To eat or not to eat: Cultured meat and its barriers ahead in transition.

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TO EAT OR NOT TO EAT:
CULTURED MEAT AND ITS BARRIERS AHEAD IN TRANSITION.

BY JORIS VOOGD.

TU Delft

"We shall escape the absurdity of growing a whole chicken in order to eat the breast or wing, by growing these parts separately under a suitable medium."

~ Winston Churchill, 1931

Preface

As the final part of the Master study in Management of Technology (MoT) at the Technology, Policy and Management faculty of the TU Delft, I conducted this thesis research project. The thesis involves an analysis of the Dutch cultured meat industry in transition context.

When I started the MoT master, I already had a Dutch HBO degree in Product Design and multiple years of working experience as a mechanical engineer. Nevertheless, I still aspired to follow a Master that address multiple disciplines and a more holistic approach towards technologies. While this would complement my background, I also would be able to experience different, less related fields. Yet, the switch from working life back to study life at times was challenging. Not only was MoT more theoretical then my rather practical background, study work was never truly finished. Finding that work-life balance and the reduced income took me some time to get used to. Yet I really challenged myself and stepped out of my comfort zone, growing both personally and intellectually, which I am quite proud of.

Sustainability is something I find both necessary as interesting. For a carnivore in that respect, it is quite difficult to fulfill appetite in a responsible manner. I envisioned that many people faced this issue and therefore wondered why cultured meat was not already in the supermarkets. Moreover, I was curious how a future with cultured meats could look like and what would be necessary to accomplish this. This led to the transition of cultured meat in the Netherlands as direction for my thesis. The transition proved to be very compelling and sometimes worrying, yet it taught me significantly about transition requirements for both cultured meats as other sustainable innovations. This would not have been possible without the very willing and kind respondents involved in this research. You provided the information that contributes to the interesting results, for which I am very grateful!

The thesis process was reasonable but sometimes challenging. For example, I found it hard to accept an unproductive day, which occasionally resulted in frustration. Nevertheless, I have learned a lot from this period (see reflection chapter). Apart from the interesting subject, this was also due to the good and, above all, pleasant supervision I received. The guidance from first supervisor Neelke Doorn, second supervisor Geerten van de Kaa and advisor Martijn Wiarda has been very constructive. The sessions we had always gave me food for thought so that I could often figure out the next steps myself. Furthermore, the guidance was professional but accessible, which meant that I never experienced the sessions as unpleasant. I would like to thank you as people sincerely for this. In particular, I would like to thank advisor Martijn. You guided me on the most regular base and were always willing to give advice. Moreover, it was fun to discuss my subject with you, thanks!

In my personal environment I also would like to express my gratitude. My friends for their interest and generous gestures. Furthermore, I thank my sister and parents for their willingness to listen and support me continuously during this master. In addition, my parents always let me free to follow whatever dreams I have, which I cherish. Moreover, even though my girlfriend went through challenging times herself, she was always willing to discuss my thesis topic or make life easier in other ways, for which I am truly grateful. In particular I would like to thank my grandparents. Without their contribution, this career switch, this future, would never have been possible for which I am grateful for the rest of my life, thank you!

I hope you will enjoy reading this thesis!

Joris Voogd
Amsterdam, August 14, 2022

Executive summary

Conventional meat (CVM) and the related livestock industry are considered to contribute significantly to negative environmental impacts, animal suffering and threats to public health. Nevertheless, the demand for meat is still growing which is majorly due to global population growth. Lab-grown cultured meat (CM) is anticipated to be environmental-friendlier, animal-friendlier and potentially allows for public health benefits. However, it is not yet introduced in the market and it faces multiple development challenges related to the technology, consumer acceptance and socio-politics. Furthermore, while CM stakeholders possibly aim for a meat transition, the challenges are hardly addressed in transition context. Transitions are generally studied across the levels of landscapes, regimes and niches using the Multi-level perspective (MLP). Moreover, Strategic niche management (SNM) can be used for assessing the internal processes that determine the success of a niche. On the basis of the MLP, SNM and the CM niche industry, this research therefore is intended to answer the following research question: *What are the barriers to the transition of cultured meat from niche to regime perceived by stakeholders?* Hence, this study provides niche stakeholders insight into supporting and accelerating a CM transition. For this purpose, the case of the Dutch CM industry is chosen. By means of conducting interviews with academic, business, government and society stakeholders combined with an analysis of related policy documents, 12 barriers are identified. The landscape level involves mutually reinforcing barriers (*The environmental paradox & The Dutch political climate*). The CVM regime level also involves reinforcing barriers that provides its dominant and stable character (*Socio-Cultural lock-in, Techno-Economic lock-in, Institutional-Political lock-in and Regime perspectives*). The CM niche industry level in turn, involves barriers that impede the process of the articulation of expectations (*Operational constraints & Imagining*), impedes network formations (*Insufficient incentives & Network disunity*) and impedes learning processes (*Limited accumulation of knowledge & Dependent on innovation diversity*). As these niche processes also reinforce each other, the CM niche industry possibly is entangled in a vicious circle, affecting niche nurturing and hindering reciprocal interactions between the levels. The barrier interactions and reciprocal interactions between the levels combined, determine that the window of opportunity for a CM transition is potentially only limitedly on the rise. Moreover, the effects of moderate landscape change, gradual regime reorientation to the landscape, limited institutional change and an insufficiently well-developed niche, are indicators that the transition is potentially on a transformation pathway. Based on the theoretical implications of this study, future research should aid a better articulation of niche expectations by the CM industry to attract new stakeholders and enhance learning processes. Furthermore, studying the CVM regime capabilities and specifying intentions in relation with CM, especially since the regime barriers could become CM enablers, potentially gives further insight into how the transition could be governed. With regard to practical implications, the potentially occurring transformational directionality failures could be addressed with mission-oriented innovation policies. Moreover, the possible transformational demand articulation failures would optimally be resolved if participation possibilities with the general public for exploration would be implemented. The mentioned failures also relate to transformational reflexivity failures for which CM stakeholders should anticipate the effects that impact the pathways for transition. Furthermore, when comparing the used policy documents with the interviews, the documents predominantly address the need for facilities and incentives regarding the CM niche industry. Although this also is constructive and necessary for the establishment of the Dutch CM industry, the influential landscape and regime developments are hardly considered. Hence, addressing the regime with true pricing for CVM and the landscape with implementing societal challenge-based mission policy instruments, possibly also accelerates the transition. Although CM is still fraught with uncertainty and has not yet been introduced in the market, approved by the regulatory authorities and is yet to be scaled up, it could have a major impact on a better sustainable future. In the end, as it will benefit all, that projection in itself makes CM worthy of further investigation.

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Abbreviations

Abbreviations	Explanation
A1-3	Academic Stakeholders 1-3
B1-3	Business Stakeholders 1-3
CAC	Cellular Agriculture Consortium
CACp1	Cellular Agriculture Consortium growth plan Pillar 1: Education
CACp2	Cellular Agriculture Consortium growth plan Pillar 2: Public Research
CACp3	Cellular Agriculture Consortium growth plan Pillar 3: Scale-up facilities
CACp4	Cellular Agriculture Consortium growth plan Pillar 4: Social Integration
CACp5	Cellular Agriculture Consortium growth plan Pillar 5: Start-up/innovation Climate
CM	Cultured Meat
CVM	Conventional Meat
EFSA	European Food Safety Authority
EU	European Union
G1-3	Government Stakeholders 1-3
MANFQ	Ministry of Agriculture, Nature and Food Quality
MLP	Multi-Level Perspective
P1	Policy document 1: Cellular Agriculture Consortium growth plan application
P2	Policy document 2: Cellular Agriculture Consortium growth plan governmental approval
RA	Regulatory Approval
S1-5	Society Stakeholders 1-5
SNM	Strategic Niche Management
ST-systems	Socio-Technical systems
TIS	Technological innovation system

1 Introduction

There seem to be a growing consensus about the negative effects of conventional meat (CVM) consumption and production. According to a report of the United Nations Food and Agriculture Organization, the livestock industry currently is accountable for a global 18% greenhouse gas emissions, 8% of water demand, and requires 26% of the world's ice-free surface (Steinfeld et al., 2006). Due to its demands for space furthermore, it has caused for biodiversity loss and tropical forest deforestation (Machovina et al., 2015). The livestock industry in that respect, has shown a considerable negative impact on the environment. In addition to these environmental concerns, studies indicate livestock production as being animal-unfriendly due to animal suffering (Loughnan et al., 2010). Moreover, the consumption of meat, is suggested to be a contributor of threats to public health (Walker et al., 2005). Despite these effects, the demand for meat is still growing (Godfray et al., 2018). By 2050 it is estimated that the production will have been expanded with 76% (Alexandratos & Bruinsma, 2012). In addition to urbanization, growing economies and fluctuating markets, population growth seems to be the main factor for such increase in demand (Bhat & Fayaz, 2011). It is estimated that by 2050 global population will be represented by more than 9,5 billion people (Roser et al., 2013). To be able to feed this entire future world population with meat and other proteins in an environmental-friendlier, animal-friendlier and perhaps healthier manner, different sources of food will be required (Nadathur et al., 2017).

Cultured meat (CM) or In Vitro Meat is considered to be highly comparable to CVM, as it is aimed to deliver basically the same product. However, several studies anticipate that such lab-grown meat could have multiple advantages over CVM. While the technology is not yet developed for global commercial purposes and the benefits are not yet proven in practice, several projections about its future production suggest significant environmental progress (Hartmann & Siegrist, 2017; Tuomisto et al., 2014). Furthermore, it is believed that the technology can harvest the stem cells necessary for CM production, without raising and harming large amounts of livestock (Stephens et al., 2018). Additionally, it might allow for public health benefits as antibiotics and other contaminating factors are absent in the production of cultured meat (Post et al., 2020). Moreover, it is suggested that the profile of nutrients in CM can be adjusted (Gaydhane et al., 2018; Tuomisto, 2019). In theory, a possible CM product thus could be created that is healthier than CVM (Arshad et al., 2017; Kadim et al., 2015).

Although the suggested benefits of CM could encourage a higher degree of development, the current industry remains relatively limited. For instance, CM is not produced yet on scale neither is it globally commercially available or applied throughout different markets (Bryant & Barnett, 2018; Stephens et al., 2018). As a result of this position, CM is hardly capable of competing with the current CVM sector. This observation gives direction to the problems CM need to overcome in its development. It will function accordingly, as an initial point of departure for this study.

1.1 Problem statement

An ultimate goal of CM technology could be to resolve the issues related to CVM and result in a reduction in demand of existing meat markets (Welin & Van der Weele, 2012). An objective for CM advocates therefore could be a sustainable transition from CVM to CM. Still, the CM industry consists of merely a few niche start-ups which are facing fundamental problems which could limit the progress of the transition (Gaydhane et al., 2018; Stephens et al., 2018). Hence, for further development, several barriers need to be addressed.

The barriers that CM is facing in its development entail technical, consumer, and social-political related challenges. Firstly, and perhaps most importantly from the technical feasibility side, the production

process currently is hardly capable of producing large quantities of CM products (Kadim et al., 2015; Tuomisto, 2019). Multiple causes are at the root of this, including cell resources, culture conditions and production costs (Post et al., 2020; Stephens et al., 2018; Zhang et al., 2020). The main barriers, however, seem to be the costs of the growth medium and the designs and sustainability of the bioreactors necessary for large-scale production (Post et al., 2020; Tuomisto, 2019). In addition, several studies express the need for specific production scenarios required to produce sustainably, as this otherwise could become critical (Alexander et al., 2017; Tuomisto et al., 2014). This suggest that the environmental benefits of the CM technology possibly are still uncertain. Secondly, multiple consumer related considerations are being questioned in the literature. The acceptance of the consumer hereby seems to take up most of this category. According to multiple literature reviews, consumers in general tend to be reluctant to eat CM due to concerns about its perceived unnaturalness, taste and physical appearance, healthiness, anticipated price, safety and feelings of disgust (Bryant & Barnett, 2018, 2020; Chriki & Hocquette, 2020; Treich, 2021; Verbeke et al., 2015). Moreover, several studies observe friction among consumers when it comes to changing meat consumption patterns (Hartmann & Siegrist, 2017; Macdiarmid et al., 2016). This is furthermore expressed, in both international (Tiberius et al., 2019) as national conducted surveys among the population such as in Germany (Weinrich et al., 2020) and the United States (Wilks & Phillips, 2017). Finally, barriers in regard to CM developments also lay within a social-political dimension. For its introduction into the market, many regulatory challenges are to be confronted which differ politically from one nation to another (Guan et al., 2021; Penn, 2018; Servick, 2018). See for instance, Post et al. (2020) for the differences between the United States Foods and Drugs Administration and the European Novel Foods Regulations which CM should comply with. Other studies furthermore, shed light on the importance of inclusion of certain stakeholders of the CVM industry such as rural producers (Newton & Blaustein-Rejto, 2021).

Taking the above into consideration, multiple scholars have put effort into identifying the barriers that CM and its industry are facing. Moreover, they are predominantly being addressed in light of its development towards commercialization. Yet, while population growth increasingly leads to the need for a sustainable food transition, i.e., the protein transition, in which the replacement of meat plays a central role (Geijer, 2017; Tziva et al., 2020), the barriers are hardly addressed from the perspective of a transition. Van der Weele et al. (2019) compares meat alternatives as directions for a transition, and mentions several preconditions for the future of CM, which are comparable with the above-mentioned barriers. Other studies particularly suggest the need for a protein transition (Aiking & de Boer, 2020), identify associated barriers based on the production of CM (Hübel & Schaltegger, 2022) or for a specific market (Newton & Blaustein-Rejto, 2021). Although, the context of a CM transition is present, these primarily address challenges regarding scaling up and commercialisation. Barriers that directly relate to and effect the outcomes of the transition, seems not yet identified. Furthermore, hardly any study apparently, is using transition literature, whereas this could be important for understanding the causes of the barriers to transition.

