and B02 interviews). This protectionism is also confirmed by my observations at the FoodValley summit; a large number of actors participated in it and even showcased part of what they do, but during discussions with some companies representatives, they admitted that the main reason for their participation was to see what everyone else is up to and make sure they are not left behind. Consequently, the interactions for "descriptive schemata" are classified as competition.

The next aspect is the "normative schemata" one. For this aspect, throughout all the interviews conducted, actors described that the beans socio-technical niche does not encounter any regulatory barriers concerning the 'Novel Foods' regulations (O01, O03, B01, B02). The only legislative aspects that beans niche actors deal with are the regular food safety measures that every food actor across all niches must abide by (B03 interview). Consequently, this aspect is classified as neutralism.

The last aspect is "concepts". Initially, all beans actors commented that they want to see their niche progressing and eventually reducing the animal-based product usage (B01, B02 and B03 interviews). The concepts "animal-free", "sustainable", "efficient", "plant-based" and "healthy" were found to be used to describe the beans niche, as seen in section *4.3.3*. Throughout my interaction with several actors of this niche and after interviewing some of them, I found that most of them are idealists and would like to see the beans socio-technical niche grow as much as possible, regardless of their own company's growth (B01 and B02 interviews). Therefore, beans actors work together in this aspect, as they realize the value it brings for the entire niche and the interaction is characterized as symbiosis.

5.5 Conclusion

All the previous results can be found collectively in *figure 5*.

Dimension	Aspect	Insects	MicroAlgae	Beans
Organizational	Supply	Competition	Neutralism	Neutralism
	Food Product Creation	Competition	Neutralism	Competition
	Market-Channels	Neutralism	Neutralism	Competition
	Research	Symbiosis	Unclear	Symbiosis
	Finances	Unclear	Unclear	Unclear
Dimension	Aspect	Insects	MicroAlgae	Beans
Conceptual	Descriptive Schemata	Competition	Competition	Competition
	Normative Schemata	Symbiosis	Symbiosis	Neutralism
	Concepts	Symbiosis	Symbiosis	Symbiosis

Figure 5: Intra-Niche Interactions

Looking at the results, it can be inferred that there is a variety of different typologies of interactions, at an intra-niche level. Starting with insects, in terms of both the organizational and conceptual dimensions, the interactions were characterized as either symbiosis, competition or neutralism, while the "finances" aspect could not be determined. For beans, a variety of symbiosis, competition and neutralism occurred as characterizations in both the organizational and conceptual dimensions. In terms of the micro-algae intra-niche interactions, the organizational dimension could potentially be characterized as neutralism. Nevertheless, the inability of two out of the five underlying aspects to be defined makes it impossible for a conclusion to be made. The micro-algae conceptual dimension is showing a variety of interactions, with symbiosis and competition occurring as aspect classifications.

Taking the insects results, "supply", "food product creation" and "descriptive schemata" are described as competition. This suggested competition is related to the development of products or production systems and actors are competing for resources and knowledge regarding these aspects, as they want to gain a competitive edge against their counterparts. In terms of "markets," there is neutralism, which is the outcome of the insect niche's weak links to the retail and consumer parts of the value chain. Lastly, "research", "concepts" and "normative schemata" are all suggested to be symbiosis. This mode of interaction is justified by the actors supporting each other with resources or simply benefiting each other to progress in aspects that would benefit the entire niche, like more supportive regulations, more scientific knowledge or raising awareness on the benefits of insects as an industry.

Looking at the micro-algae results, the "organizational dimension" aspects that where defined, "supply", "food product creation" and "market-channels" are all suggested to be neutralism. This shows that most actors work in isolation to each other and do not exchange resources, as they all work in a highly fragmented and disconnected innovation-niche. In terms of "descriptive schemata", actors are competing for acquiring knowledge that could help produce larger volumes or better products to differentiate from each other. Lastly, the "normative schemata" and "concepts" aspects are symbiosis, meaning that micro-algae actors work together in topics that could benefit the entire niche, like promoting regulations and for raising awareness on the benefits of micro-algae as a protein source.

Moving to the bean beans niche, in terms of "supply" and "normative schemata" the interaction is characterized as neutralism. This is justified by the fact that beans have been in the food market for a long time and for the most part, the supply side and regulations have been mostly sorted out in the past, making the interactions neutral. In terms of "food product creation", "market-channels" and "descriptive schemata" competition is suggested as a relationship, as actors compete against each other for the knowledge and resources to acquire more customers and to create better products than their internal counterparts. Lastly, in terms of "concepts" and "research", the beans actors cooperate and combine their resources for large projects that could not individually carry out, to achieve more knowledge and awareness on beans as a protein source, which would benefit the entire niche.

Looking at the classification of each aspect across all three niches, it was found that for the "organizational dimension" the underlying aspects showcased no commonalities, but the opposite happened in terms of the "conceptual dimension".

Starting with the "organizational dimension", the lack of emergent patterns can be justified by the different kinds of networks actors of the three niche-innovations develop. The actors of each niche create different kinds of networks and collaborate in different ways, based on the different values of the actors involved in every niche. Using Pel's (2013) wording, there are local explanations for niche-innovation specific events, which in turn impact the way actors interact with each other. This difference is also impacted by the different maturity levels of the three niche-innovations. As seen in the previous paragraphs, beans showcase more competition in the product development and market parts of the value

chain, while insects showcase competition in the production part and micro-algae actors work in isolation for the entire part of the value chain.

Moving to the "conceptual dimension", aspect-specific commonalities emerged. Specifically, the niches are suggested to interact in a way of symbiosis for the "concepts" aspect and in a competitive way for the "descriptive schemata" aspect. In the case of "normative schemata", the two niches that experience 'Novel food' regulations both interaction in a way of symbiosis, while the beans experience no such issues and, therefore, interact in a way of neutralism. The patterns in terms of the "conceptual dimension" aspects form in a very clear and almost identical way.

The last, yet most important conclusion of this chapter, has to do with the emergence of intra-niche interactions in the first place. As it is already described in the theory section of the introduction (chapter 2), existing scientific literature focuses traditionally on the sociotechnical regime/niche-innovation interactions to study socio-technical transition pathways. Modern research also studies cross-niche interactions, as described in chapter 4, yet no previous research revealed intra-niche interactions as relevant to the socio-technical transition pathways. Researching these interactions, as seen throughout this chapter, generate measurable results. This means that these interactions exist and that they can be measured.

The results of this chapter (chapter 5) and the previous one (chapter 4) are discussed in the next chapter, chapter 6, in connection to their meaning for the Dutch protein transition and the overall implications they could have in the academic literature of sustainability transitions.

Chapter 6: Discussion and Conclusion

6.1 Introduction

In this final chapter, the discussion on the insects, micro-algae and beans transition pathways results together with an overall conclusion are included. In the previous chapters, the cross-niche interactions among the three niches (chapter 4) and the existence and typology of intra-niche interactions (chapter 5) were both elaborated. In section 6.2 of this chapter, the research discussion is provided. The research discussion includes a summary of the results and the interpretations of the results, the implications brought by the results, the research limitations and the recommendations for practitioners of future research. Afterwards, in section 6.3, the research overall conclusions are provided. In the conclusion part, the answer to the main research question is given, together with a reflection on the research, where a new model for understanding socio-technical transitions is introduced, the recommendations for future research are mentioned and lastly, the contributions on the scientific field are emphasized. The last part, 6.4, is the epilogue, the closing paragraph of the entire research.