Transitions are generally studied across the levels of *niches* (micro-level), *regimes* (meso-level) and *landscapes* (macro-level). Within this so-called Socio-Technical System, *"the interlinked mix of technologies, infrastructures, organizations, markets, regulations and user practices that together deliver societal functions"* (Geels et al., 2017, p. 1242), niche technologies such as CM, attempt transitioning to regimes. To accommodate this transitional process, scholars regularly make us of Strategic Niche Management (SNM) (Li et al., 2015; Markard et al., 2012). SNM typically consist of the niche internal processes of *the articulation of expectations, network formation,* and *learning processes* which determine the transitional success of the niche (Kemp et al., 1998). In addition, scholars also consider exogenous factors in the regime and landscape levels critical to bring about transitions (Schot & Geels, 2008; Smith et al., 2010). These different level dynamics of niches, regimes and landscapers together, gives a clear impression of the Multi-level Perspective (MLP), which combined with SNM, could be useful to identify barriers to transitions (Geels & Schot, 2007).

In light of the above, a gap in the literature seems identified. The CM industry is limited to a few start-ups at the niche level, which are facing barriers to commercial development. Yet, it is not clarified what and how barriers affect a transition. It is therefore, unknown how the CM industry could evolve from niche to regime level. The aim of this study is to fill this gap using transition theories.

1.2 Research objective

Based on the identified gap in the literature, the main objective is to provide niche stakeholders and scholars insight into the processes that are hampering a CM shift from niche to regime, i.e., transition barriers. By this means, this could increase the understanding about how a CM transition could be supported and accelerated. This will be done in this study, by focusing on barriers to the transition of CM that can be found both in the external levels as in the internal processes of the CM niche. As the MLP and SNM can provide this, and typically focusses on niche shifts to regimes, this literature will function as the theoretical basis.

1.3 Research questions

To achieve the objective and guide the research process, multiple research questions are established. The main research question covers the sub-questions. The sub-questions do not necessarily need a certain course and order. Instead, they form a coherent entity of different components with which the main research question will be answered. The main research question and sub questions for this study are:

What are the barriers to the transition of cultured meat from niche to regime perceived by stakeholders?

1. What are the perceived barriers related to the landscape level?
2. What are the perceived barriers related to the regime level?
3. What are the perceived barriers in the niche processes of the articulation of expectations, network formation and learning?

1.4 Relevance

Understanding the processes that induce barriers to transition seem to be relevant for stakeholders and scholars who are currently engaged with CM. Indeed, if policy makers, companies and managers, institutions and NGOs aspire to transition CM to regime level, transition management strategies for actions potentially are required. In that respect this study might provide insight into the directions of intervention. For instance, it might provide niche actors insight into what is needed to enhance network formations and attract potential actors. Furthermore, it could indicate the effects that the regime has on the transition. Hence it could guide stakeholders in overcoming the negative effects of the barriers. From a theoretical point of view, this study is particularly relevant for CM scholars. However, some results might also be relevant and applicable for other related fields. Other niches that also develop sustainable developments, such as other meat alternatives, potentially also could yield the same conclusions. Nevertheless, this study might provide additions for the use MLP and SNM theories. In any other case, it will majorly be contextualising for the used transition theories. Yet, the result of this study might also demonstrate the need for further research directions. For instance, the direction of the transition could be further studied in alignment with the MLP related transition pathways.

2 Theory

This section will elaborate upon the theoretical foundation of this study. More specifically, it is intended to clarify and describe the transition literature used to eventually be able to analyse the barriers to the transition of CM. To provide a contextual background this chapter starts with describing Transitions and Socio-Technical Systems. A description of the Multi-Level Perspective and corresponding transition phases will follow. This chapter ends describing Strategic Niche Management and its internal niche process dynamics.

2.1 Transitions

Transitions are generally understood as a phase of change, in which the fulfilment of a new societal need is considered the objective (Geels, 2019; Sengers et al., 2019). Within this phase that can take multiple decades, existing operations of production and consumption in societies shift to more sustainable conditions (Markard et al., 2012). Rationales for transitions are, accordingly, related to challenges faced by complete societies and industries. This may include both social and economic problems such as poverty or financial crises (Markard et al., 2012). A more recent prevailing rationale for transitions, however, is fundamentally embedded in the environmental burden that mankind has induced over the years (Farla et al., 2012). In this regard, scarcity of natural resources, greenhouse gas emissions, and pollution, to mention a few, could function as a motive for sustainable transitions. Such change driven by fundamental problems requires deep alterations of societies (Markard et al., 2012). It may therefore affect multiple different domains such as energy, food, and transportation industries (Farla et al., 2012). Furthermore, a phase of transformation in society tends to substitute existing sectors (Farla et al., 2012). By partial reason of this, transition process also can be characterized to involve non-incremental innovations (Markard et al., 2012). Hence, the technological development that comes about, is not comprehensively based on existing paths and technologies. Instead, the innovations are of the more radical type, which has the ability to disrupt existing systems (Twomey & Gaziulusoy, 2014). Indeed, as the fulfilment of a social need in transitions, such as dealing with sustainability challenges, requires major changes, incremental innovations will be insufficient. Potential outputs of transitions are therefore new emerging sectors, organizations, business models, products, and services (Markard et al., 2012). In conclusion, the delivery of new societal functions in transition has a broad scope in terms of impact, which can affect different layers of society.

2.2 Socio-Technical Systems

Possibly due to the mentioned stratification of transitions where stakeholders in different dimensions contribute, the literature often observes transitions from a Socio-Technical system (ST-system) perspective (see for example; Damman & Steen, 2021; Geels et al., 2016, 2017). System perspectives recognize the presence of technology and presume structures based on different interrelated components and functions in societies (Savaget et al., 2019). In this regard, a comprehensive multi-disciplinary view on how certain processes in society are generated can be established. ST-system perspectives indeed encompass a diverse range of interconnected stakeholders and institutions that deliver societal functions, e.g. energy (Geels, 2019). This set may for example be represented by firms, consumers, policy makers, researchers, media, collective movements, and public institutes (Geels, 2019; Markard et al., 2012). Whereas Technical System perspectives mainly assume technology utilization and focus on the production side of artefacts and knowledge creation, ST-systems additionally incorporate the user environment and consumption (Geels, 2004; Savaget et al., 2019). Hence, in addition to actors producing technologies, it acknowledges the importance of social groups such as the aforementioned consumers and collective movements (Geels, 2004).

With respect to the above, ST-systems can be considered to be capable of producing both technical and non-technical assets (Markard et al., 2012). In a sense, Geels (2004), confirms this by characterizing ST-systems with processes of co-evolution between technology and society. In this context, the output of transitions occurs through the interplay of different stakeholders. Savaget (2019) also follows this way of explanation, by characterizing ST-system change, as processes of variation, selection, and retention. An important component of ST-systems in a sense thus involves the dynamics and adaptability between stakeholders. Furthermore, the frames in which these transitions take place are partly formed by institutional rules (Geels, 2004; Markard et al., 2012). These rules are determined by social groups and declare certain types of behaviour. A distinction can be made, between hard and soft rules. For example, public institutions determine the hard rules, i.e., regulations, that actors and technology in ST-systems must comply with. Still, soft rules, i.e., norms and values, that are indirectly imposed by e.g. cultures or collective movements, additionally also influence how transitions take place. Social interactions as sources of inspiration and feedback, therefore ensure that the institutional rules are maintained or changed (Geels, 2004). Considering this, the rules could structure activities in transitions.

A multitude of theories exists that can be used to study socio-technical transitions. The four variants considered most influential are Technological Innovation Systems (TIS), Transition Management (TM), MLP and SNM (Markard et al., 2012; Twomey & Gaziulusoy, 2014). Although many of the contributing authors have Dutch roots, the theories differ in focus and analytical approach in studying transitions (Li et al., 2015). However, to study transitions across landscapes, regimes and niches which is also done for this research, academics primarily use the MLP and SNM. Both are being discussed in the following sections.

2.3 Multi-level Perspective

The MLP theory is a framework which can be used by scholars to analyse transitions in ST-system context (Geels, 2019). The framework presumes a stratification of socio-technical transitions, by means of 3 levels; *landscapes*, *regimes,* and *niches* (Figure 1). Hence, a broad scope can be established to identify the dynamic processes that may declare how such a shift originates (Twomey & Gaziulusoy, 2014). Landscapes can be considered as the exogenous environment in which the contextual setting of transition dynamics is determined on macro-level. Regimes, in turn, form the meso-level in which stable established technologies are being retained. The niche is on micro-level and involves experimenting technologies aiming for a radical break-through in the ST-system.

According to the MLP, transitions arise from a window of opportunity where the levels mentioned come into alignment with each other. In this process, the niche tries to diffuse to the level of the Regime (Geels, 2002). Provided that regimes are stable and aligned, i.e., the involved social groups share the same interests and follow certain rules, radical inventions in most cases will remain at niche-level (Geels, 2004). Hence, processes of tension and de-alignment are particular when transitions come about. The levels of landscapes, regimes, and niches that describe the direction of socio-technical transitions, next to the phases of the window of opportunity in transition, will separately be treated in the following sections.

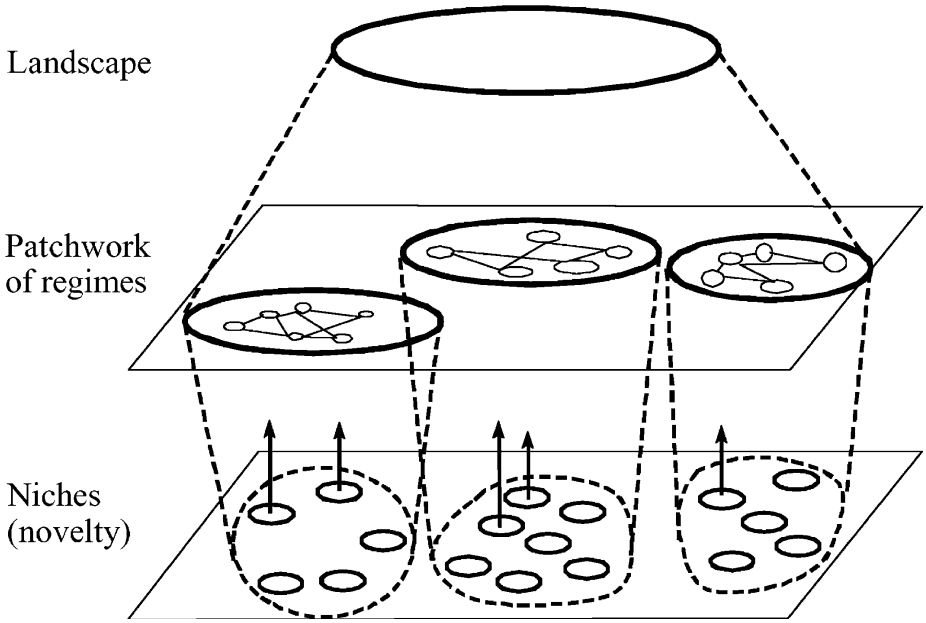

Figure 1. Levels in ST-system transitions

2.3.1 Landscapes

The landscape (macro-level) is an important level that contains (de)stimulating factors for transitions. It is furthermore, considered to be an exogenous environment that moves beyond the direct control of regimes and niches (Geels & Schot, 2007). This likely has to do with the nested and hierarchal character of the MLP. Landscapes determine the boundaries in which regimes are embedded and regimes in turn, embed the niches (Figure 1)). The chosen term of landscapes is furthermore, coherent with boundaries as it partly refers to the materialistic and spatial delimitation of societies such as cities and countries (Geels, 2002). Yet, while a boundary can be considered as a relatively hard line to cross, landscapes are subject to change. This is, however, a relatively difficult process and time-consuming (Geels, 2002). This possibly can be explained by the fact that landscapes involve slow-changing macro-economic and macro-political developments, cultural beliefs, and societal concerns (Geels, 2002, 2019). Still, landscape change also might occur due to sudden external shocks such as wars, fluctuating oil prices, and economic recession (Geels, 2019; Geels & Schot, 2007). Eventually, such change in landscape environment might stimulate a window of opportunity for the start of a transition to occur.

2.3.2 Regimes

Within the ST-system the regime (meso-level) is considered as the dominant and stable level delivering societal functions (Smith et al., 2010). It is represented by incumbent stakeholders such as firms, engineers, policy-makers, regulators, and users (Geels, 2019). Regimes and their involving stakeholders follow and influence certain trajectories for socio-technological development. These tracks are routine-based and path-dependent, which is why regimes are mostly only capable of producing incremental innovations (Geels, 2004). By means of institutional rules furthermore, the occurring actions in regimes are shaped and to some extent determined (Geels, 2019). These frames possibly give rise to mechanisms of dominant lock-in, which is making innovation adopters and users dependent on the mainstream stakeholders and technologies of regimes. Three types of lock-in are observed in stabilizing regimes (Geels, 2019). Firstly, techno-economic lock-in within regimes can be the result of sunk investments and economies of scale (Geels, 2019). This may ensure that in terms of efficiency in knowledge and capital, it is not attractive to switch to other ways of operating. Secondly, social and cognitive lock-in ensures for example, that engineers are bounded by routines, i.e., shared beliefs in ways of developing, which limits creativity for radical ideas (Geels, 2004). Another social lock-

in follows from societal groups with 'social capital' e.g. cultural lifestyles, and the involving rules embedded that determine user practices for specific technologies (Geels, 2019; Geels & Schot, 2007). Lastly, mechanisms of institutional and political lock-in can be present. Such lock-in corresponds to imposed regulations and standards that are constructive for incumbents, which possibly is making it harder for stakeholders outside the regime-level to operate (Geels, 2019). In addition, due to established relations of incumbents with policy networks, activities of lobbying also may hamper development outside the regime (Geels, 2004). In sum, regimes are defined by incumbents consisting of different social groups that interact based on certain stabilizing rules. By this means, it produces stable mainstream technologies and societal functions.

2.3.3 Niches

Niches (micro-level) define the environment in ST-systems that allows for deviating the rules of the regime (Geels, 2004). It is furthermore, considered as a protected space in which radical innovations can develop without being directly competed by the stability and dominance of the regime (Smith et al., 2010). Hence, these spaces form incubation rooms that are shielded against mainstream market selection processes (Geels, 2002). Not least for this reason, actors in niches are also seen as relative outsiders who generate radical inventions through pioneering and experimental activities. These actors comprise mainly start-ups, entrepreneurs, and activist movements (Geels, 2019). Even as protected spaces from regimes, niches involve significant uncertainty and de-stability. The rules that structures activities are not yet defined, neither are social networks with developing stakeholders completely established (Geels, 2004). As a result, intensive activities of trial and error are continuously present to define and ultimately mobilize a niche for a transition. Certain other niche processes characterize how radical innovations succeed, which will be elaborated in the SNM section.

2.4 Transition phases

According to Geels (2019), the MLP presumes transitions occurring in four phases (Figure 2). The first phase is characterized by experimenting and feasibility testing activities for radical novelties. The degree of uncertainty and failure at this point, therefore, remains relatively high and the development is still taking place mostly in laboratories and R&D departments. In the second phase, actual niche market formation starts to develop, by means of actors mobilizing innovations and resources into more stable configurations. In the third phase, pressing forces on regimes due to increasing maturation of the niche and landscape-level changes due to shocks e.g. economic recession or gradual developments such as environmental concerns, are opening the window of opportunity. At this point, radical niches may find momentum diffusing to regime-level and disrupt mainstream markets. While initial de-stabilization as a result might occur in regimes, the chance of failure of the transitional niche breakthrough is still present. Incumbent regime actors, for instance, might counteract with other socio-technical developments to fit with the new landscape. In the final phase, the breakthrough from niche to regime is a success and the entire ST-system has been transformed into a new stable form to which the rules and institutions have been adapted.

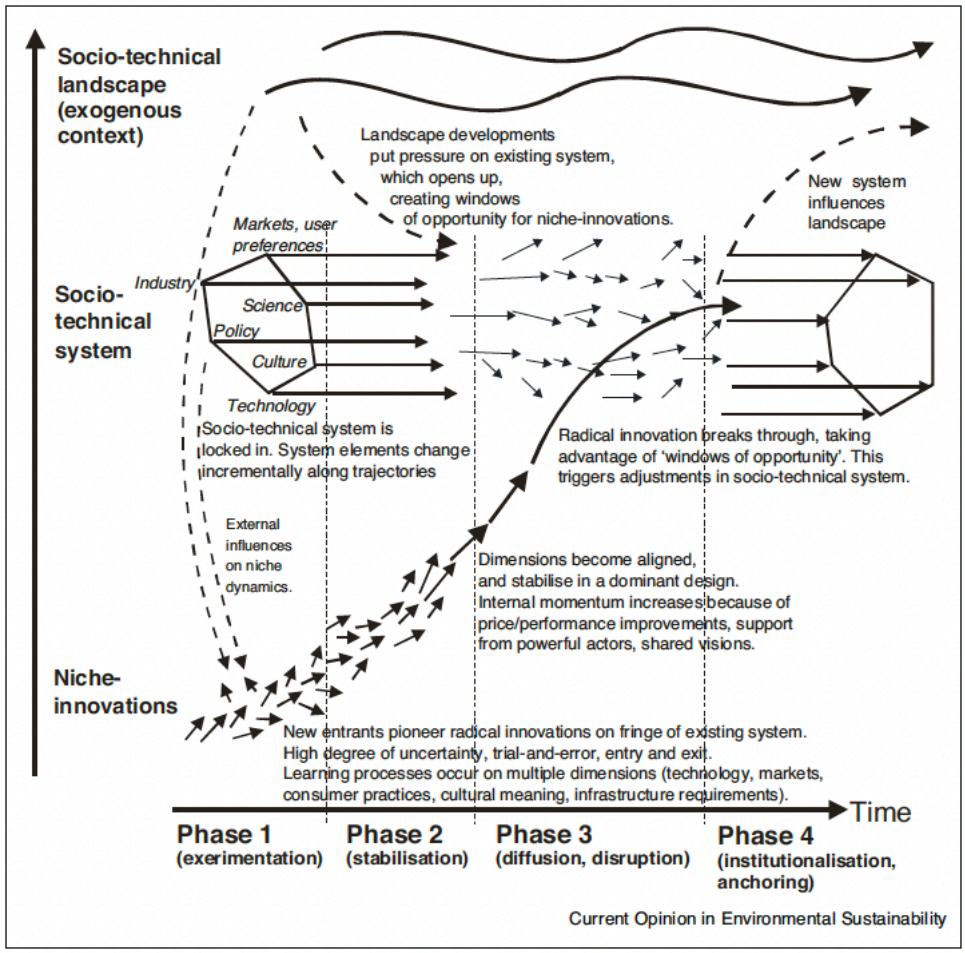

Figure 2. Socio-Technical Transition Phases (Geels, 2019)

2.5 Strategic Niche Management

An important driver for SNM is concerned with the formation of innovations from experimental concepts to successful technologies. Success in this respect, is achieved when targeted management allows a niche transitioning to the level of the regime. Still, regimes are observed to contain interrelated and reinforcing factors that could hamper innovations. These rules such as established regulations, user practices, and infrastructures, as discussed in the regime section, lead to lock-in power, making radical innovations in particular, harder to develop (Hoogma et al., 2002). Niche stakeholders, therefore, create programs allowing for developments that do not confirm with the regime rules and their mainstream technologies (Schot & Geels, 2008). Within these shielded environments free from regime exposure, independent and competition-free technological experimentation can take place. Its controlled protective conditions for this purpose, eventually ensure experiments evolving into actual real-world practice (Hoogma et al., 2002). The process of nurturing niches, therefore, predominantly defines what SNM entails:

"Strategic niche management is the creation, development and controlled phase-out of protected spaces for the development and use of promising technologies by means of experimentation, with the aim of (1) learning about the desirability of the new technology and (2) enhancing the further development and the rate of application of the new technology" (Kemp et al., 1998, p. 186).

In the initial phase of nurturing, a niche is only considered to be technical in nature, i.e., protected from market selection processes that partly determine innovations (Caniëls & Romijn, 2008). Hence, experiments or demonstration projects take place in laboratories and R&D environments, shielded from regimes. Eventually, a technological niche may evolve into a market niche. Application in a specific market then prevails and most of the protective conditions are no longer present. This entails that the niche is in a more mature state to retain itself both commercially as from the rules present in regimes (Schot & Geels, 2008). Eventually, a niche may create an existing or new regime when it can bend the rules correspondingly to its own developments.

2.5.1 Niche internal formation processes

Three main processes are regarded to the internal processes involved in SNM; *articulation of expectations, network formation* and *learning*. Each of these niche internal processes will be discussed in the following sections. The sections will elaborate both what they require and what makes the process important for niche formations. The last section will present the dynamic character between the processes and define why they are interrelated.

2.5.2 Articulation of expectations

At the very beginning of developments, the potential and feasibility of a certain technological direction remains ambiguous and indefinite (Kemp et al., 1998). It is for this reason that stakeholders still might be cautious in their involvement and contribution. Yet, it is important that stakeholders attempt expressing expectations and making promises about the technology, to steer a niche in a specified direction. These expectations or visions about technology scenarios might prove the value and potential of the presumed objective a niche is heading. Hence, it mobilizes existing stakeholders and possibly attracts new stakeholders and investments, which possibly increases niche momentum. Furthermore, three elements of expectations; robustness, quality, and specificity are considered important in SNM (Raven, 2005; Schot & Geels, 2008).

Firstly, expectations can become robust and in a sense stabilized if different stakeholders share the same perception on what might be achieved (Raven, 2005). Coordinating stakeholders in the same direction, therefore, can enable more thorough support and legitimize investing time and resources in the technology in question. Secondly, to raise the quality of expectations, the credibility should be uncompromised, i.e., based and supported by facts and tests. In addition, a variety of experiments or research publications should also be allocated to support the expectations. Thirdly, expectations can become more specific if the technological, economic, and social aspects in terms of benefits and impact are being defined (Kemp et al., 1998). In addition, Kemp et al. (1998) also acknowledge to couple certain expectations to societal problems as this might result in more active cooperation. Envisioning the course of development into steps and agendas furthermore also adds to specifying expectations (Raven, 2005).

In general, if the expectations of actors are capable to be robust, specific, and qualitative, it is assumed that niche management success might be increased (Schot & Geels, 2008). Still, expectations also relate to the process of network formation, as it significantly contributes to attracting potential stakeholders.

2.5.3 Network formation

To provide a niche with necessary resources for development, stakeholder relations are crucial. As this formation process requires a diversity of stakeholders such as producers, users, regulators, and social

groups, a network is required in the establishment of a niche (Caniëls & Romijn, 2008). In the early phases of network formation, the size and diversity will remain relatively limited. This probably can be related to the establishment of expectations and promises by stakeholders. In the case these still are under-defined, stakeholder responsibilities might remain unclear and the formation of stakeholder relationships thus also becomes difficult. Hence, vested interests and commitments to technologies still might be compromised (Raven, 2005). Yet, a network of stakeholders is crucial in the emergent of niches. According to Raven (2005), this has to do with that stakeholders can sustain developments, define expectations, and articulate new demands and requirements. Engaging in cooperation and co-evolution as soon as possible, therefore, raises experience and resources, that ultimately may contribute to a stable network.

Two typical elements, furthermore, are important in forming a network. Firstly, the composition of the network is of special interest. The composition and its diversity or broadness Schot & Geels (2008) are referring to, could determine the direction and type of innovation that a network can produce. Involved actors that also have vested interests in dominant regimes, may, for instance, enforce basing innovations on existing technologies. Instead of producing radical innovations, the niche in that respect, might only be capable of delivering incremental innovations. Hence, there also should be a willingness of stakeholders to invest effort and resources, in a direction that might not yet have proven itself. Motivations in terms of short financial gains are furthermore, to be avoided (Caniëls & Romijn, 2008). Moreover, while stakeholders majorly embedded in regimes are presumed to be avoided, larger companies as such indeed have the resources for niche support (Raven, 2005). A balance, therefore, probably should be made in powerful stakeholder involvement with relatively lower ties to existing regimes. Kemp et al. (1998) furthermore, also advises to be cautious, participation in niches also might be a strategic move of competitors in achieving a competitive advantage. The second important element of forming a network in the niche concerns the alignment of actor activities (Raven, 2005). This has to do with the degree to which strategies, beliefs, practices, and visions of participating actors are coherent (Caniëls & Romijn, 2008). According to Raven (2005), this can be achieved if the network involves cross-functioning cooperative relations, especially if they also have a substantial history. Similarly, Schot & Geels (2008), acknowledge networks to be deep, i.e., with stakeholders capable of mobilizing commitment and resources through personal networks. Hence, already established networks may have an advantage in that respect, as these can benefit from stable stakeholder relations that increasingly might be aligned. Moreover, the incorporation of users and third parties also contributes to network stability, as the expectations and needs of the parties affected could guide development directions (Caniëls & Romijn, 2008; Kemp et al., 1998).

2.5.4 Learning processes

Managing a niche typically comprises uncertainty and different conceptions about its future direction (Hoogma et al., 2002). The process of learning and articulation of ideas, therefore, is presumed to be a predominant aspect of SNM. Experiences with respect to economic, technological, or environmental performance, for instance, may reveal needs or issues to be addressed (Raven, 2005). In this regard, learning processes enable niches to become more socially embedded (Kemp et al., 1998). Learning furthermore, might also be especially important in the early niche formation phase, since the impact of articulations at that time can be remarkably large. Schot and Geels (2008) furthermore, define multiple articulation dimensions from which niches are able to learn:

1. Technical aspects and design specifications
2. Market and user preferences
3. Cultural and symbolic meaning
4. Infrastructure and maintenance networks

5. Industry and production networks
6. Regulations and government policy
7. Societal and environmental effects

If stakeholders in niches can learn from the above dimensions, the identification of potential opportunities or barriers in the development process increasingly might become predictable. As a result, governing a niche to regime level, what ultimately is the aim, potentially will be les compromised. The involvement of second-order learning rather than first-order learning, hereby may mainly improve and advance this process (Raven, 2005). First-order learning refers to the conduction of knowledge within the borders of predefined rules and norms, and is usually based on facts and data (Schot & Geels, 2008). What is considered critical here, is that the actual root-cause of an issue, might be neglected. Second-order learning in contrast, seeks to define deeper underlying assumptions of issues and learning. Hence, this type of learning approves altering the borders of the rules and norms that a problem defines (Raven, 2005; Schot & Geels, 2008). Raven (2005) furthermore, emphasizes that these forms of learning especially are important in the involvement of users. With comprehension of the underlying needs and assumptions of this group, a niche technology could develop more efficiently. This requires interactive learning processes between users and producers.

2.5.5 Niche internal process dynamics

The niche internal processes of articulation of expectations, network formation, and learning can reinforce each other. They involve furthermore, interrelated functions that may enhance the design of experiments in the process of niche formation. In the dissertation of Raven (2005), an overview of these dynamics is provided by means of Figure 3. According to the author, expectations and promises may convince actors to design and participate in experiments. In the very initial phase, the required characteristics of expectations; robust, quality, and specific, might still be relatively limited. This is possibly due to the composition and alignment of the network. Since merely a small group of stakeholders initially will participate, diversity and conformity in relations are neither yet established. The actual experiments, however, might enhance learning processes at the different dimensions mentioned, and contribute to the stability of expectations within the network. Outcomes of experiments in that regard, could specify expectations which attracts new stakeholders forming the network. The conformity and falsification of experiments by this means, could result in the design of a new experiment. The fact that this process is protected from potential failure by means of funding and environments free from regime exposure, means that this cycle can take place repeatedly and can contribute to the formation of a niche.