6.2 Discussion

6.2.1 Results Summary

The key findings on the cross- and intra-niche interactions of the three niche-innovations pathways are:

- Currently, the cross-niche interactions of the three niches, in terms of their organizational dimension, all seem to be neutralism. These interactions are suggested to change in the future into a variety of interaction modes, like competition, symbiosis, neutralism and commensalism.
- Currently, the cross-niche modes of interactions among the three niches for their conceptual dimension are classified as competition, neutralism and commensalism. The future of the knowledge and expectations modes of interactions will become symbiosis, while the remaining interactions on norms and concepts will stay in their current form of neutralism and competitions, while these interactions are suggested to become stronger.
- The lesser developed micro-algae niche-innovation is currently showcasing weaker cross-niche interactions in terms of its organizational dimension than regarding its conceptual dimension.
- Currently, all intra-niche interactions seem to be diverse with regards to the underlying aspects of both their conceptual and organizational dimensions.
- Currently, the underlying aspects of the organizational dimension for all intra-niche interactions seem to be different for every niche-innovation.
- Currently, the underlying aspects of the conceptual dimension of all intra-niche interactions are suggested to follow an almost identical typology of symbiosis for norms, regulations and concepts and competition for knowledge and expectations.

6.2.2 Interpretations

At this point of *chapter 6*, the interpretations on the meaning of the results of this research are presented in the following bullet points, starting from the most important one and finishing with the ones having less impact on the research's goal:

- At the beginning of the research, it was hypothesized that cross-niche interactions would be very influential to the transition pathway of the niche-innovations and the intra-niche interactions were not conceived to be important factors since there was no reference to them in

the scientific literature. Throughout the research, the intra-niche interactions became more important, after key stakeholder kept referring to them, together with the researcher's observations. Eventually, intra-niche interactions were included as part of this research as potentially influential factors to the niche-innovations pathways.

- Almost all dimensions of all the interactions studied, except for the current organizational dimension of cross-niche interactions, were found to include a diversity of interactions for the aspects they are comprised of. Breaking down the dimensions to their aspects and defining them, showcased that dimensions are incoherent in both internal and external socio-technical niche interactions. This finding is contrary to the initial research hypothesis, as it was initially expected, based on previous scientific literature, that dimensions can be defined with only one mode of interaction. The results of this research contradict this hypothesis. This finding is interpreted as the outcome of studying a transition while it unravels. A transition in the making, like the protein transition, leaves room for actors to interact in the arenas of development between and inside niches, in many ways, since every aspect of the transition does not have a predetermined pathway. In this way, the interaction of actors, through exchanges of resources and meanings on each aspect of the technologies (nodes of interaction), add up to courses of action that, eventually, provide local explanations to the transitions' situated-complexity (Pel, 2013).
- The conceptual dimension of the cross-niche interactions is expected to remain almost identical through time, as the underlying aspects across all three interactions are suggested to remain similar in the future. This finding indicates that possibly the interactions for these aspects or this dimension, have reached an equilibrium point. This point is not a permanent point that will remain the same throughout the transition, but it represents a state where actors have reached a satisfactory explanation regarding this "situated-complexity" (Pel, 2013). This equilibrium point could change, provided that the other aspects or dimensions that influence the transition pathway change first, and change in ways that would force the actors to challenge the equilibrium point and search for better explanations to the transition's pathway. Contrary to that, the organizational dimension of the cross-niche interaction is currently neutralism, interpreted as not many cross-niche interactions regarding resource transfers take place. Nevertheless, organizational cross-niche interactions are suggested to shift into heterogeneous modes. Maybe cross-niche interactions' start and finish earlier with regards to the niches' conceptual dimensions and then the organizational dimension follows.
- The organizational dimension of cross-niche interactions is currently neutralism for the interactions among the three niche-innovations. This is interpreted as little exchange of resource taking place at the moment, or exchange that is not considered influential to the niche-innovations transition pathways. Nevertheless, in the future, it is suggested that niche-innovations are expected to exchange resources with each other and to compete, help each other's growth or be neutral, depending on the kinds of resources at stake.
- Considering that the organizational dimension of intra-niche interactions of micro-algae was found to be neutralism, while the other two niches' internal interactions were heterogeneous is interpreted as having a direct correlation to the fragmented and lesser developed state of the micro-algae niche compared to the other two.
- Throughout the research, it is mentioned that the beans socio-technical niche is better developed than the other two niches, with the insects' niche being slightly better developed than the micro-algae one. Combining this observation with the current and future interactions of all niches, it is assumed that intra-niche interactions are stronger in the earlier phase of the transition than the cross-niche interactions, which in turn develop over time. This is suggested based on the comparison between the intra-niche and cross-niche modes of interactions of all niches. Starting with micro-algae, it is suggested to currently be developed in its intra-niche conceptual dimension, yet not in the current intra-niche organizational and cross-niche organizational and

conceptual dimensions. Following the same line of logic, the insects' niche is suggested to be developed in both the organizational and conceptual dimensions, while not so much in both the cross-niche organizational and conceptual ones. Lastly, beans which are the most mature niche, are strongly developed in the intra-niche dimensions, yet their cross-niche interactions with other niches are weak, due to their underdeveloped current state.

6.2.3 Implications

Starting with the first major finding of this research, intra-niche interactions are a factor influencing the transition pathways of niche-innovations. As it has already been described in *chapter 2*, during the evaluation of existing scientific literature on transition studies, the existing models of Strategic Niche Management and Multi-Level Perspective (Geels & Schot 2007; Kemp, Schot & Hoogma 2007) heavily emphasize the socio-technical regime/niche-innovations interactions as important factors of socio-technical transitions studied in the long-term, through a macroscopic lens. Moreover, the Technological Innovation Systems literature in place, which adopts a more mesoscopic lens than SNM and MLP, includes the impact of cross-niche interactions as factors impacting the pathway of niche-innovations together with the socio-technical regime/niche-innovations interactions (Magnusson & Berggen 2017; Musiolik, Makard & Hekkert 2012; Sanden & Hillman 2011). This research's finding is that there is an extra layer in the niche-innovations' transition pathways, which is intra-niche interactions, meaning internal arrangements of resources, knowledge and expectations. This layer has not been pointed out in previous literature, due to the microscopic lens required to capture it. Moreover, the intra-niche interactions, are suggested to be more influential in the earlier stages of socio-technical transitions, like the protein transition. This means that finding and analysing intra-niche interactions would potentially only be possible on active transitions, as these interactions potentially reach equilibrium points, or are outperformed by cross-niche interactions and eventually regime/niche-innovation interactions in the later stages of the transition.

Moreover, the application of the Sanden and Hillman (2011) model regarding the cross-niche modes of interaction on the underlying interaction dimensions, generated key insights on its applicability. Initially, this model was found to be capable of defining the modes of interaction between socio-technical niches at an aspect level. However, it fails to explicitly point out the possibility that the dimensions of cross-niche interactions might include a variety of dissimilar interactions in terms of their underlying aspects. Specifically, the research conducted revealed that the underlying aspects of both conceptual and organizational dimensions could be accurately defined, yet each dimension included more than two and often three modes of interaction. This challenges the initial hypothesis that the results would be a clear-cut characterization of the dimensions of the interaction, yet it generated key insights on the dynamics within the dimensions and how these, in turn, influence the transition pathways of the three niche-innovations.

Furthermore, the integration of Sanden and Hillman's (2011) model with Pel's (2013) nested case methodology proved to be successful. Pel's (2013) methodology provided the contextual knowledge required to understand how the actors participating in the transition reduce complexity, by providing local explanations to niche-internal and cross-niche exchanges of resources and context. Conversely, Sanden and Hillman's (2011) framework provided a practical tool, which made the research objectives measurable, at a micro-level, which is different than what it is intended to work for, which is a meso- or macro-level. This customized framework was also tested on the research of the intra-niche interactions and it successfully measured the intra-niche interactions.

Lastly, some weaker findings of this research, suggest that not only the dimensions that Sanden and Hillman (2011) introduce exist, but that they also occur at different time-points in the cross-niche

interaction. In specific, the conceptual dimension interactions possibly occur before the organizational ones, as throughout the data collected, the conceptual dimension was found to be better developed and more consistent in their expected future development. Connecting it to Pel's (2013) methodology and IBL overall, it practically translates describes that in their effort to reduce complexity and provide local explanations, actors first interact with others, both intra- and cross-niche, in conceptual dimension terms, regarding e.g. expectations, knowledge, institutions etc., and then in organizational terms, e.g. exchanging resources, making partnerships etc.