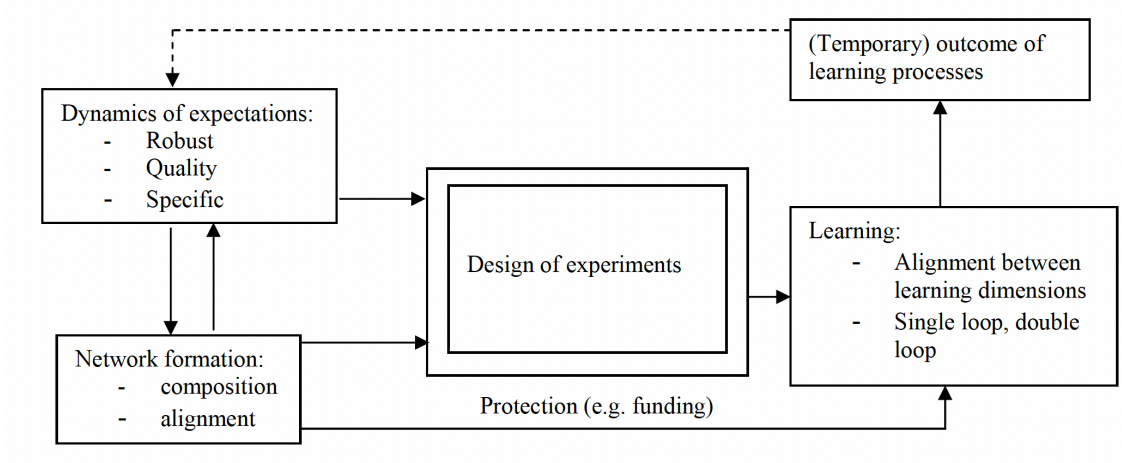

Figure 3. Niche internal process dynamics in the design of experiments (Raven, 2005)

3 Lab-grown Cultured Meat

This chapter is devoted to CM, its origins and present developments. It starts with a description what CM exactly is, then the evolution of CM will follow, and this chapter ends with defining the obstacles that CM according to the literature currently is facing.

3.1.1 What is cultured meat?

To define and separate CM from other artificial meats, the products roughly can be categorized in meat substitutes, modified meat, and CM (Bonny et al., 2015). Meat substitutes, as the name suggests, are alternative sources of protein such as plant, algae, or fungi-based products. Modified meat, that still is most directly comparable with CVM, represents all processed meats that are based on genetically modified organisms. Defining CM, in turn, is less straightforward. The terminology used, such as cell-based meat, clean meat, artificial muscle proteins, lab meat, synthetic meat, in vitro meat, and even Frankenstein meat, already reveal some of its characteristics and side effects (Post et al., 2020; Stephens et al., 2018). This suggests significantly how its status still is evolving and tend to be contested and ambiguous (Stephens et al., 2018). A compact definition of what CM exactly is, however, could be regarded as a product that reproduces CVM in vitro conditions (Post et al., 2020). In vitro, in this respect, refers to the scientific laboratory setting at which cells and tissue necessary for CM production are being produced. That mentioned, interpreting the production process also could define CM.

CM is part of cellular agriculture industries that involves cell-based biotechnologies. Furthermore, the CM sector can be positioned at the border of medical tissue engineering, i.e., the practice of assembling cells into functional tissue, and food science. In addition to producing CM, the industry also is committed to reproduce other animal-derived products such as eggs, seafood, leather, and milk (Post et al., 2020). In general, the process of cultivating meat firstly involves taking muscle tissue from a live animal by means of a biopsy as presented in Figure 4. In the next step, stem cells are being isolated from the tissue, to stimulate them on dishes in either muscle or fat cells. For this to occur, a culture medium provides the necessary nutrients and hormones in simulated conditions, replicated from the inside of the respective animal. Furthermore, with a scaffold, usually in the form of a sponge-like material, the growth of cells into tissue is enhanced as this provides the temporary or permanent mechanical support in forming 3d structures (Chriki & Hocquette, 2020; Post et al., 2020). The eventual end product at this stage still is mostly confined to a product like minced meat. Actual organized muscle tissue with blood vessels, nerves, fat cells, and connective tissue is more complex. Yet, the development of such a cultured piece of steak is also on the rise (Chriki & Hocquette, 2020).

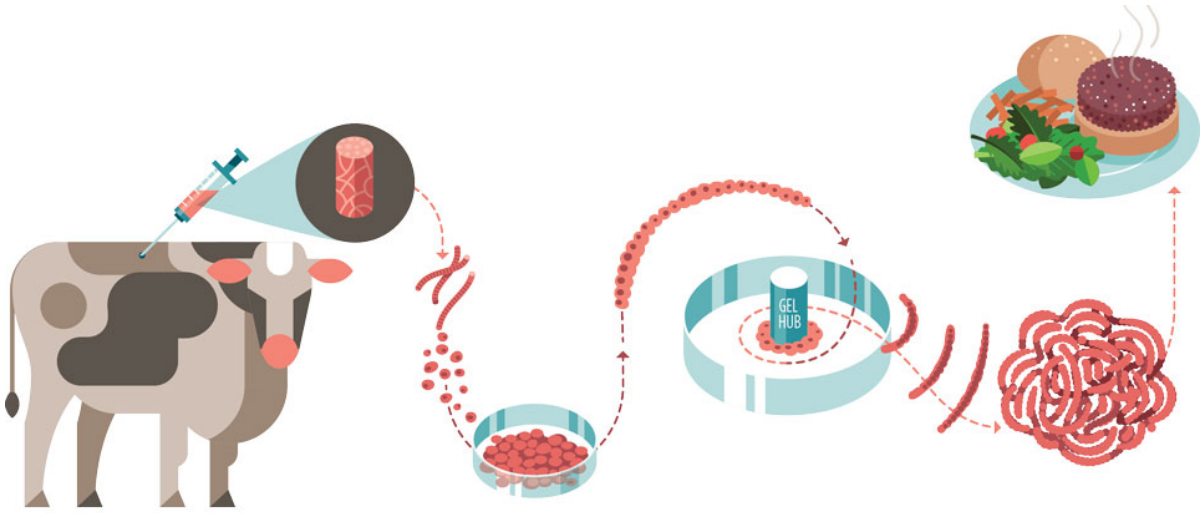

Figure 4. Cultured Meat production (www.eatingwell.com)

3.1.2 Cultured meat evolution

In 1931 already, Winston Churchill speculated in his essay 'Fifty Years Hence', about the idea of producing chicken muscles for consumption without the need for living animals (Bhat et al., 2015; Kadim et al., 2015). In the early 2000s eventually, the National Aeronautics and Space Administration (NASA) investigated the opportunities of cultured tissue to provide space stations with sustainable supplies (Zhang et al., 2020). This resulted in edible cultured fish products based on the cells of goldfishes (Kadim et al., 2015). Meanwhile in 1999, independent Dutch researcher Willem van Eelen, also patented the conceptual process of in vitro stem cell harvesting, to tissue culture (Bhat et al., 2015). The Dutch government seemingly also acknowledged its presumed potential, since they began to fund several different PhD projects based on cell cultivation in 2005 (Stephens et al., 2018). These pioneering activities eventually resulted in 2013, in the first actual cultured meat burger presented in a London press conference. Professor Mark Post ensured financial support by Sergey Brin, Google's co-founder, to develop the burger at Maastricht University (Stephens et al., 2018). The lab-grown burger took three months to grow and costs over $330.000 to produce. Furthermore, while the colourless appearance was adjusted with beet juice and saffron, the test panel mentioned that the taste was comparable with CVM (Bhat et al., 2015). Currently, around 70 start-up companies are actively involved with the development of CM (Ding et al., 2021). The state of the art is yet harder to determine, most companies do not reveal their development improvements. Moreover, as the field considers different animal meats and approaches, the road to worldwide commercialization on scale does not consist of a single product. Yet in 2020, the first regulatory approval (RA) of CM was a fact. The Food Agency of Singapore approved eating cultured chicken of start-up Just, in a restaurant (Ding et al., 2021; Treich, 2021). Hence, while single CM products exist, global politically approved production on scale still has challenges to overcome.

3.1.3 Cultured challenges

Since the emergence of CM, several challenges have been cultivated simultaneously. Technical challenges that are regarded to scaling up of the production process, are considered with automation and the necessary bioreactors that produce the biological processes. Depending on the end product, i.e., minced or muscle, partly automated production on scale involves a series of bioreactors that increase in volume, mentioned by Post et al. (2020) as a 'seed train'. As there exist a difference in cell versus tissue reactors, and an integrated, fully automated system is not yet developed, the process is labour-intensive. Moreover, monitoring an exponential cell growth in the first phase of cultivation, still often requires manual culture dishes before the bioreactors can put into use. Costs of producing on scale are therefore relatively high which also impedes accomplishing economies of scale (Post et al., 2020). While definite estimations about future production scenarios are relatively hard at this stage of development, studies also reveal the high amounts of energy the production still requires (Stephens et al., 2018). Yet, while the latter could be considered as critical, one could be cautiously positive with regard to the sustainability of CM. Several studies indicate that the respective technology of CM involves plenty directions of innovative potential, meaning that it could become more sustainable than currently presumed (Stephens et al., 2018). This also aligns with the problems encountered with the production. If the labour-intensive instances dissolve, and integrated bioreactors allows for automation and streamlining the 'seed train', it seems reasonable to assume that efficiency raises with respect to energy also can be expected. Nevertheless, a life cycle assessment (LCA) performed in 2014 presented in Figure 5, already presumed that the greenhouse gas emissions, land and water use of CM, is more sustainable than several other sources of protein (H. Tuomisto, 2019). Yet, one should bear in mind that the meat substitutes regards processed products. The data available for CM regards unprocessed products, i.e., the meat is for instance not yet produced into an actual burger.

The mentioned developments depend furthermore, on regulations. CM in Europe for instance, still is in the process of complying with the safety regulations. CM in this regard, should be covered by the Novel Food policy regulations, approved by the European Food Safety Authority (EFSA). This application is significantly complex, bureaucratic and time consuming. It must consist of product information about safety, identity, production process, compositional data, suggested usage and its intensity and the expected rate of intake before considering market introduction (Ding et al., 2021). Furthermore, the commission also determines the terminology to use; the names of steak, burger and sausage, for instance, initially where prohibited (Post et al., 2020). The framing of CM probably also influences consumer acceptance, another challenge of CM. Consumers in general seem to be reluctant to eat CM. This has to do with expressed difficulties in changing meat consumption patterns. Furthermore, anticipated concerns of its unnaturalness, taste and physical appearance, healthiness, anticipated price, safety and disgust feelings regarding CM, are also reasons for consumers to be reluctant. This indeed implies that consumer acceptance is related to perceptions about envisioned future states of CM, even though practical evidence is not globally present yet. This is also mentioned by Post (2020, p. 10); "A major limitation of all research on consumer acceptance is its hypothetical nature". The relevance of the earlier mentioned concerns, therefore, are difficult to determine as hardly any commercial CM products are available yet. However, this does not mean that this should be ignored, but rather that more experience with CM is needed.

In respect to the above, it could be beneficial to better understand the position of CM in transition. This might enable gaining insight in the processes involved that determined the origin of some of its concerns. The theoretical basis of the MLP for example, could reveal cultural believes and political (lobbying) developments, that determinates populations solely eating CVM. This furthermore, may also lead to the observation of lock-in mechanisms induced by powerful stakeholders in CVM markets, making it for some consumers less attractive to even consider CM. Moreover, the internal processes of SNM could also contribute, and perhaps present that the CM niche failed in constructing a sound network. Failing to include necessary stakeholders, might impede the possibilities of experience and learning processes for further development, which in turn could hamper specifying expectations. The absence of politicians in that regard, could declare why the application and approval of the Novel Foods regulations in the EU are still in process. Furthermore, the absence of the general public might declare why the consumer acceptance still faces significant challenges. In sum, while several CM challenges still are present, the forecast of a food product that could lower the environmental burden and CVM concerns significantly, legitimises further investigation. Furthermore, as a CM transition is on the rise, that direction could be accelerated and supported by research.

Figure 5. Life Cycle Assessment (LCA) results of different sources of protein (Tuomisto, 2019)

4 Methodology

The methodology of this study will be elaborated in the following sections. First, a short overview is given about the research design by means of describing the research flow diagram (Figure 6). Second, the research approach is discussed with a background based on the methodological theory, the introduction of the case and the stakeholder selection method. The third section elaborates the data collection approach. The fifth section discloses the data analysis with its reduction and interpretational approach. And finally, the last section shed light on the validity of this research.

4.1 Overview research design

As mentioned in the introduction, this study aimed to answer the following research question:

What are the barriers to the transition of Cultured Meat from Niche to Regime perceived by stakeholders?

In light of the main research question, a descriptive case study was utilized. The Dutch CM niche industry here represented this case. For the collection of data, interviews with influential stakeholders were held. The Quadruple Helix framework that helps revealing stakeholders and the dynamics between them, was accordingly used for stakeholder respondent identification. In addition to the interviews, two policy documents also were added to the sources of data in this research. To define the sub questions of this research, i.e., the barriers related to the landscape, related to the regime and the internal barriers to the CM niche industry, the interview questions were deductively composed based on the MLP and SNM. Eventually, the results were transcribed into text fragments. The analysis of the transcripts and policy documents in turn, also involved an MLP and SNM based analytical lens. Hence, the deductive thematic analysis, ensured interpreting the data into themes or barriers that impede a CM transition. By this methodological approach, the study intended to answer the main research question. See Figure 6 for the overview of the methodological research design.

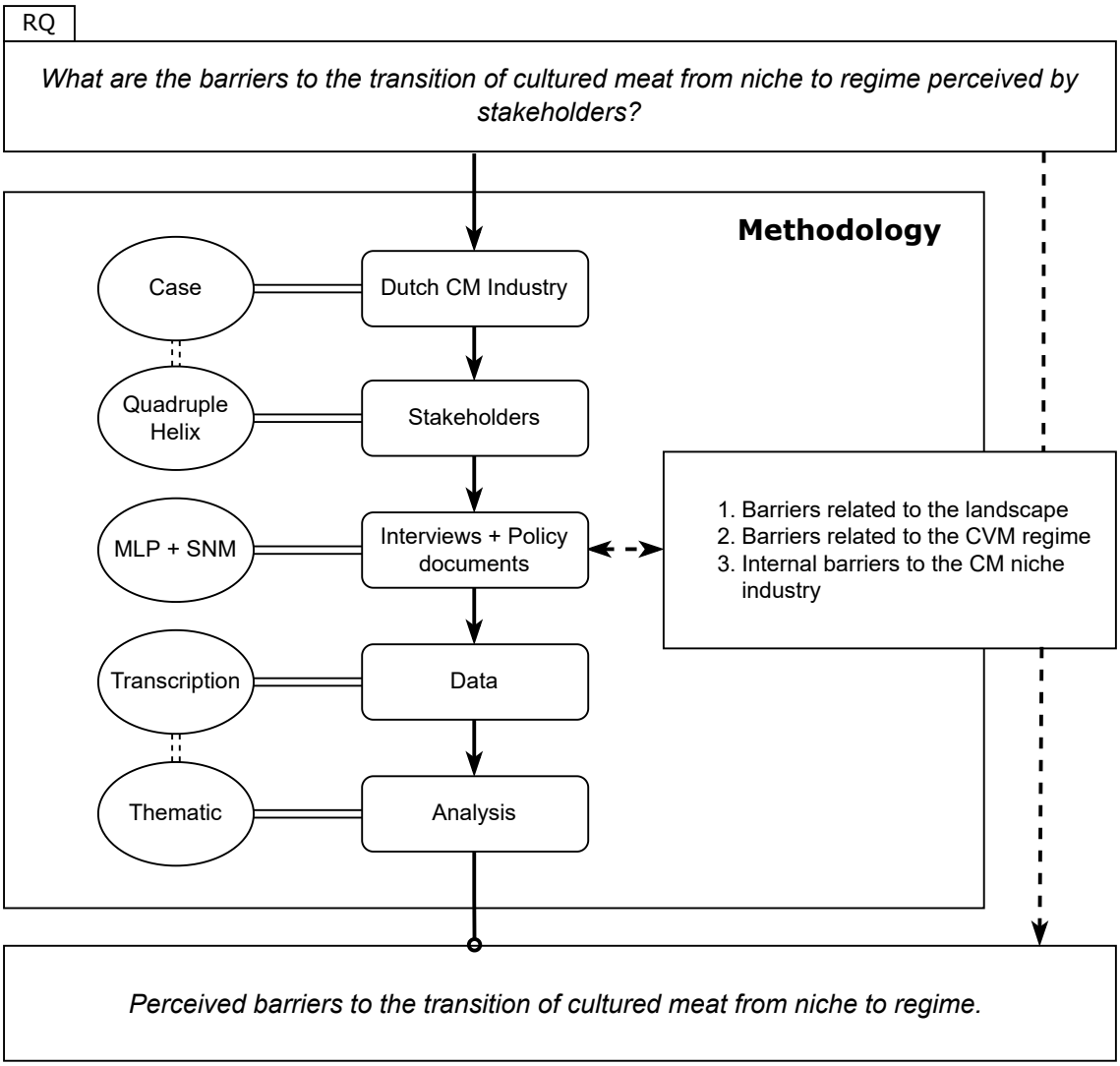

Figure 6. Research Flow Diagram

4.2 Research approach

4.2.1 Background

As mentioned in the introduction of this study, relatively little is known of barriers impeding a CM transition. Hence, as this is not well understood, this subject requires a deep yet holistic understanding, which requires rich data. This study therefore was based on qualitative data and implemented a descriptive research methodology. Qualitative research enables scholars defining new concepts and theories (Bryman, 2012). While this particular study was not intended for new comprehensive concept generation, it indeed aimed to identify barriers that also requires rich data. This study furthermore, described characteristics of the CM industry, and descriptive research typically answers research questions to define particular objects (Sekaran & Bougie, 2016). Furthermore, a case study design was chosen as methodology because this research required certain features. Firstly, as researching CM barriers in transition context is relatively novel, a representative subject was needed that to some extend could be generalized. Secondly, an intensive, focussed analysis was required to provide the necessary rich and holistic data. Thirdly, this study was relatively practical in the sense that it addressed real-life processes within a certain industry. Furthermore, it included perceptions of stakeholders, which is why a particular setting could be constructive to give context to the phenomena of transition barriers.

4.2.2 Case of the Dutch cultured meat industry

The Dutch CM industry was selected as the case to represent CM industries worldwide and functioned as the demarcation, which is considered important when conducting case studies (Baxter & Jack, 2015). Whereas it was assumed that all demographically divided CM industries worldwide resides in a niche market environment, the Dutch CM niche was of special interest because of various reasons. Firstly, the Netherlands is considered to be one of the initial contributors in global CM development. Accordingly, the first actual CM-burger is a Dutch invention; it was tasted and presented in a talk show in London back in 2013 (Bhat et al., 2015). What initially was found interesting of such a pioneering environment, was the possibility of demonstrating the necessary interventions to other niches. Secondly, the Netherlands concerns a country, which was assumed to have a relatively homogenous institutional environment. This presumably would induce a more accurate and comprehensive description of the processes involved within the industry. Thirdly, the Netherlands is part of the European Union (EU) and global economies. This could make generalized assumptions of CM industry characteristics, as far as that is possible with case studies, possibly easier to make.

4.2.3 Stakeholder selection

Due to the required in-depth knowledge and multiple perceptions on the Dutch CM industry, a purposive sampling approach was chosen. Preliminary specified target groups that are typically for this approach, hereby provided the required data points. The different units of observation in this study, therefore consisted of key contributing stakeholders of the Dutch CM industry. An approach that scholars implement to define relevant stakeholders in systems that produce innovations, is the quadruple helix framework. The quadruple helix assumes four components that produce knowledge and innovations (Carayannis & Campbell, 2012). These helixes of academic research, business, government and society hereby interact dynamically on cross- and bidirectional fashion (Figure 7). As transitions provide societal functions that involve stakeholders in all these helixes (Markard et al., 2012), the quadruple helix helps this study to define an image of relevant stakeholders present in the Dutch CM industry. The functionality of the helixes and their interaction is provided in appendix A.2.

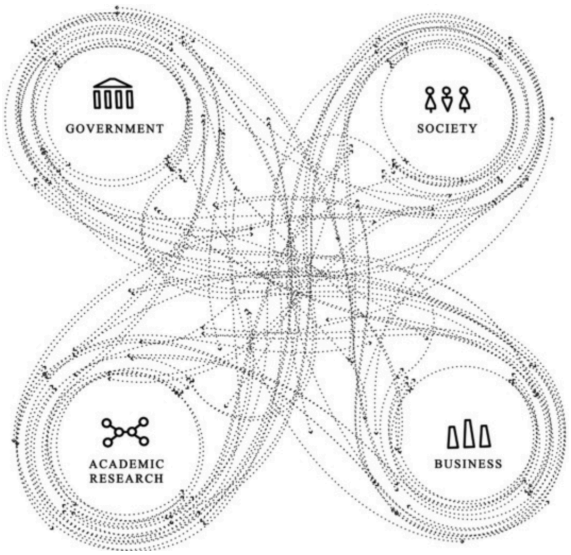

Figure 7. Quadruple Helix Framework (Schütz et al., 2019)

4.3 Data collection

To define barriers based on the perception of stakeholders, semi-structured interviews were conducted. A benefit of a structured interview is that such a pre-defined and strict question and ordering format, enables researchers analysing scoped issues, such as case studies. This was considered appropriate as multiple interview questions were deductively determined based on the MLP and SNM. Yet, an unstructured character could bring openness and flexibility with tailored questions to the respondent, which might enhance grasping complex phenomena such as transition barriers. The combination of the two therefore guided the interview questions. To potentially making the result more comprehensive, two policy documents also were used as extra sources of data. The first policy document (P1) involves an application from the Cellular Agriculture Consortium (CAC) for the approval of growth plan for a Dutch cellular agriculture ecosystem of which CM is a component. The CAC is an initiative of multiple stakeholders of the cellular agriculture industry. Yet, many stakeholder respondents of this study are also involved. The second policy document (P2), is the corresponding partial approval of the CAC growth plan from the government.

With respect to the respondents, these were predominantly approached by email. However, a snowballing approach was also conducted at which each interviewee was asked for possible new suitable candidates. For the sake of time of the respondents, the interviews itself were mainly held using online meetings via Microsoft Teams. Yet, one interview was also done via telephone and another one via email. The interviews mostly lasted not longer than a full hour. In light of duration of this study, the initial aim was to involve 10 respondents in this study. However, the response to the interviews went beyond expectations and resulted in 14 interviews with stakeholders. Table 1 provides insight in the type of respondents that participated in the interviews. What is striking that the most respondents involve society stakeholders. Which, as the result provided, is not that remarkable, as most transparent activity from the industry can be found in that dimension.

Table 1. Academic, business, government and society stakeholder respondents.

Academic Stakeholders		Business Stakeholders	
A1	Former professor in Bio-ethics	B1	Vlees.nl
A2	Researcher at CE Delft	B2	Respect Farms
A3	Former professor in cell biology	B3	Mosameat
Government Stakeholders		Society Stakeholders	
G1	Policy officer at MANFQ	S1	Planet B.io
G2	Policy officer at MANFQ	S2	Cultured meat lobbyist
G3	Member of the house of representatives	S3	Editor at Food and Agribusiness
		S4	Former executive of SDG Holland
		S5	Culinary reviewer

MANFQ: Ministry of Agriculture, Nature and Food Quality, SDG: Sustainable development goals.

4.4 Data analysis

To analyse the interview and policy documents a thematic analysis was conducted. While the policy documents were already in text format, the audio or video recordings of the interviews were also transcribed into text fragments. Furthermore, deductively derived categories where established. The categories were: Barriers related to the landscape, barriers related to the regime, barriers to the articulation of expectations (niche), barriers to network formations (niche) and barriers to learning processes (niche).

The actual process of the thematic analysis involved two main steps. Firstly, the process of coding started by labelling units of text from the transcripts to allocate them under the heading of the theoretically derived categories. Secondly, when large quantities of coded units of text were revealed, the coding units per category were clustered under themes. This instance of axial coding, involved making connections between codes with overarching contexts into themes (Bryman, 2012). Hence codes that described the same theme could be aggregated. This process of coding, clustering and categorising enabled this study to define the barriers per level of the ST-system. See figure 8 in the appendix A.3 for an overview of the steps involved with the thematic analysis of this study.

4.5 Validity

To increase the construct validity, i.e., the identification of accurate operational measures for the concepts studied, this study used several tactics. Firstly, by including multiple different groups of stakeholders by means of the Quadruple Helix selection. Secondly, by incorporating different policy documents in combination with the interviews as sources of data. By this means, a chain of evidence was aimed to be established. With respect to external validity, i.e., the extent to which a study can be generalized to a context beyond itself, case studies in general suffer from hardly being able to represent other cases (Sekaran & Bougie, 2016). Many scholars therefore recognise on the basis of case study designs, that it is difficult to make statements that also can be applied to other issues (Bryman, 2012). Yet, generalized assumptions in a sense could be made about this case. The CM technology is for instance, per definition internationally oriented, as in various parts of the world people attempt scaling up CM technology. That said, CM technology is also relatively novel and the industries around the world are in a relatively similar stage of development. Furthermore, the CM industry is globally still quite small, and the Dutch CM industry is in that respect a relatively large entity. Moreover, as the Netherlands is part of the European Union and CM needs to comply with the EFSA regulations, generalized assumptions potentially also can be made with other countries of the European Union.

5 Results

In this chapter the results of the data analysis of the stakeholder interviews and policy documents are presented. Hence it intends to define the perceived barriers on landscape, regime and niche level. The sections are furthermore divided according to these levels, whereas the niche section also contains barriers at the processes of articulation of expectations, network formation and learning. Although the delineation of barriers in some cases is clearly defined, they also can overlap or be linked to each other.

As mentioned in the Methodology chapter, the data sources include Academic, Business, Government and Society stakeholders and additionally policy documents of the Dutch CM industry. Quotes and citations are therefore respectively referred to as A, B, G, S for the stakeholders and P for the policy documents. For instance, if Academic stakeholder number two is quoted, it is presented as A2.

5.1 Barriers related to the landscape

The landscape is not limited to a specific industry. Instead, it represents wider overarching developments that possibly are slowly changing. As the landscape defines the macro-level and boundary of the ST-system of meats, it contextualizes the CVM regime and the CM niche industry.

5.1.1 The environmental paradox

Primarily, all respondents observe a broader environmental awareness due to the changing conditions on the earth. Yet, there is a contrariety in that global meat consumption growth, driven by growing populations and prosperity, is also observed. Furthermore, polarizations in regard to sustainability and supporting the environment progressively emerge in societies. In general, people are therefore selective in supporting the environment which restricts sustainable developments. The paradox of this with respect to meat expresses itself in different ways. Firstly, people are presumably in a transitional phase of ambiguity with regard to meat consumption and production. Stakeholder A1 explained this by stating: "You should not expect people to change their minds straight away, but there is a long period of time between that and people being very ambivalent about meat". Secondly, the government in this respect, also has a dualistic role to play. For instance, there is friction when it comes to policies changing food consumption patterns, as people do not want to be directed. Yet, according to the respondents, people also express that they would want to be guided as long as things are not forbidden and "no meatballs are taken away" (A1). Thirdly, only selective social groups such as youngsters and people who can afford it, tend to be involved with meat consumption reduction. Others are more conservative. According to the respondents, people also mainly expect the new generations to make sacrifices for the environment, while they also have to pay the ultimate bills for the current investments needed. Fourthly, people demand meat that is produced in an animal-friendly and environmentally-friendly way, yet in general the majority seem hardly willing to make concessions. Thus, in general, selective ambiguous environmental behavior is observed within societies. People make demands and are not entirely prepared to make concessions, which also limits sustainable developments. Respondent S2 summarized this problem by stating: *"The truth is not inconvenient enough".*

5.1.2 The Dutch political climate

According to the respondents, the Dutch political climate exhibits several characteristics that impede sustainable initiatives. Firstly, the current political climate seems, mainly focused on increasing

economic growth by improving labor productivity. According to respondent S4, the partial objective of this is to be able to solve various future problems: "that is really the reasoning behind earning a lot of money, so that you can solve all the problems you create after the fact. Instead of saying: We're going to use this money to reduce a number of problems, thus tackling them at the front. And that applies to environmental costs, for example, which you obviously don't have to incur if you prevent the problem". In addition, according to the respondents, the majority of the current Dutch cabinet also mainly values issues that have less to do with the environment, which may jeopardize sustainability in society. The stakeholders mentioned that this is also reflected in the Dutch National Growth Fund of the government, in which many societal projects are involved, such as the CAC. The purpose of the fund is ensuring long-term economic growth and not solving societal or environmental problems. Consequently, the political climate, according to the respondents, also seems to rely on future generations. Secondly, by nature of the democratic system truly solving such long-term problems also is not attractive, as politicians can be re-elected within 4 years. Hence, in the views of the respondents, striving for short-term instead of long-term gains is the norm, as these are the most uncompromised for the electorate. In conclusion, the respondents consider the Dutch political climate not entirely conducive to the environment. This therefore could limit sustainable developments, especially if it is unlikely to generate money directly.