6.2.4 Limitations

In this part, the most important limitations of this research are presented, together with their potential impact on the aforementioned results.

The first major limitation of this research is that not every part of the value chain was researched on. Specifically, an analytical choice while designing this research was to not include the consumer perspective into the framework. This by any means did not mean to disregard the impact of consumer perceptions and consumers as actors in the transition pathways. The reasoning behind this choice was dual. On the one hand, including consumers in the research would singlehandedly increase the anticipated workload and resources to an extent that would make the research impossible to be executed within the workload of an MSc thesis. On the other hand, sampling for only a small number of consumers to conduct semi-structured interviews would significantly increase the risk of bias in the data collection. Nevertheless, not including consumers as actors could harm the research internal validity, which is why throughout all the interviews conducted, questions on the perception and behaviour of consumers, as perceived by other actors were made. This might adaptation does not completely solve the problem, yet it mitigates the potential harm it could do to the research validity to the minimum possible degree.

A second limitation of this research has to do with studying only three alternative protein socio-technical niches. This limitation is another methodological choice made during the design phase of the research. More protein niche technologies could be included in the research, yet studying them all would be impossible in terms of the logistical planning of an MSc thesis. Moreover, the three niches that were eventually studied did not occur randomly but were chosen, based on specific criteria connected to the technologies' degree of maturity, the different sources of protein (animals, micro-organisms and plants) and the researcher's preference. This creates issues with the external validity of the research, meaning that the results are potentially not representative of all the protein alternatives and therefore the results of the research could not be generalized for the entirety of the transition.

The last limitation which again connects to the logistics of an MSc thesis is the small sample of thirteen (13) interviewees. Considering that the interviews had to be scheduled and transcribed and that as part of the research many resources had to be invested in desk and content research, a relatively small amount of interviews had to be planned. Nevertheless, several steps were taken to ensure that this does not harm the internal validity of the research. At first, multiple sources of data where used, such as observations, field notes, content research and desk research. Secondly, four (4) interviewees were deliberately chosen to be 'common interviewees', meaning that they were adequately knowledgeable and involved in all three niches. These interviewees worked as context-rich sources, which provided the ability to compare niches and to cross-check whether the niche-specific interviewees provided the researcher with biased information. Lastly, regardless of the small interviewee sample, the interviewees were positioned in many different roles in the value chain, thus providing information that was not biased due to their specific role.

6.2.5 Recommendations

Initially, further research should include consumers as part of the research design since they are an indispensable part of all alternative protein niche-innovations value chain. Including the consumers could practically happen in various ways, like interviewing alternative protein consumers, observing supermarkets or retail points where alternative protein products are sold, surveying large amounts of consumers or even using consumer behaviour literature on the alternative proteins, to better understand aspects that were overlooked in this research.

A second suggestion for practically implementing similar research is studying all the available niches, or effectively sampling socio-technical niches out of the available options. This would serve in two ways. On the one hand, studying more socio-technical niches would help produce more knowledge on the interactions of alternative proteins that were not studied as part of this research, while on the other hand a larger sample or a random one would increase the external validity of this kind of research.

A third suggestion relates to sampling for interviewees. The separation made in this research, on niche-specific and common interviewees is judged as successful and is suggested to be further implemented in other relevant studies. Moreover, opting for larger interviewee samples would further increase the internal validity of this research design.

Lastly, regarding a different scientific approach, longitudinal research on the protein transition is highly suggested. Specifically, this research identified the modes of interaction present in the current Dutch protein transition. These interactions are part of a dynamic system that is expected to rapidly shift over time in its future forms. Designing a study that would repeatedly monitor the change on the resource circulation and the shifting of perceptions regarding the niche-innovations over a long period, would help generate more information on the importance of intra-niche and cross-niche interactions, whether these impact the transition pathways of niche-innovations equally and even which interactions act as incubators of successful niche-innovations that eventually alter the established socio-technical regime.

6.3 Conclusion

6.3.1 Answering research question

This research aimed to identify the interactions influencing niche-innovations' transition pathways and better understand the formation of transition pathways. The answer to the research question posed includes two parts. Initially, the results show that the transition pathways of all three niches are impacted by not only interactions from other niche-innovations, but also from interactions inside the niche-innovation. The next part of the answer has to do with describing these interactions impact the insects, micro-algae and beans transition pathways.

Starting with the cross-niche interactions, their current state is characterized as neutralism in terms of resources and networks, meaning that the three niche-innovations currently do not interact in a meaningful way to the transition for this dimension. Additionally, the niche-innovations currently interact mostly in a neutralism way in terms of norms, regulations, expectations and knowledge, which again shows that there is no significant interaction for these aspects. In contrast, the three niches currently interact competitively in terms of the concepts and understandings linked to each niche. Despite the current situation, the interactions among the three niche-innovations are expected to shift over time. The three niches are suggested to develop a symbiosis relationship in terms of creating food product applications, meaning that they will benefit each other's transition pathway for this aspect. The same symbiotic relationship is expected to happen between insects/micro-algae and beans/insects in

terms of knowledge and consumer expectations. Contrary to that, the three niches are expected to compete against each other for the consumers and consumer behaviour knowledge and the competition between them for concepts will become even stronger. The last interaction that is expected to develop concerns finances, where insects and micro-algae are expected to benefit from the potential financial success of beans and therefore have easier access to funds.

In terms of intra-niche interactions, the insects' niche actors are believed to currently be in a competitive relationship with each other in terms of production, food product development and try to create and protect the knowledge on both of these aspects. At the same time, insect-related actors were found to work together in establishing large-scale research projects, in overcoming normative and regulatory issues and in promoting the benefits of insects as a protein source. For the remaining aspects, the relationship was either neutralism or unclear. Moving to the micro-algae niche-innovation, the actors were found to be completely fragmented and isolated from each other and exchanging almost no resources with each other. Nevertheless, the micro-algae actors were found to work together in larger-scale regulatory and normative issues, as well as in advancing the position of micro-algae as a protein source through highlighting its benefits. A competitive relationship was found regarding knowledge created from micro-algae actors, who all seem to try to keep it for themselves and protect it from others. Lastly, regarding the beans niche, there is a neutralism relationship regarding production and regulatory issues, as the mature phase in which it means that these aspects have already been addressed or are irrelevant to the transition pathway at the moment. In terms of food product development, access to markets and consumers and the knowledge in both of them, beans actors are competing against each other, trying to gain a competitive advantage for themselves. At the same time, beans' actors work together in large-scale research projects and promoting beans as a protein source, understanding that this will help the entire niche.

6.3.2 Reflection – Adapted model

The current scientific knowledge around niche-innovation pathways revolves around the notion that the interaction between the socio-technical regime and the niche-innovation is the most important one in defining the niche innovation pathway. This Multi-level Perspective is traditionally depicted as seen in *figure 6* (Geels and Schot, 2007). Novel research has proposed cross-niche or inter-niche interactions as influential to the niche-innovation pathways (Sanden and Hillman, 2011). Building on the previous theories and models, based on the findings of this research, an adapted MLP model is presented. This model describes the interactions occurring at a niche-innovations level as it is seen in *figure 7.* This model is a graphical representation of the cross-niche and intra-niche interactions that every niche is subjected to. Specifically, the red lines depict the interaction of cross-niche resources and conceptual schemata, the black lines depict the interactions of intra-niche resources and conceptual schemata the blue lines depict the eventual niche pathway, defined as the outcome of all interactions, including the sociotechnical regime/niches ones, which are not depicted in *figure 7* but are occurring. To simplify the visual message of this model, the interactions on only one niche-innovation are drawn in *figure 7*, yet it is important to indicate that each niche-innovation's resources and conceptual schemata are used as a means to influence the transition pathways of other niche-innovations. Moreover, the same resources are utilized internally in every niche-innovation from the niche actors to set the niche-innovation's internal pathway. This creates a complex system of intra-niche, cross-niche and regime/niche interactions that all impact the transition pathway.