5.2 Barriers related to the conventional meat regime

The regime at meso-level of the ST-system, concerns the complete CVM sector from production to consumption. It contains furthermore, processes that provides its stable and dominant character. As the barriers will demonstrate, this ensures a tendency to remain dependent on CVM practices. Hence, since the CM industry is not part of the regime and CM is not considered as CVM, it inhibits the CM transition in Dutch society.

5.2.1 Socio-Cultural lock-in

In the regime certain socio-cultural mechanisms and user practices arise that declare why people remain committed to the consumption and production of CVM. Several factors explain such behavior. Firstly, it is a tradition to eat meat in the Netherlands. It used to be a luxury good but due to rising global prosperity and industrialization, especially after WWII, meat has become more accessible. Moreover, people associated meat as necessary for your health. Hence it has become embedded in our culture and out of habit people have become accustomed to it. For many people, according to the respondents, dinner also is dedicated to meat as the main ingredient; the meat is firstly selected and only then the combining vegetables and carbohydrates are chosen. The tradition furthermore, created a certain emotion around meat which makes it difficult neglecting meat. Respondent G3 mentioned about this: "In the House of Representatives, we talk about 'a nice piece of meat', so there is a sense of what food is in a family". Thirdly, with respect to the emotion surrounding meats, it still is seen as a symbol of status: "It is like driving an expensive car" (S5). Furthermore, many Dutch people are proud of the efficiency at which the Netherlands can produce and maintain livestock. A dissenting voice between farmers is therefore also experienced as a betrayal of the sector. Secondly, certain characteristics of meat products also ensure that people remain devoted. Price is an important factor, meat is cheap, and people are hardly prepared to make concessions in this respect. And if they do not need to, the alternative should be as tasty. That said, most people love the taste of meat and therefore hardly can resist it. According to culinary reviewer S5 this is partly due to biological mechanisms that occur when certain substances or flavors present in meats are eaten: "When we eat sugar, it triggers a dopamine response in our brain, which we like, and the same goes for umami". The respondents demonstrated that CM is still socially and culturally significantly embedded in Dutch society. This potentially makes the entry of CM difficult, especially as it has to meet certain expectations.

5.2.2 Techno-Economic lock-in

From a techno-economic point of view, there are also regime factors that impede meat alternatives entering the market. Firstly, CVM is deeply rooted in the Dutch economy. Its sectors contribute significantly to employment and the earning capacity of the Netherlands, which, as mentioned earlier, is considered fundamental in the Dutch political climate. The magnitude is according to the respondents furthermore reflected in the export; the Netherlands is the 3rd largest meat exporter in the world and the 1st in Europe. For many, the efficiency of producing livestock is also a national pride, regime stakeholder B1 for instance stated: "We have a very flat economic feed management approach: You want to use as little feed as possible for 1 kg of meat and we are just incredibly good at doing that and we have it completely under control". The prevailing regime attitude therefore is that it would be a waste to give up this industry. Moreover, the business models of CVM also generate a lot of money and thus do not encourage the emergence of other models. Secondly, the industry is also deeply rooted in the Dutch spatial order: "54% of the land surface is used for agriculture" (B2). Moreover, it is seen as a method to utilize unusable land and residual streams. Furthermore, its spatial infrastructures are highly capital intensive, which means that significant investments are made, and economies of scale need to be achieved. For many participants in the value chain there are therefore, still many costs to depreciate which is why it is also difficult to switch to another sector. In addition, the necessary infrastructures again also provide many employment opportunities. As a result, thirdly, the level playing field for alternatives, is according to the niche stakeholders also out of proportion. The CVM industry would involve plentiful subsidies and due to the economies of scale, the price level for meat products is extremely low. This makes the market entry requirements for meat alternatives extremely difficult. Hence, as the economy and employment are so successfully intertwined with the CVM industry, it is challenging for CM to enter the market.

5.2.3 Institutional-Political lock-in

There are also institutional and political factors that contribute to the stability of the CVM industry. Firstly, past policies have had a major influence. After WWII, the government significantly invested in intensifying and stimulating agriculture and the production of meat. According to respondent A1, this was a deliberate decision: "After the war, under the motto 'never hungry again', the production and consumption of meat was promoted tremendously". Hence subsidies contributed to new technologies to increase scale and productivity. This policy therefore, also contributed to influencing the socio-cultural lock-in mechanisms, because people began to associate meat with prosperity. As a result, secondly, the industry became increasingly embedded in both politics and institutions, which is currently still noticeable. From a political point of view, the industry has according to the respondents, a noticeable authority in the government. This is partly due to interlinks with the Ministry of Agriculture, Nature and Food Quality (MANFQ). Respondent S4, for example, acknowledged that it is difficult there to speak freely: "If you have discussions with LNV, and I have those quite regularly, then it is quite difficult to be able to say out loud that what we are doing is not good and that it should be reduced". Correspondingly, institutions with governmental links, such as the nutrient center, also remain affiliated with CVMs. Furthermore, there seem to be very few subsidy programs to make livestock more redundant. In addition, as the industry remains economically attractive, institutions such as Wageningen University, also maintain embedded and continue researching into conventional agriculture and meat innovations. Moreover, the industry also seems to have a significant presence in the lobby as will be demonstrated in the next barrier. As a consequence, changes in such an intertwined system are very complicated: *"These are supertankers that you want to change direction. That does not happen from one moment to the next" (A1).* Hence, instituting regime independent meat alternatives is challenging.

5.2.4 Regime Perspectives

Many regime stakeholders acknowledge the environmental issues with the current meat industry. Nevertheless, several factors, i.e., vested interests and regime perspectives, pressurizes dissenting developments that occur apart from the regime. Firstly, it is presumed by regime stakeholders that CVM is necessary for sustainable circularity. The food industry for instance, produces substantial residues that currently can be disposed via livestock. Yet, due to cross-border characteristics, practicing CVM circularity solely in the Netherlands would, according to regime stakeholders, still be unrealistic because large parts of Europe share the same institutional environment. Stakeholder B1 stated the following about this: "In America they send it from the east to the west coast and then it is circular, well that is 3000 km, 4000 km. And we transport it 800 km away and then it's not right anymore". Instead, the regime thus considers that all within Europe should be treated as a circular system and no longer as export. Furthermore, the statement saying that not eating meat is best for the environment, is according to regime stakeholders "simply not true" (B1). They also express, that there is no sense in eating less meat, because the remaining meat would be exported anyway, as this is already occurring. Moreover, dissenting voices from incumbents, as mentioned earlier, are also presumed as a betrayal of the industry. Secondly, there is ambiguity among regime stakeholders as to how sustainability should be implemented. For example, large meat-processing companies emerge that work on two tracks, both on CVM as plant-based alternatives. Yet, most solutions to sustainability are sought in incremental innovations based on the existing ones. As mentioned earlier, the regime also considers it a waste of economic contribution if the conventional sector would be reduced. Thirdly, it is presumed by the stakeholders that lobbying activities from the regime are rare and redundant due to its constant economic contribution. Yet, several other stakeholders reported the opposite and referred to the regimes authority as mentioned in the Institutional-Political lock-in section. In addition, government stakeholder G3 mentioned the occurrence of fake-news in the house of representatives after a debate about abuses in abattoirs: *"subsequently, a mail full of fake information about meat being climate-neutral arrives".* In general, the attitudes of regime stakeholders on meat consumption and sustainability thus seem to be mainly accommodating the CVM sector and hence, inhibits radical developments.

5.3 Internal barriers to the cultured meat niche industry

The niche processes of articulation of expectations, network formation and learning processes are critical to bring about transitions from niche to regime. The factors impeding these processes therefore, define the niche barriers at micro-level of the ST-system. For each niche process, these will be addressed in the following sections.

5.3.1 Barriers to the articulation of expectations

5.3.1.1 Operational constraints

Multiple operational constraints are compromising the articulation of expectations in the Dutch CM niche. This could be regarded to relative state of the CM technology. According to stakeholders it still is in the early stages of experimentation at which research and development belongs to the prevailing operations. Furthermore, the technology is also not yet introduced in the market. A substantial part of the accumulated knowledge is therefore based on theory and extrapolation. Moreover, the technology largely depends on government subsides. The two CM start-ups, Mosameat and Meatable, possibly are in a further state, however, this is difficult to determine as their progress is hardly publicly disclosed. Yet, due to the state of CM technology, the niche direction is relatively unpredictable as it significantly can be influenced by societal behavior and technological breakthroughs. Several

operational constraints declare the current state of the technology. Firstly, it has merely proven itself on lab-scale, experience with large-scale behavior is lacking. For instance, factual evidence of its environmental benefits on scale is still uncertain. According to the respondents furthermore, there are especially many hurdles to overcome to produce an economically viable product. This period of uncertainty is also reflected in policy paper 2 (P2): 'A major challenge is to scale up to reduce the cost of these products. This is an uncertain phase that may take ten to fifteen years '. Secondly, CM need to comply with the European Novel Food regulations via the EFSA before market introduction is allowed. That approval takes several years, but the technology is not sufficiently prepared to start it. As a consequence, thirdly, there are still many unknowns regarding consumer demand and acceptance. This currently needs to be predicted, but the actual market preferences remain uncertain. Thirdly, the niche is also dependent on external factors such as the level playing field in the market and supply of resources such as renewable energy. Consequently, these operational constraints and uncertainties hinder the factual demonstration of the technology's potential. Therefore, it is also difficult to articulate a true CM vision among the niche stakeholders.

5.3.1.2 Imagining

The Dutch CAC is founded to raise governmental subsides, via the ministry of Agriculture, Nature and Food Quality (MANFQ) to enhance the establishment of the cellular agriculture industry, of which CM is part. Ranging from universities, NGOs, research institutes and companies, many of the main CM stakeholders, including several respondents, take part in this. The aim of their application is an industry ecosystem based on five pillars; stimulation of education (CACp1), public research (CACp2), scale-up facilities (CACp3), social integration (CACp4), and a start-up climate (CACp5). This could be considered as an expectation for the industry, yet there appears to be no uniformity among the stakeholders, which also will be demonstrated in the network formation sections. Furthermore, a vision is not primarily part of the debate either: *"When you speak of the vision of 10 years from now, we don't really talk about that much. It goes as fast as it can" (A1).* Moreover, as mentioned in the operational constraint barrier section, there are many uncertainties that can strongly determine the direction of the niche. The stakeholders are therefore also cautious about future expectations; many perceive a price-competitive CM-burger in 10 years' time as a major challenge. Apparently, a clear CM strategy within the MANFQ also seems to be missing: 'There is no specific strategy on cultured meat yet, it is still under development. The aim of the (CAC) proposal is to build a new ecosystem, while a national flanking policy seems to be lacking (P2)'. Furthermore, although CM is primarily positioned as a disruptive technology, there is also a tendency to approach it as a continuity that majorly makes use of existing regime infrastructures. That also impedes a unified vision. In addition, the lacking vision among stakeholders possibly also contributes to a distorted CM perception in societies as next section will illustrate.

From a societal perspective, according to stakeholders, CM suffers from image-problems. This is partly due to misconceptions among the general public. Firstly, many people do not know what it is and merely associate it with artificial future food that will be produced in a laboratory. This unfamiliarity also makes people doubt its naturalness, food safety and taste. Secondly, the image of CM is also affected by the rising development of other meat alternatives. Plant-based products for instance, is heavily processed food which is not always experienced as tasty by people. Furthermore, precision fermentation foods, that mimics meat with micro-organisms, involves genetic modification, which is sometimes wrongly associated with CM. Thirdly, the CM image also has to do with the media: *"The knowledge of journalists, it is just very limited" (S2).* Furthermore, there are concerns that incorrect framing, i.e., fake news from specific social media channels, can create huge misunderstandings and further undermine social acceptance. Moreover, there are also sentiments circulating in other European countries that are influencing the perception of CM, which causes people to feel that CM is

being forced upon them. In general, there thus seems a lack of clarity among both stakeholders and the general public about what will be expected from CM.

5.3.2 Barriers to network formations

5.3.2.1 Insufficient incentives

The absence of several resources and facilities are presumably impeding the formation of a stable CM network. In the primary instance, this is rooted in the fact that there is insufficient public funding available for the industry. The two start-ups suffer less from this because they can attract increasing investment through shareholders. However, they also would benefit from a socially embedded ecosystem to institute the CM industry in Dutch society. On multiple fronts this is currently is not the case, which is why the CAC anticipated for investments in these areas. Firstly, on all different educational levels, there are no studies offered that specifically address the CM industry. Consequently, the industry suffers from labor shortages and primarily needs to rely on stakeholders from abroad. Secondly, there is a deficiency in the Netherlands of knowledge institutions and researchers in the field of CM. The public sector therefore is insufficiently involved and knowledge accumulation and innovation exploitation, both technically as socially, is compromised. Moreover, there are insufficient incentives to start research groups; the current researchers mainly do this out of personal interest. Thirdly, the construction of an industry network is limited because scaling up the technical process is highly capital intensive and requires specific engineering knowledge. Furthermore, scale-up facilities are also absent. Hence, new industry stakeholders need to undertake large risky investments, which hampers entry into the Dutch industry. Fourthly, there seem to be a lack of social commitment and embedding of the industry. This is due to the complex RA process that it has to comply with formally and corresponding lack of public participation. The latter is important to include potential stakeholders, such as the agricultural sector, to gain experience with local upscaling. Moreover, it is also difficult to increase social acceptance because consumers are not allowed to taste CM. Fifthly, there is hardly a start-up climate for CM, partly because it is also scarcely facilitated. The innovation pipeline is consequently also compromised, as the incentive for innovations is limited. Moreover, this also implies that there is no network of resources that can contribute to accelerating the growth of start-ups. As a result, the Netherlands is not an attractive location for CM start-ups to establish, which possibly is one of the reasons why there are currently only two. Moreover, there is another risk involved here: if nothing changes, the established start-ups may go abroad. The lacking incentives is therefore a significant barrier for a CM network.