This model creates a potential new understanding of what happens at the niche-innovations level and could shed light in the interactions that eventually shape each niche-innovations transition pathway.

Nevertheless, there are many more questions to be answered regarding this topic to better understand the types of interactions that shape transition pathways and which interactions are the most impactful to the pathways. Several parameters have to be further explored to reach this level of understanding and answers the following questions. Which interactions are the most influential in shaping niche-innovation transition pathways? Does the importance of the different types (cross-niche, intra-niche, regime-niche) of interactions change over time? Are the underlying dimensions of transition pathways a methodological tool of analysis, or different stages in which interactions unravel?

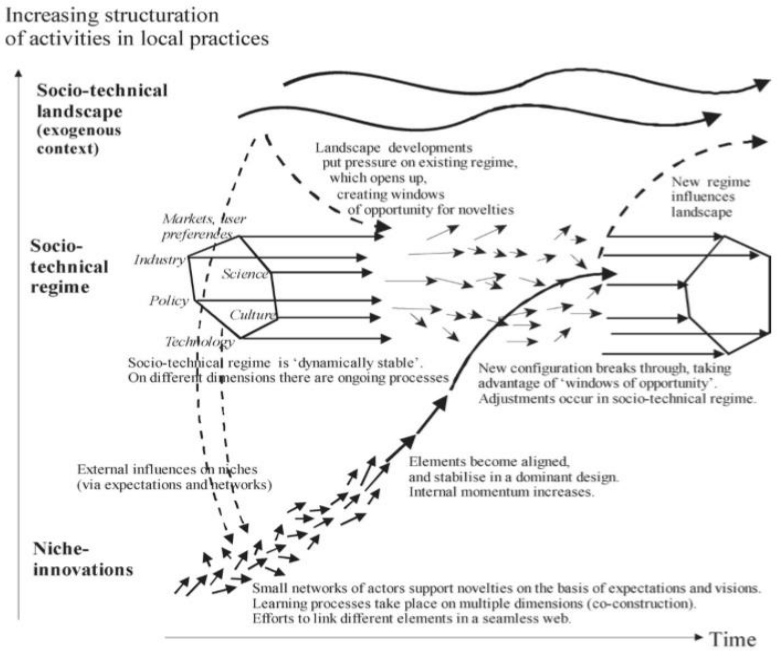

Figure 6: Multi-level perspective on transitions (Geels and Schot, 2007)

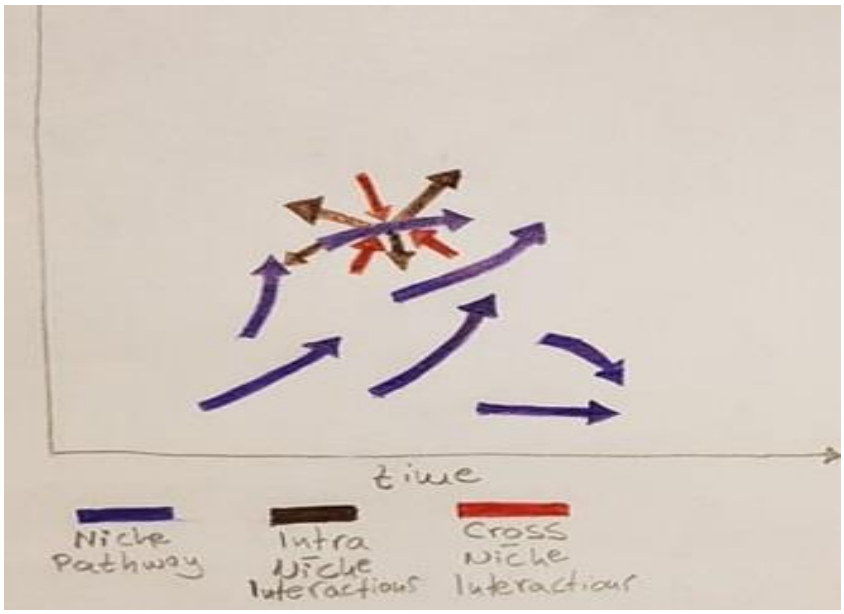

Figure 7: Niche-level interactions model - Adapted

6.4 Epilogue

This MSc thesis started with the purpose of a better understanding of the transition pathways of sustainable food technologies. Within this context, the case of alternative meat niche-innovations pathways chosen as a case study. Using a customized framework adapted to the needs of the study and various sources of data, ranging from interviews and observations to content research and literature analysis, novel findings were eventually found. Even though there is a long way to go to comprehend the complexity of the socio-technical systems of our world, like the food systems, the consideration of intra-niche interactions as impacting the niche-innovation pathways, could be a step into reducing uncertainty and maybe helping sustainable technologies find their way into society faster.

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Chapter 8: Appendixes

Appendix I – Foodvalley Dutch alternative network brochure

Appendix II – Actor Lists

Insect Actors:

Investors
Banks: Rabobank

Farmers/ Production Companies
Start-ups
De Krekerij: cricket based burgers. (https://krekerij.nl/)
Good Bug Food: pancakes, powders, chocolate, pasta made using crickets, grasshopers, mealworms or buffalo worms (https://www.goodbugfood.store)
Kreca Ento-food: Whole insects and FlourCrickets made with buffalo warms, grasshopers and mealworms (https://www.krecafood.com)
ProtiFarm: Insect protein concentrate, textured insect proteinbufflo beetles (https://protifarm.com)
Tinyfoods: dried Crickets, buffalo warms, grasshopers, mealworms (https://tinyfoods.nl/)
Tjirpfood: cricket-based croquettes and pasta (https://www.tjirpfood.nl/)
Companies/firms
Protix
Fair Insects
Italbugs
New Generation Nutrition (is also a knowledge broker)

Retail Sellers

Consumers

Research Institutes
WUR (Arnold Van Huis, Jonas House)
University of Groningen

Governance
Dutch Ministry of Health
Ministry of Agriculture, Nature and Food Quality
Food regulators Dutch Food & Safety Authority (NVWA)
Netherlands organization of applied sciences (TNO)

Knowledge brokers
Foodvalley & The Potein Cluster (TPC)
Schuttelaar & Partners
The Green East
Start-life
NGN
MVO Nederland
Proveg

Micro-algae Actors:

Investors

Private investors (Individual or groups):
Banks: Rabobank

Farmers/ Production Companies

Start-ups
The algae factory
FUM I Ingredients
Companies/firms
Corbion
Phycom
Duplaco
Algae Innovations (production)
AlgaSpring
ALGAE 4 YOU
Napurin
Garden Gourmet (Nestle)
Synalgae
It's Greenish

Retail Sellers

Albert Heijn
Jumbo
National Sports Centre Papendal

Consumers

Research Institutes

WUR(Sarah D'Adamo)
DutchSoy

Governance

Dutch Ministry of Health
Ministry of Agriculture, Nature and Food Quality
Food regulators Dutch Food & Safety Authority (NVWA)
Netherlands organization of applied sciences (TNO)

Knowledge brokers

Foodvalley & TPC
Microalgen platform
Schuttelaar & Partners
The Green East
Start-life
Green Protein Alliance
MVO Nederland
Proveg

Beans Actors:

Investors
Private investors (Individual or groups):
Banks: Rabobank

Seed Sellers

Traders

Processing companies
Start-ups
Willicroft, plant-based cheese
De Nieuwe Melkboer
Freggies
Companies/firms
Biorefinery Solutions (BRS)
Labeij Food Products bv
Innogusto
Lacto Trade
MFH pulses
Multiflour
Ojah
Vivera
SoFine
Nextfoods
Goodbite
The vegetarian Butcher
BUMI Organics BV
Boonbonen
Foodforimpact
Green table

Retail Sellers
Albert Heijn H
Jumbo
Ekoplaza

Consumers

Research Institutes
WUR
DutchSoy

Networks

Governance

Dutch Ministry of Health
Ministry of Agriculture, Nature and Food Quality
Food regulators Dutch Food & Safety Authority (NVWA)
Netherlands organization of applied sciences (TNO)

Knowledge brokers

Foodvalley & TPC
Schuttelaar & Partners
The Green East
Start-life
Louis Bolk Institute
CHIEF
Green Protein Alliance
Green Food Lab
MVO Nederland
Proveg

Appendix III – Interviewee List

Below the list of the actors interviewed is provided with the code-number of the interviewee, together with a classification as Insect-specific actors (I), micro-algae-specific actors (A), beans-specific actors (B) and overview actors (O).

I01: De Krekerij (insects burgers ompany)	**I**
I02: Arnold van Huis (professor of Plant Sciences, WUR)	**I**
I03: Protifarm (Insect production company)	**I**
A01: Micro-Algen Platform (Micro-algae focused platform)	**A**
A02: FUMI Ingredients (Micro-algae ingredient start-up)	**A**
A03: Maria Barbosa (profssor of bioprocess Engineering)	**A**
B01: Williecroft (plant-based cheese company)	**B**
B02: Rival Foods (plant-based meat company)	**B**
B03: Innogusto (alternative meat product producer)	**B**
O01: TheProteinCluster-FoodValley (alternative protein network)	**O**
O02: Willem Blom (Impact Investor)	**O**
O03: Stacy Pyett (Program Manager Proteins for Life, WUR)	**O**
O04: Ekoplaza (Supermarket chain)	**O**

Appendix IV – Interview Rubric

General questions			Notes
Vision	Q1: What future of protein transition and the role of meat and meat alternatives do you find desirable? What elements does the end-goal involve and why?		suggestion
Future of Niche market	Q2: What is the role of your technological niche on the protein transition? Where do you see your niche market in the future?		
Dimension	Information	Question	
Organational	Value chain/ Resources	Q3: Can you briefly describe the value chain for your ABI niche? What is your role in the ABI value chain? Do you share any of these with other alternative protein niches? Q4: Which are the key resources for your niche/company to achieve your goals?? (especially how do you get access to finances). Do you share any of these with other alternative protein niches? Q5: Which elements of the value chain are strong, and which are problematic? How do you solve/capitalize on them?	
	Network interactions	Q6: Are you part of broader networks relating to alternative protein technologies? (According to the answers ask about interactions with other niches)	Notice the way people talk about the networks
	Determine the type of network (e.g. Learning, Political)	Q7: What is the main purpose of such networks and how are you operating/benefiting within them? (According to the answers ask about interactions with other niches)	Notice how they perceive/use these networks
Conceptual			
Aspect	Information	Question	Notes
Descriptive Schemata-Technical knowledge		Q8: What are the key kinds of knowledge required for your niche technology? Is this knowledge similar for other alternative protein niches?	Knowledge expected to need
		Q9: Where does this knowledge come from? Do other alternative protein niches impact this knowledge transfer?	
Descriptive schemata-Expectations		Q10: What technological breakthroughs are required for your niche technology? What would achieving these breakthroughs mean for the niche and its market? Do you believe that technological advancements on other alternative protein niches would help your own niche succeed?	

Normative		Q11: What norms and attitudes do you encounter across your ABI value chain? Both supportive and hindering.	
		Q12: Do norms and attitudes from other niches interfere with your value chain? Do you interfere in these niches? In which ways?	
Hard regulations		Q13: What are the major regulations(Supportive and hindering) in place for your niche?	(based on the answers, ask about similarities or differences of other niches)
		Q14: What do you think of these regulations?	
		Q15: How are these regulations impeding or enabling the progress of your niche?	
Concepts	(Each interviewee will be asked only on their own ABI area of expertise)	Q16: Do you think that your niche has similarities with other alternative protein niches? In which aspects?	
		Q17: What makes your technological niche unique in comparison to others?	
General		Q18: How does the future of alternative protein niches looks like? Where do you see your niche compared to others? (follow-up question possible if interesting answers are given).	

Appendix V – Interview Questions

General

Vision

Q1: What future of protein transition and the role of meat and meat alternatives do you find desirable? What elements does the end-goal involve and why?

Q2: What is the role of your technological niche on the protein transition? Where do you see your niche market in the future?

Organizational (Current, desired VC. Interactions and overlaps with other alternatives through Networks)

Q3: Can you briefly describe the value chain for your ABI niche? What is your role in the ABI value chain? Do you share any of these with other alternative protein niches?

Q4: Which are the key resources for your niche/company to achieve your goals?? (especially how do you get access to finances). Do you share any of these with other alternative protein niches?

Q5: Which elements of the value chain are strong, and which are problematic? How do you solve/capitalize on them?

Q6: Are you part of broader networks relating to alternative protein technologies? (According to the answers ask about interactions with other niches)

Q7: What is the main purpose of such networks and how are you operating/benefiting within them? (According to the answers ask about interactions with other niches)

Conceptual (ask about similarities 8-10)

Q8: What are the key kinds of knowledge required for your niche technology?

Q9: Where does this knowledge come from? How is it transferred? What is the role of other niches in this?

Q10: What technological breakthroughs are required for your niche technology? What would achieving these breakthroughs mean for the niche and its market? Do you believe that technological advancements on other alternative protein niches would help your own niche succeed?

Normative (norms and attitudes across the value chain)

Q11: What norms and attitudes do you encounter across your ABI value chain? Both supportive and hindering.

Q12: Do norms and attitudes from other niches interfere with your value chain? Do you interfere in these niches? In which ways?

Good food institute

Regulations

Q13: What are the major regulations(Supportive and hindering) in place for your niche?

Q14: What do you think of these regulations?

Q15: How are these regulations impeding or enabling the progress of your niche?

(based on the answers, ask about similarities or differences of other niches)

Concepts

Q16: Do you think that your niche has similarities with other alternative protein niches? In which aspects?

Q17: What makes your technological niche unique in comparison to others?

General

Q18: How does the future of alternative protein niches looks like? Where do you see your niche compared to others? (follow-up question possible if interesting answers are given).

Appendix VI – Interview Transcriptions

The interviews transcripts are available upon request. In case any reader is interested in viewing them, please contact me vie e-mail at sofianoshteodoros@gmail.com.