5.3.2.2 Network disunity

The unity between stakeholders and corresponding activities can influence the formation of a network and hence the direction of a niche. With respect to the CM network however, multiple contradicting tendencies are impeding stable formations. Firstly, there is tension about CM technology upscaling. There are stakeholders investigating the possibilities of multiple local small-scale production sites, using parts of the current agricultural infrastructure. Others solely believe in large-scale factory production in which the agricultural sector hardly participates. Secondly, friction is present with regard to the timing of the social CM implementation. The CAC emphasizes direct social embedding from the early stages, while the government envisages a more technocratic approach, requiring further technological proof. Consequently, the CAC application is only partially approved without investments for CACp4: 'The committee believes that the size of the application is not in line with the current state of development of the sector and the technology' (P2). Thirdly, due to the partial approval the CAC is concerned about the possibility of start-ups moving abroad, while the committee actually believes that the Netherlands could become frontrunner. Which is remarkable, because investments CACp5 were also not approved. Fourthly, due to insufficient public incentives, knowledge accumulation

predominantly remains within start-ups that have to deal with intellectual property and competitors. Hence general knowledge diffusion hardly is present, which is why other stakeholders acknowledge the necessity for open-source development. In general, the alignment between the stakeholders thus seems limited, which also impede stable network formations.

5.3.3 Barriers to learning processes

5.3.3.1 Limited accumulation of knowledge

With regard to learning processes, there are several factors that limit the accumulation and diffusion of knowledge. Firstly, due to the lacking public incentives, i.e., no education, research institutes and participation possibilities, there are too limited resources to build up expertise and make knowledge available. Hence, scientific scrutiny is also compromised as there are hardly any peers to review publications, which is especially important in the early technology stages. Furthermore, research also remains limited because grants are scarce: "So, there are actually too few grants that stimulate work in this area. And then, as a professor, you are going to adapt your work to the kind of grants that are there" (S1). In addition, the ongoing RA also inhibits public experimentation and involvement of potential stakeholders that could advance knowledge. Secondly, the CM scenarios are furthermore relatively unknown as the technology is merely proven on lab-scale. Large-scale behavior in terms of technology, economics, regulations, cultural and environmental effects therefore, largely depends on extrapolation and predictions. A significant proportion of learning processes thus still needs to occur. Furthermore, as CM still is forbidden, the consumer acceptance especially is difficult to determine: "There is very little predictive value in it, because nobody can imagine what it is. So, you can't improve the product" (B2). Thirdly, most of the knowledge is generated in private companies that hardly exchange progress due to intellectual property and competition. Hence, according to stakeholders, venture capitalists largely determine the transparency and direction of CM, which presumably is where the return on investment is the highest. This is furthermore risky, because the stakeholders also expressed concern about the possibility of start-ups relocating abroad if the start-up climate remains unchanged. In total, there thus is still much uncertainty about the future of CM, which prevents processes of knowledge accumulation and diffusion from taking place optimally.

5.3.3.2 Dependent on innovation diversity

Scaling-up CM technology partly depends on innovation diversity that it cannot always control. The absence of these developments however, could impede learning processes and hence niche growth. Several dependencies are difficult to control currently. Firstly, CM technology requires new value chains as many resources for large scale are non-existent. For instance, current lab-scale productions can use standard laboratory equipment, whereas large-scale productions require equipment redesigned for mass output. Furthermore, specific commodities, such as hormones are also not yet available for large quantities. Hence, CM scale-up depends on revisions of both equipment as commodity supply channels. Secondly, these chains involve companies from the pharmaceutical sector, which is quite unsuitable for productions on food-scale. Contrary to CM productions, pharmaceutical productions have to meet the highest quality standards and costs are less of a factor. Furthermore, it is challenging to gain knowledge from this sector as regulations and intellectual properties are very strict. Hence, to include these pharma companies during scale-up, a change of their operational paradigm is necessary. Thirdly, scaling-up is also dependent on the complex RA process of the EFSA. The trajectory approximately takes 1,5 years and if applicants change formulation or production along the way, they need to resubmit and start all over. Moreover, as CM is completely new, the first applicant serves as an example for the competition and need to spend the most money. There thus is less incentive to start first and hence, CM would actually benefit from a less comprehensive process. Fourthly, since CM is completely new and still forbidden, a business model

hardly can be defined as it is relatively unknown what value CM products can deliver. Hence, this inhibits supply and demand iterations, which such a technological push approach requires. Moreover, the CM product range and quantities can be self-determined as it no longer depends on complete animals, which also requires market iterations. Fifthly, the technology, when it indeed becomes disruptive, also dependents on governmental adaptations: "The government must also make that switch from focusing on the dominant system to focusing on a new one" (B2). For instance, by offering subsides and even the earlier mentioned level playing field. In summary, the CM niche industry should be aware of that scaling-up comes with dependencies that it not always can control and hence, could impede transition developments.

6 Discussion

This study aimed to identify barriers, perceived by academic, business, government and society stakeholders, that the CM industry faces ahead in its transition to the regime. This chapter first provides a discussion of the barriers per level, to give insights to accelerate and support the transition. Table 2 is hereby supportive and presents the barriers with a summary of the corresponding features. The sections that follow, shed light on the theoretical and practical implications and ends with the limitations involved with this study.

Table 2. Overview Barriers per Level

Level	Barrier	Features
Landscape	1. The environmental paradox	Ambiguity phase determines selective environmental behavior
	2. The Dutch political climate	Economic growth focus, Nature of democratic system
Conventional meat regime	3. Socio-Cultural lock-in	Tradition, Emotion, Meat product characteristics
	4. Techno-Economic lock-in	Rooted in economics and spatial order, Dominant in level playing field
	5. Institutional-Political lock-in	Policies contribute to regime growth and authority
	6. Regime perspectives	Meat necessary for circularity, Only EU circularity is possible, Mainly CVM sustainability solutions, Lobby activities are rare
Cultured meat niche industry		
▪ Articulation of expectations	7. Operational constraints	Merely lab-scale proof, Regulations, Consumer demand
	8. Imagining	Lacking stakeholder vision, societal image-problems
▪ Network formation	9. Insufficient incentives	Education, Research, Scale-up facilities, Social embedding, Start-up climate
	10. Network disunity	Scale-up tensions, Social implementation, Transparency
▪ Learning processes	11. Limited accumulation of knowledge	Lacking knowledge institutes, CM scenarios unknown, Venture capital dependent transparency
	12. Dependent on innovation diversity	Scale-up resources non-existent, Pharma paradigm, EFSA approval, CM business model, Government adaptations

6.1 Interpretation

The results chapter described the identified barriers, this interpretation section in contrast delineates how barriers might interact and reinforce each other as part of multi-level developments. Furthermore, the differences between the barriers identified via the respondents and the barriers retrieved from the policy documents are also briefly discussed. The interactions are first considered per level and proceeds by considering the reciprocal interactions between levels that determine the transitional meaning.

6.1.1 Multi-level development

The macro-level of the landscape demonstrates that *the environmental paradox (1)* and *the Dutch political climate (2)* determine that sustainable niches such as CM typically are impeded. In contrast, the regime is stabilized by the barriers as they are constructive for CVM practices. These effects can be considered typical as the landscape is a regime and niche embedding exogenous environment, capable of pressurizing ST-system behavior (Geels, 2002). It therefore, contextualizes and provides boundaries in which change processes occur beyond the direct control of the other levels (Twomey & Gaziulusoy, 2014). Ambiguous tensions with respect to meats and its environmental problems are also observed in other studies (Onwezen & van der Weele, 2016; van der Weele & Driessen, 2019). Moreover, a Dutch decline of environmental policies influenced by political developments are similarly observed (Wiering et al., 2018). Nevertheless, the first barrier possibly also preserves the nature of the political climate, as incentives to change the economic nature to a more sustainable nature, are relatively limited. Furthermore, in a phase of ambiguity, it might also maintain a ST-system climate in which transformative reflexivity failures occur (Weber & Rohracher, 2012). Reflexivity in this sense, is aimed at the ability to monitor, anticipate and involve stakeholders in self-governance to achieve transformative goals. In addition, general political governance in transition is also presumed to face related issues; ambivalence about societal problems, uncertainty about its long-term effects and the fact that transitions often endure multiple political climates (Kemp et al., 2007). Consequently, the barriers are possibly mutually reinforcing and further stabilize regime developments, hence inhibiting anticipatory niche activities.

The meso-level of the regime concerns the mainstream technology of the ST-system, i.e., CVM. Importantly, while this study identified CM transition barriers related to the regime, these also could become enablers. This highly depends on the actual implementation of the CM industry. The question is whether CM will indeed become a radical and regime-disruptive technology, largely absorbed into the regime or a combination of the two. Nevertheless, since this relation and CM expectation is not yet crystallized, these factors remain barriers. Considering this, the institutional regime rules are possibly driven by landscape developments and constructive for each other. The *environmental paradox (1)* of the landscape potentially drive the norms and values, i.e., soft rules, that creates cultural lifestyles and social capital in accordance with CVM practices, which explains the *Socio-Cultural lock-in (3).* This establishes a support base for the sunk investments, economies of scale and knowledge capital in the *Techno-Economic lock-in (4)* barrier. As a result, and potentially because the later also fits into the *Dutch political climate (2)*, standards and regulations, i.e., hard rules, are also in accordance with CVM practices. Hence, the CVM regime is institutionally embedded as the observed *Institutional-Political lock-in (5)* describes. Furthermore, in a study obtained in institutionally overlapping country Germany, highly comparable factors impeding sustainable CVM production are found. Barrier 3-5 respectively relate to the factors of; consciousness complex (cognitive reactions influence stakeholders), industry infrastructure and economic conditions, and regulatory environment (Hübel & Schaltegger, 2022). The interaction between barriers of this research and that similar factors are observed in a neighboring European country, enhance the possibility of different types of system failures. The lock-in mechanisms demonstrate that the regime is dominant and stable which supports

path dependencies and might give rise for *network interaction failures*, since the incentive to interact with other (niche) stakeholders is relatively low. Instead, cooperation for development predominantly occurs within the regime. Furthermore, *institutional failures* seem to occur, as institutions majorly follow regime practices (Weber & Rohracher, 2012). The *Regime perspectives (6)* might also influence the stabilizing rules and hence, determine actions and all occurring lock-mechanisms. Furthermore, it potentially can be used as a deliberate strategy to oppose to sustainable meat alternatives (Geels, 2019), which similarly is found in the German study. In a sense, the CVM regime thus is stabilized and dominant, which means that radical novelties apart from the regime, such as CM, typically face an uphill struggle.

The micro-level involves niche processes and concerns the CM industry. The process of articulating expectations and visions is important to align activities in a desired direction (Kemp et al., 1998). CM in that respect, is impeded because the *operational constraints (7)* make the scenarios unknown, which also influences the *imagining (8)* barrier that demonstrates the absence of a collective, unified vision and the CM image-problems. Nevertheless, the CM industry can be considered from a technological innovation systems (TIS) perspective. The performance of TIS, i.e., the network of actors and rules within a specific technological field influencing technological change, can be determined with functions (F1-F7) (Hekkert et al., 2007; Markard & Truffer, 2008). Articulating expectations in that respect, is comparable with the guidance of the search function (F4), i.e., the ability of visions and regulations to steer developments, and legitimacy creation function (F7), i.e., growth of interest groups. However, both barriers demonstrate that these cannot perform adequately. Furthermore, the expectations are also practically not robust, qualitative and specific, which SNM considers important (Raven, 2005). It is difficult to be robust, because there is barely a stable aligned perception of what should and could be achieved. Moreover, hardly qualitative and thus based on facts, because there is an excessive lack of knowledge for its factual demonstration. Hence, making expectations specific is also difficult, as most of the technological, economic, political and social CM impact is still unknown. The niche potential is also challenging to determine without participative experimentation with demand and user needs. As this currently is forbidden, the transformation possibly might be impeded by demand articulation failures. (Weber & Rohracher, 2012). Furthermore, as the general public and CM stakeholders hardly can develop a shared vision, the transformation might also be obstructed by directionally failures (Weber & Rohracher, 2012). A delineated transformative direction also would require stakeholder coordination processes which adds to the importance of network formations.

Network formations are important to sustain stable niche configurations (Raven, 2005). However, the lacking *network disunity (10)* and *insufficient incentives (9),* possibly determine deficiencies in attracting and educating stakeholders into the network. Hence, the coordination of stakeholder activities becomes difficult, which could contribute to the mentioned directionality failures (Weber & Rohracher, 2012). Moreover as the collective network composition is incomplete, stakeholder diversity and cross functioning cooperative relations are also difficult to establish (Schot & Geels, 2008). From a TIS perspective, especially barrier 9 might also contribute to system misfunctions. It namely compromises entrepreneurial activities (F1), knowledge development (F2), knowledge exchange (F3), guidance of the search (F4), market formations (F5), resource mobilizations (F6) and legitimacy creation by interest groups (F7). In that sense, barrier 9 is an important determinant in the functioning of the system. Yet, barrier 10 also compromises knowledge exchange (F3) and legitimacy creation (F7). Remarkably, the barriers to network formations thus possibly impede all TIS functions (Hekkert et al., 2007; Markard & Truffer, 2008). Moreover, since the network integration of the general public is still prohibited, the aforementioned demand articulation failures may be exacerbated (Weber & Rohracher, 2012). This is relatively critical because the involvement of consumers and third parties is important for network stability (Caniëls & Romijn, 2008). Furthermore, the insufficient incentives might reinforce network disunity, which makes the alignment of stakeholder activities difficult, especially since disagreements about transparency and public investments are observed (Raven,

2005). Incentives and learning processes are therefore important to attract and align potential CM stakeholders for stable niche network formations.