Appendix VII - Results Analysis

Insects Actors

			Interviewee		
Dimension	Aspect	Information	De Krekerij	Arnold van Huis	Protifarm
General		Vision	We should eat 40 – 60 meat and other protein sources/ We should eat more beans, insects, seaweed etc. /We should not stop eating meat / the seaweed niche is hugely interesting / Consumers awareness is crucial / We are now competing with our products against vegetarian products / We think we fit in somewhere in the flexitarian and meat eater side. Then all different niches have their own target market accordingly. The market will be fragmented.	The protein transition is of course larger than only insects, there are also micro-organism based proteins, plant proteins algae etc. It is equally important I think, as we need a diet change /	Protifarm is an agritech company producing sustainable ingredients from insects / We believe is that we need to eat and drink more effectively. Ingredients from insects can play a big role in that / We aim to make insect nutrients more available for the mainstream consumer / I think the bigger thing is finding the correct balance between niches and I definitely see insects playing a big role there / The whole transition - vegan/vegetarian thing happening, even Beyond Meat, Impossible Foods, I think benefits everyone and has helped us to move ahead faster / I think we are going to see a lot more pulses probably, algae becoming a real thing / I would say there could be an overlap among niches and insects, but insects can do a broad range of things / Therefore, I think that each protein niche is going to find it's into applications that make the most sense for them.
		Importance			
		Future of the market			
Organizational		Access to resources	We need farmers to transition/ Involving chefs and consumers to make insect products successful / We work closely with three collaborations of farmers / We have also set up an association called the Insector / We are also working together with companies from other sectors / We are working closely with chefs as they know how to convince the consumers / We work closely with people and suppliers of e.g. the vegetarian butcher who have worked with those kind of companies / supermarkets are not that interested in insects at the moment	Companies that use these ingredients to put in hamburgers, bars or other things and then sell them on the market – mostly on the Internet / I think that the challenge is mainly consumer attitudes / supermarkets are becoming more and more open to use insects/ small farmers are in a difficult position and what you see in the NL from the universities they are setting up facilities in order to help farmer starting their business /	we are at this stage the breeder and also the processor / Partner for feed and partners in the consumer-based products market / Foodvalley. But our network is mostly within the insect niche / WUR, Utrecht Uni, we also have a lot of partnerships in Europe - research projects / We get knowledge from within, but a lot of it comes from universities on certain topics /
		Network Interactions			
		Network Roles			
Conceptual	Descriptive Schemata	Technical Knowledge	Farmers need to be certain that they can sell the insects they farm. / In Dutch retail price is the most important and the product to be a bit tasty / Insects have all the necessary micronutrients/ We need the same volumes as chicken to compete against it / texture, taste, usability, price are important to consumers / the knowledge created in other alternative protein niches also benefits us /	if you use waste products to rear insects, you have huge benefits / I know other niches a little bit, but that is so different from insects that I do not see how they could possibly strengthen each other. Algae I think is also a completely different business. It is a completely different setup. I do not see much room for collaboration in this / certain aspects, like the breeding of insects, the genetic improvement of insects that have the potential to be improved.	They are of course extremely efficient in upcycling low value feed streams into high value ones. This is the most important thing / Knowledge and experience on technical processing is consistently rising / I think a weak spot is still in the companies that have to make consumer products / Marketing is crucial and that's lacking right now / We build a lot of knowledge ourselves, but we are also part of the universities / There is a lot to learn from other niches, but not so much in aspects like processing / You can learn from industries like algae, where they have their own problems to market products. It is interesting to see how they bring their ingredients to the market / The real interest is in the things that we are now discovering, like the bio-acting compounds or the chitin and other things / Insect genetics could be very important - working on natural selection of bigger insects / some breakthroughs are also required at processing, for us to produce in a more efficient and sustainable and therefore cost-effective way
		Expectations			
	Normative Schemata	Hard regulations	Uncertainty with the food authorities / There are many restrictions as to how insects can be used / Institutions is in general problematic, but for all niches as well / Food safety regulations are slow and can kill innovation	Maybe legislation is an issue, although that has been addressed / The problem is that to file the permission for a certain insect, it is a very expensive procedure	They are clear, which is good. It just takes a while to move through them. It is definitely an obstacle for us, but it is not something that is a really big issue / Of course other companies can learn from us, but we cannot share everything. I would be happy to share some general ideas, but unfortunately you cannot copy one to one / For a lot of companies, insects are very new, very innovative / What we usually see is that there is very limited knowledge among stakeholders on the topic on the nutritional side, on the applicability of insect ingredients, sometimes on legislation / As an industry when we are able to use more feed streams, as right now we are relying by EU regulations, that could be a breakthrough moment, because that would mean that we could produce in a cheaper way.
		Normative Rules			
	Concepts		I am a protein transition person, not an insect person / Plant-based meat analogues might be unhealthy and as they require a lot of energy, not very sustainable. / Insects are very efficient / Our customers are people that are already aware of sustainability issues / not vegan, also not vegetarian because of religious or animal welfare reasons / There are also people interested in the experience of trying something new / People used to buying some alternative protein products are also more interested in buying other types / If we could rear insects on waste streams, that could be the most sustainable protein I can imagine	you have to deal with the phobia that people dot eat they do not know / you can indicate to people the environmental and health benefits, this might change the situation / it is apparently easier to use insects than to use cells from livestock animals. (Rubio) / Insects better than the other alternatives in terms of environmental impact/ In the supermarkets you see them all together in the alternative products – I am not sure whether there is competition between niches / sustainability can be a motive for many consumers to buy those products/ . If they are vegetarians for animal welfare reasons, then maybe they will not consider insects altogether / Yet even for plant-based products, so many insects die due to insecticides etc.	What Insects are a super effective way of producing high quality nutrients / I definitely see insects as a separate unique category. You cannot directly compare them with anything else. Insects are in terms of biology quite special / They can do things that other plant based sources, or algae sources cannot do / I would say algae is the main parallel to insects / Algae are also very novel, they are maybe a few years ahead in terms of production, they also have marketing issues. So I think they are the best think insects can compare to / However, insects are still quite different to algae in terms of production, marketing

Micro-algae Actors

Dimension	Aspect	Information	Micro-Algen Platform	Fumi Ingredients	Maria Barbosa
General		Vision			
		Importance			
		Future of the market	the amount of animal proteins consumed is way too high and that has to decrease/ Our ambition is to make the world healthier and more sustainable and part of that is building networks and alliances / cultured meat is one niche that requires technological breakthroughs more than microalgae / I think that the niches themselves are not competing at all the microalgae sector and also the insect sector, companies want to have more competition to become better / microalgae companies would not compete against insect companies as they target different customers / Unawareness and invisibility are the problems / If insects, microalgae, cultured meat, seaweed, all grow, they could solve the issue of future protein demand / Maybe if all niches grow, it will be the same as with meat, as pork, beef and chicken, are not directly in competition to each other / I think that at the moment the niches are rather stimulating each other	We need to decrease the animal protein we consume / I don't believe that the future will be either plant-based or animal-based only, rather it will be a combination of both / Algae will be an niche as they feed of CO2 and they are a carbon mitigator / There are current many players in the market; companies producing proteins from plants, insects and it is a healthy race between niches / If we all collaborate, we will create great knowledge / What I have found however is that people are really keen to help with things that they can share. Yet everyone is also doing it alone as part of the process. / Eventually there will be a lot of players, not a dominant one / It is also interesting to explore co-development across different niches	At the moment micro-algae is being produced, but it stays within a niche market, as it is expensive, and is used for medium to high value products and not at the replacement of soy / I think there will not be one solution, there will be a combination of different solutions, like insects - it is an animal, a different source of protein / Micro-algae seem to be very secretive. However, the niche is so small, that there is actually no competition so they should be more open to sharing information for the best of everyone / There will be a lot of sources of protein and there will be insects.
Organizational		Access to resources			
		Network Interactions			
		Network Roles	The sector and the value chain as too fractioned and differentiated / Connections are needed / We are currently in an explorative phase / connections with the government and Ministry of Agriculture / Cooperating with the Noord Sea farm seaweed network / AlgaePARC and WUR / Supermarkets (would) sell microalgae products /	There is not a lack in supply, but rather in a lack of products / Because there is not a high volume of algae protein the market does not know about their existence too much / Everybody will have a distinctive advantage compared to the rest and food companies will choose which ones they will prefer for their products / The most problematic element about algae is the production cost, which compared to plant-based proteins is very high / We are part of Foodvalley and TPC, StartLife, we are a spin-off of WUR/ We get good networking from these networks, both with other companies and experts	It is really needed to develop the whole value chain / It is still a bit expensive, but it is as the egg and the chicken. The demand has to come now from the market / Who will be the producer is still unanswered / StartLife /We know the players in the Netherlands and we even have contacts and projects with some of them / Reactor supplier / Corbion, Unilever, Phycom / The main purpose of all these networks, are collaborations and knowledge transfer / Big agricultural companies that have no experience with algae are looking into investing in it / Farmers and horticulturalists are looking into algae as a possible alternative / Dutch farmers are very business-oriented and switching to algae would not be an issue / There are questions about who would do the treatment of biomass however / In conviencing farmers to produce algae there could be competition; the decision would probably be on the market they know and that they know will be profitable
Conceptual	Descriptive	Technical Knowledge			
		Expectations	There is a lot of technical knowledge in the network / We try to achieve what the Noord Sea Farm has / The biggest growth problem for algae companies is that in order to produce in bulk, they need certainty that there is a buyer / Extraction & drying technologies are also required, as the cost is too high / Drying & extraction technologies from seaweed can be useful / Micro-algae protein composition its close with insects and both have good potential	the scale of production, price, the legal aspect are key aspects for the success of niches/ In terms of functionality of proteins, algae also have an advantage. Their proteins have specific function very interesting for food applications that you cannot find in plant materials / More knowledge is required at production and product development / Knowledge will mainly come from universities / Other niches are absolutely another source of knowledge, especially cultured meat and meat structuring on other niches / Production costs need to become lower as now we are a premium product / a lot of food companies are looking for new ingredients and the reason for that is that consumers are demanding new ingredients	There is a lot of interest from the vegan community and the vegetarians / Prototyping is still an issue / Knowledge will also come from outside algae / In fundamental research, methodologies can be shared with other protein niches. But it is hard, as knowledge among niches is completely different / Considerations of having a common project between insects and algae – did not go through, as it was only focused on the technical aspects
	Normative	Hard regulations			
		Normative Rules	Novel food regulations are the main barrier, as not everything can be placed in the market / the efforts to tackle regulations are not cross-niche, they are rather intra-niche, as the content of dossiers is different / GMO regulations as well is a regulation	Lab grown meat will take more time in terms of legislation, while plant proteins are already in the market. Micro-algae are somewhere in between / Legislation is a bottleneck not only for microalgae, but also for all types of new ingredients and product. They need to go through the novel food legislation. This take time, money, resources	People start considering algae as a food and protein source more than ever before / There are many hurdles on legislation to use algae on food / the insects community is moving smarter than algae. We should also look at it, how they did it /
	Concepts		Algae products for more sustainably focused people / Algae as an ingredient is maybe the future / With seaweed market growing however, I do see micro-algae benefiting from that as people will get used to eat greenish products and to the taste / Micro-algae and insects both require people getting used to something different and in market acceptance / Insects and Micro-algae could even maybe help each other into convincing consumers to consume them.	Sustainability-wise algae has an advantage / People see micro-algae as a very cool thing but not as a true player / Attitude-wise I do not think that niches interfere a lot to each other. Algae are maybe a bit similar to insects – people can try them out once / I think that people are not mixing their feelings for alternative proteins as a whole; so if someone doesn't like insects it doesn't mean that they also don't like algae or the other way around. We are all playing in the same market and we all want to contribute / Consumers liking one niche will probably stick to it and become a bit more receptive to trying out different alternative protein niches / We can have similarities with other niches as we are targeting the same market/consumers. Yet algae are more flexible as it has more things to offer	Algae are plant-like proteins / The productivity per area is also quite high if you compare it to most agricultural plants / Micro-algae for places where you don't have fertile land / You can also grow it on sea water / algae and insects together as possible parallels / Then if for example we talk about insects and algae, it is also important that people know the difference / Micro-algae and insects can be used in places where nothing else works - showing the sustainability aspects of it / Different consumers will use different alternatives and the consumer preferences will again dictate what will happen / Algae for example position themselves on the vegan sector / Vegans would not eat the insects / At a certain time in the future, there will be some competition between protein niches for certain mainstream applications

Beans Actors

Dimension	Aspect	Information	Plant-based Cheese	Rival Foods	Innogusto
General		Vision	What I want in the future, is that we all eat plant based diets / Once you are fully vegetarian or vegan, you do not necessarily consume meat substitutes often / Higher costs make plat-based, legume-based, insects and algae niche products, as lower prices are needed to attract new customers and more customers are needed to make it cheaper / There is enough space for all of us here. I don't get why we should always be competitive in any sense. Its ok that our partners can have other partners / If one of these markets were to grow, this would also help us grow as well	At the moment still the plant-based sector is small comparing it to animal-based / Then there are also other products, like insects, cultured meat / cultured meat companies have completely different challenges / Making animals redundant in the value chain is many people's goal and this is why they do not want to use insects / The same goes for cultured meat, there are people that are really critical on whether this will be affordable and sustainable in the future / It is a growing market that I think there is enough space for multiple product categories and for consumers to decide based on quality, convenience and price / I think the whole industry of trying to achieve change from animal based and meat based towards plant based products or insect products is a common challenge	For our company the future is that we integrate as much as different types of meat substitutes because we don't work with one specific / you don't have to educate the customer, we have to bring food that they like and it's tasty / soy is not that popular anymore, as pea, fava bean and other things are gaining popularity
		Importance			
		Future of the market			
Organizational		Access to resources	We aim for short and local value chains / We share a lot of parts of our value chain with other companies / We make partners that believe in the same values as we do / We need governmental support, we need some action groups to step in on that with us to fight these naming rights / We need partners willing to transition in the way they farm, to work with us / We are part of Impact Hub, where we get to know companies that do similar things and we learn from them; they have genius ideas /We are part of organizations for farmers because we want to know what is important to the farmers / We are part of the GPA / We gain contacts and therefore know people to help us with our problems / Indirectly, we also see what other people are doing and what challenges they face	We have collaboration with WUR, where fundamental research is done on the alternative proteins / Pea protein is something that is not going to be available to everybody in the coming years, as the fields where peas are grew on are too little / Plant based proteins suppliers / Selling on restaurant chains and the food service / We do not go directly to supermarkets, as we cannot produce the kinds of volumes required for that / We have suppliers that also supply other companies / For pea proteins, supply is rather problematic / Starthub and Startlife / Collaborating in the Plant Meat Matters large consortium that is public-private partnership together with the university and other companies, big ones like Unilever and also suppliers, equipment manufacturers etc. / We are part of ClimateKIC, an acceleration program for companies working in the climate improvement / Receiving Financial benefits, Business guidance and Networking / We work together with chefs / It is also more often that investors do not want to use insects, as they are still animal based sources.	Foodvalley and The Protein Cluster give us an outlet to communicate and express our views but also to be part of the overall development process happening / We are also participating in developing structure facilities and programs to boost this protein transition / There is a need for chefs to start developing much more on the gastronomic side / The value chain is very traditional. Especially in the distribution market, they are not proactive / The caters are more conscious about needing to change
		Network Interactions			
		Network Roles			
Conceptual	Descriptive Schemata	Technical Knowledge	The technical knowledge is hardly transferred / Everyone is scared of giving away their competitive advantage, but there is lack of knowledge between giving away you competitive advantage and simply sharing knowledge without killing your own business / I think that breakthroughs in one niche would impact others as well. If everyone starts eating insects, this would also transfer well to us	WUR is doing research in creating ideal ingredients for plant based meat products / I see the university as being one of the main stakeholders transferring knowledge for many niches, including ours / Needing technical knowledge to scale up / Companies do not share all their knowledge to protect their competitive edge / It is a peer learning process while holding your competitive advantage / Other niches benefit us in terms of business plans and IPRs /	Technological breakthroughs in texture and taste are required / More knowledge about the consumer is needed as companies focus more on the technical side rather than what consumers want
		Expectations			
	Normative Schemata	Hard regulations	After the coming summer we will not be allowed to use the word cheese for plant based cheese / Farmers are very much willing to adapt / The naming issue is a huge block for us right now / There are not that many regulations to help us as well	We have no real regulations. Insects on the other hand have to pass through them. This is an advantage for us / Regulations are needed, the system is however quite slow and expensive, and this should be changed to accelerate innovation in the food industry	The reputation of FoodValley also adds credibility to our business / Changes in food consumption happen on request of the customer or the government
		Normative Rules			
	Concepts		I think a very important reason why we are a niche is just the higher cost of our products / there are not so many things that make us unique / No niche will take over the entire market e.g. insects, algae or plant-based / customers will get to create their own personal norms and preferences / We will have an array of solutions and everyone will get to choose their own	People often say "Don't call it plant based meat, it's something different"/ comparing to cultured meat, plant based products have the potential to be more sustainable than cultured meat / Looking at sustainability, then using plants is a sustainable alternative to animal based products / Comparing to insects, the consumer acceptance is better / Insects and cultured meat often claim that their protein compositions are closer to that of normal meat than plant based / I see micro-algae as ingredients in products and insects as bulky ingredients in products	I have tasted products based on insects and sometimes I liked it, while some others I didn't. / I am now working together with a company that wants to offer us the possibility of developing micro-algae products. It is green, so from a customer/marketing perspective you have to create a concept that people love / insects are a big threshold for people / People creating these algae, they do not have a concept in their minds. They are lacking the skills of branding; of what kind of product they can create

Overview Actors

Dimension	Aspect	Information	The Protein Cluster / Foodvalley	Willem Blom	Stacy Pyett	Ekoplaza
General		Vision	For Foodvalley, the protein transition is broader than plant based proteins and fungi, algae, insect and pulses, soybean, fava bean and pea copanies are included/ We want to take that to 60-40 plant to animal protein / awareness in consumers and retailers is a big win necessary / The success of plant-based enables other alternatives like clean meat, insects, seaweed can become a thing / Eventually there will be a combination of different niches depending on the audience you have / Seaweed won't become as big as regular meat or plant-based meat	I have made some investments in cultured meat and plat-based companies / I want to veganize the farm to fork supply chain / A product usually revolves around great taste and affordability and availability / I'm in talks with two companies making pea milk and I have made more investments / I'm not a big fan of insects' protein because it still using the animal and is not removing the animal from the supply chain	We are over-consuming animal based protein and we need to reduce that for reasons of health, sustainability and equitability / In total, we need to reduce the proportion of animal proteins we consume and at the same time we also need to reduce the overall protein amount we consume / Ideally, we would come some 25-30 grams of animal protein per person per day / Starting with pulses, they are the most accessible alternative for Europe/ For algae we cannot extract the protein very well, we cannot digest the cell wall / Insects can play a role in upcycling our waste / I also do not expect that we will massively accept consuming insects in rich countries within a generation / It is also possible to bring together people from different technologies. These people are usually pretty happy to work together - but if they have the same niche they work on, there is competition / I do think the success of pulses paves the way for the other niches	Our vision is that plant based is preferred, animals should be a by-product of plant agriculture and it is acceptable to eat them, but animals should not be the main contributor - plant should be / Our role is to stimulate sustainability in our customers and the consumer to receive sustainable products / We also sell a lot of algae products, e.g. dried, or Japanese products. We are selling more and more of the algae products and we are adding more of them. / Creating this impact could possibly mean that we stimulate a snowball effect, as consumers could tell their neighbours about them and stimulate more consumption
		Importance				
		Future of the market				
Organizational		Access to resources	GPA try to build the awareness of the consumers / supermarkets also believe in the transition, but it is more of a side stream to their main business / Once insects become more mainstream they can be feasible in the supermarkets. (though not vegans and vegetarians) / We are working on a facility map between different companies from different niches open to third party use / WUR is focusing on insects / Insects are produced by insect farmer / Plant growers are open to pulses / If yo do not have growers it is hard to build a complete value chain and have a final product	I know NL investors as well and meet at the Vegan Entrepreneurs network - a network I set up here. We meet in a monthly basis to talk about entrepreneurship, the trends and innovations happening in the plant based sphere. It is a network that also attracts other investors, so it is also nice to connect with them in these events / Even the most conservative traditional meat companies are shifting away from meat and start exploring plant-based alternatives	The pulses supply chain is pretty mature. The world's biggest ingredients manufacturers are jumping on board, like Ingredion, Cargill. These companies by being buyers of those crops, they are motivating farmers to also be part of the transition / For pulses there are many investments in the B2C side / Insect supply chain more mature that algae one / There are enormous investments and strong growth in insects. / The algae supply chain is still in a very early, baby phase. / The least financial resources are going into research on algae and more are needed. // In the Netherlands, The protein Competence Center is mostly consisted of Dutch companies, the Foodvalley organization. / There are many conferences where knowledge sharing happens, to the degree allowed of course / Also discussions on the shared interest and even spinning out research to advance the industry as a whole / I don't expect that the success of pulses farmers will inspire other farmers to go into insects / Imagining a case where success in pulses inspires bigger investments or an acceleration in algae and insect niches, it will be driven by the money	Together with WUR we are researching whether lupine can be used for feeding animals in the Netherlands / We work together with smal farmers to ensure that chains are transparent and sustainable / we stimulate our customers to that with various initiatives - sharing vegetarian and vegan recipes
		Network Interactions				
		Network Roles				
Conceptual	Descriptive Schemata	Technical Knowledge	if someone really cares about the environment, then they are probably more willing to pay a higher price for sustainable products / Pulses needs more breeders to work on higher protein concentration plants / A lot of knowledge is required through the value chain, from growing to consumption / Cross-niche transfers of knowledge could be the case / consumers are changing their mindset regarding their consumption behaviour and they are open to new ideas / Once the shift of what meat is happens, then people can be more accepting to other solutions, e.g. insects. / Insect taste is not developed	The availability has tremendously increased. Talking about affordability that is still issue - price parity is not there yet. / algae it is still early ages and there is a lot of R&D going around / Especially in clean meat there is still R&D at a factory scale trying to find the right recipe	For pulses, breeding to make them more appropriate for food products is a goal / For Algae, technological breakthroughs are required / in the NL and in Europe as a whole, that the main innovation is driven as academia. I feel that we, as WUR have a really important role in this topic. / In the pulses value chain is quite close to standard business. Looking at insects and algae, there is an entrepreneurial attitude, where companies are willing to shift business model to find out what is working. There is an exploration process mostly / There are shared needs definitely, e.g. energy efficient processing - extracting the proteins with low costs. There is a need for functionality in end products.	we are having a new partner creating concepts for us, based on plant-based proteins / Alternative protein products then, like the chickpea pasta are not always better than the regular ones, e.g. I prefer the wheat pasta / In that sense, you need to know what you can use the proteins for, in order to create tasty products out of it. / Some algae contain a lot of protein and some do not, so not all are valuable for the protein transition. /
		Expectations				
	Normative Schemata	Hard regulations	As the government doesn't change it's approach, then not a lot of things can change / Regulations are important for insects and clean meat / For plant based regulations are not the case / Food regulations is slowing them down and requires many resources	I think there should be a level playing field also, from a regulation perspective, either also allowing plant based to receive similar subsidies or to remove subsidies from food market / When we talk about regulation, the system is very supportive to the animal meat industry - only look at the subsidies. 40% of all EU subsidies go to the animal agriculture	Insects get hampered by the regulatory issues / For insects, we have to work on the regulatory landscape to achieve their potential / Dutch government funds a big deal of research supporting the protein transition. There is definitely, on the policy-maker side, actions that support this. At the same time, investments in research are not always followed by regulation	
		Normative Rules				
			different protein niches could therefore serve different consumer niches eventually, based on consumer needs / awareness in consumers and retailers is a big win necessary / I think it has much to do with the target group you want to attract / Insects are more nutricious than plant-based products and have a good impact on the environment / Pulses are less efficient than insects and algae as they require more land, yet it is good for your body and people are used to it / Pulses are easier to eat for consumers than insects, as consumers are still hesitant on them	Millennials are craving for everything that is labelled plant based or vegan and still all generations shift there slightly slower / From consumer perspective the mindset is shifting / Cultured meat is the most tech-heavy and investors are focusing now on the R&D phase / Algae is in between pulses and cultured meat, not really marketable yet, but there are companies in the NL that have a go-to-market strategy already	On the consumption side there is a growing awareness that we need different protein sources and willingness to explore these protein sources. If you are then willing to take a step out of your comfort zone you are more likely to do it again / Pulses are in the last bottleneck, of making good consumer products. Insects are more on the regulatory one and algae are at the technological one.	cricket bars, or insect products, which are rather new for our consumers, it is not easy to sell always - they are also animal proteins and we see more of a trend for vegan, rather for other animal products / The main reason people change to alternative proteins is animal welfare, so more and more we have insights into how animals are grown and that organic is better / Animal welfare and health is why people reach to alternative proteins / for cricket bars, it is hard for people to see the real benefit of consuming insect products./ For insects, I have to say that I question whether there is enough market. / The impact of alternative protein products is that consumers feel good using them /
		Concepts				