Niche learning processes are indeed important to (re)articulate expectations and attract stakeholders to govern the niche direction (Kemp et al., 1998). However, the *limited accumulation of knowledge (11)*, demonstrates an inhibited development and diffusion of CM knowledge. This furthermore is enhanced by that CM is *dependent on innovation diversity (12)*. From a TIS perspective, the barriers also indicate misfunctions. Barrier 11 demonstrates that knowledge development (F2) and knowledge exchange (F3) are impeded, whereas barrier 12 relates to difficulties with resource mobilizations (F6) (Hekkert et al., 2007; Markard & Truffer, 2008). Potentially, these barriers or misfunctions also influence the 7 learning dimensions as mentioned in the theory chapter; i.e., technical, market, cultural, infrastructure, industry, regulations/policy and societal effects, because actual learning in that sense is restricted (Schot & Geels, 2008). Scaling-up and the RA in that respect, is crucial because that will determine further learning processes and actual CM implementation in society. Hence, there are possible limitations to first order learning, since the implementation is not there to be assessed (Raven, 2005). While learning at most dimensions is marginally possible, the cultural, societal and market learning dimensions are the most restricted, which is critical as the social embedding can be highly decisive for transitions (Markard et al., 2012). Consequently, without public participation, second order learning is also compromised, as their deeper underlying norms and values, hardly can be assessed without interaction (Schot & Geels, 2008). Furthermore, the restriction to learning processes and public participation, might give rise for reflexivity failures, as that acknowledges the importance of public interaction and experimentation, contributing to second order learning (Weber & Rohracher, 2012). Nevertheless, the inability to sufficiently learn in al dimensions, impedes the capacity of the niche to adapt to multi-level developments and be resilient.

Whereas the stakeholder interviews revealed all 12 barriers, it is striking that policy documents P1 and P2, i.e., the CAC growth plan application and governmental approval, merely unveil CM niche related barriers and addresses the need for facilities and incentives. Although this also is constructive and necessary for the establishment of the Dutch CM industry, the influential regime and landscape developments are hardly considered. One thus could argue that albeit all 5 CAC growth plan pillars would be approved, the threat of the landscape and regime related barriers could remain present and influence the transition of CM. Also remarkable is that P1 predominantly addresses the *insufficient incentives (9)*, but also the related *limited accumulation of knowledge (11)* and *dependent on innovation diversity (12)* barriers. P2 likewise acknowledges the *insufficient incentives (9)*, yet also unveil the remaining niche barriers of *operational constraints (7)*, *imagining (8)* and *network disunity (10)*. In this sense, P2 and the government, thus also acknowledges the importance of a better articulation of expectations. Furthermore, it demonstrates a network disunity, as only CACp1, CACp2 and CACp3 are partially approved with significantly less investments. P1 and P2 combined, thus, hardly consider landscape and regime developments yet correspond to the importance of niche processes and reveal their insufficient occurrence.

6.1.2 Transitional meaning

Reciprocal interactions between levels can be decisive for transitions. Accordingly, the landscape involves mutually reinforcing developments that hardly align with the CM niche industry. However, the industry is also not on scale, introduced in the market and still involves significant uncertainties. Still, CM stakeholders are anticipating the rising broader environmental awareness developments of the landscape. The CVM regime in contrast, is stable and largely aligns with the landscape developments and faces less incentives to change its operations or to get drastically involved with radical (niche) innovations. In addition, limited institutional change is observed, as CM is still quite distant from institutionalization and public investments are scarce. In this respect, the regime and

niche interaction are relatively restricted and barely necessary and threatful for the regime. Yet, as mentioned, the niche neither fully defined its relationship with the regime, i.e., symbiotic or competitive, which could alter the interaction and converge regime related barriers into CM enablers.

This raises the importance of the niche internal processes. The confined process of articulating CM expectations and the way in which people perceive CM significantly impedes a transition, especially since that also could determine the relationship with the regime. Moreover, it possibly discourages potential stakeholders from stepping into the network. Another impediment in that regard, involves the current process of network formations. The network composition still is incomplete and faces difficulties to establish. Furthermore, the lacking network alignment, especially regarding scaling-up, i.e., large-scale factory production vs. local-scale agricultural production, also influence that undefined interaction with the regime. Moreover, all 7 TIS functions seem to be perform limitedly, especially due to the lacking incentives in the network. These niche processes reinforce each other, the lacking aligned expectations impedes network formations and vice versa. Hence, outcomes of learning processes are also relatively limited, which in turn, could impede specifying expectations (Raven, 2005). In this sense, the CM niche industry appears to be caught into a vicious circle that is not conducive to accelerating the transition. Furthermore, the current CM niche processes are increasing the possibility of transformational system failures (Weber & Rohracher, 2012). In addition, the CM industry and the related CAC documents possibly also do not anticipate the effects of the landscape and CVM regime, which also could inhibit a CM transition.

Following these multi-level interactions, i.e., strong regime and moderate niche reinforcement by the landscape, combined with a limited regime and niche interaction, both the phase as the pathway of the CM transition can be determined. With regard to the phase, the transition still seems to be in phase 1 of experimentation, preceding phase 2 of stabilization and niche market formation (Geels, 2019). Accordingly, the CM niche uncertainty indeed is relatively high, most developments take place in R&D environments and there is no market introduction yet. With regard to pathways, there are multiple transition directions that are determined on the premises of the timing and nature of interactions, institutional rules, and actor behavior (Geels et al., 2016; Geels & Schot, 2007). With respect to the timing, landscape pressure appears to be moderate and, due to the broader environmental awareness, possibly only early disruptive change is observed. This indeed implies that the regime merely needs to partially reorient incremental developments paths to align with the landscape. Institutions therefore, also remain particularly aligned with the regime. Moreover, the niche with its dependency on subsidies and without actual market introduction, appears to be mainly technical in nature, i.e., shielded from market selection processes (Caniëls & Romijn, 2008). This possibly also declares the misfunctions from a TIS perspective. In terms of pathways, it therefore can be considered as not sufficiently developed. The effects of moderate landscape change, gradual regime reorientation, limited institutional change and an insufficiently well-developed niche, are indicators that the transition is potentially on a Transformation pathway (Geels et al., 2016; Geels & Schot, 2007). However, if early disruptive change intensifies, the CM niche is introduced in the market or the regime increases its persuasion power, the future of CM might become totally different and pathways might shift (Geels et al., 2016).

6.2 Theoretical contribution and implications

This research provides an illustration of the MLP and SNM and thus contextualizes the theoretical frameworks. Multiple barriers indeed largely fit into the theories. While this partly is because of the deductively approached research methodology, the empirical evidence itself also proves coherency with the theories. The lock-in barrier mechanisms for instance, are observed as such. Furthermore, the results are in a sense also quite actual and apply to different general societal problems. The landscape barriers for instance, possibly also apply to other climate goals and sustainability challenges, whereas

the regime related barriers also can be assigned to other meat alternatives. Scholars from related fields, thus might draw partially the same conclusions. Furthermore, the perceived regime perceptions barrier, in a sense contributes to an academic MLP critical discussion. The MLP would illustrate regimes too passively and only involved with incremental innovations. Yet, multiple scholars demonstrated that incumbents might use resistance strategies to obstruct transitions (Geels, 2019). Possibly, the expressed regime perceptions are part of such strategies. In addition, while different CM barriers related to commercialization are studied by scholars, what and how barriers affect a transition is rather less known. This research also contributes to that.

Although, many barriers deserve further investigation and acknowledgement, several research directions justify particular attention. Firstly, the CVM regime and how it interacts with the niche is not yet fully understood. The earlier mentioned effect and intention of regime perceptions are not yet fully comprehended, while this might be used as a resistance strategy. Furthermore, large organizations in the regime probably also operate ambidextrous, i.e., balancing knowledge exploitation with exploration. Hence, the possibility rises of incumbents delivering radical innovations (O'Reilly III & Tushman, 2004). This could be risky for the CM niche industry, yet also constructive, depending on its relationship with the regime, i.e., symbiotic or competitive. Furthermore, as the CVM regime barriers thus could become CM enablers, studying the regime capabilities and specifying intentions in relation with CM, thus could be valuable. Secondly, the CM niche industry would benefit from more specified articulated expectations, especially if these are aligned throughout the network. As mentioned, this might attract new stakeholders and enhance learning processes. Furthermore, it potentially could help defining the mentioned relationship with the regime. Research that specifically assesses CM expectations, where there is overlap, its internal and external requirements and what vision would be supportive, could contribute to this. Thirdly, if the selective environmental behavior in the landscape changes and the broader environmental awareness increases, the CM transition could be accelerated. However, exactly what such a social change process requires seems relatively unknown, and thus also is worth investigating.

6.3 Practical implications

As for the CM stakeholders and policymakers, there are also practical implications. Firstly, as mentioned, the lacking expectations possibly resolve in transformational directionality and demand articulation failures. Directionality could become more specified, if CM would be positioned as a societal challenge-based mission. This would require mission-oriented innovation policies and for coherency, possibly approaching CM as a mission-oriented innovation system (Hekkert et al., 2020). With regard to demand articulation failures, direct participation with the general public and hence accepting CACp4 could be the most fruitful. Yet this depends on the RA. Instead, public procurement investment strategies or coordinating CM information provision strategies could be implemented, so that the general public is directly or indirectly educated to define demand (Weber & Rohracher, 2012). Secondly, the above aligns with addressing the possible reflexivity failures, as this would also require explorative interaction possibilities with the public. Nevertheless, reflexivity also should be aimed at transition directions (Weber & Rohracher, 2012). Hence, CM stakeholders should anticipate the mentioned effects that impact the pathways for transition, as the current transformation pathway also could shift. Focusing on a mass factory production vs. local scale production, might for instance influence pathways as the latter incorporates more regime functions. Scenario planning potentially could address this. Thirdly, policy documents P1 and P2 seem to neglect the influence of the landscape and regime. Nevertheless, policy should also be aimed at these levels. The mentioned societal challenge-based mission approach potentially also could increase the broader environmental awareness of the landscape. Yet, especially addressing the level playing field in which CM will be positioned, possibly would be most directly effective. True pricing that internalizes societal costs of

CVM, in that respect, could be a policy instrument to consider (Caniëls & Romijn, 2008). Fourthly, the barriers to network formations thus possibly drive all TIS misfunctions. Furthermore, the *insufficient incentives (9)* provides another significant issue; an industry is needed to create value and legitimize education, while education is needed to create that industry. In that sense, if the government would approve P1 completely (CACp1-5), these potentially could be resolved. However, and this applies to all four mentioned implications, it also depends on the goal of policy. Is that achieving true societal benefits or predominantly economic growth?

6.4 Limitations and future research

While the reliability is typically considered difficult for case studies (Bryman, 2012), this study especially has a disadvantage. It namely involves dynamic social behavior and a continuously evolving CM industry, which makes it difficult to yield similar results. In addition, the selection of stakeholder respondents might also be different per occasion due to the time constraint of this study. Nevertheless, reliability is possibly raised by including transcripts and a thematic analysis that involves deductive coding rules. Furthermore, institutionally and regulatory, the analyzed ST-system shares multiple aspects with the EU and neighboring countries, not to mention the EFSA approval. Even though, these cross-border characteristics potentially enhances the external validity, it might also influence the results of this case study. Moreover, this study focuses on barriers, which could imply that certain landscape developments aligned to the niche, are being neglected in this study. In addition, this study and the MLP pays less attention to regime perspectives and its impact, while the corresponding barrier provided such indications. Even though this research includes many influential CM stakeholders, future research should convince both instead of one of the Dutch CM start-ups to participate. The start-ups are in a slightly more mature technological state, and thus could provide interesting insights. Furthermore, it should also aim for both constructive as destructive CM transition developments and increase focus on the effects of regime perspectives.

7 Conclusion

The main objective of this study was to provide CM niche scholars and stakeholders insight into the processes in the form of barriers that impede a Dutch CM transition from niche to regime. Based on an academic framework of the MLP and SNM theories, the following main research question guided this objective:

What are the barriers to the transition of Cultured Meat from Niche to Regime perceived by stakeholders?

The barriers that the Dutch CM industry faces ahead in transition are found in different MLP levels and SNM processes. The landscape level involves mutually reinforcing barriers: *The environmental paradox (1) & The Dutch political climate (2)*. Furthermore, the CVM regime level, also involves reinforcing barriers: *Socio-Cultural lock-in (3), Techno-Economic lock-in (4), Institutional-Political lock-in (5) and Regime perspectives (6)* that provides its dominant and stable character. The niche level in turn, involves barriers that impede the articulation of expectations: *Operational constraints (7) & Imagining (8)*, impedes network formations: *Insufficient incentives (9) & Network disunity (10)* and impedes learning processes: *Limited accumulation of knowledge (11) & Dependent on innovation diversity (12)*. As these niche processes also reinforce each other, the limited articulation of CM expectations impedes network formations and vice versa, learning processes are also compromised, which influences defining expectations. Due to this apparent vicious circle, the complete SNM process of niche nurturing is possibly affected. Hence, this also determines the reciprocal interactions between the levels and makes the regime and niche interaction relatively limited. Furthermore, the CVM regime is significantly reinforced by landscape developments, while the CM niche moderately is being reinforced by it. The level interactions and corresponding barrier interactions combined, see Figure 8, determine that ST-system alignment and a window of opportunity for a CM transition is potentially only limited on the rise. Hence possibly only early disruptive change is observed which is partially why the transition still is in phase 1 and follows a Transformative pathway.

Although this study takes a critical view of the CM industry and its environment, and significant uncertainties remain with regard to market introduction, RA and scaling up, CM remains an important phenomenon to explore further. In a sense, CM is efficient and about applying design thinking to conventional meat where the desired end product can be realized immediately. As this product possibly could contribute significantly to a brighter sustainable future, benefitting all, that projection in itself makes CM worthy of further investigation.

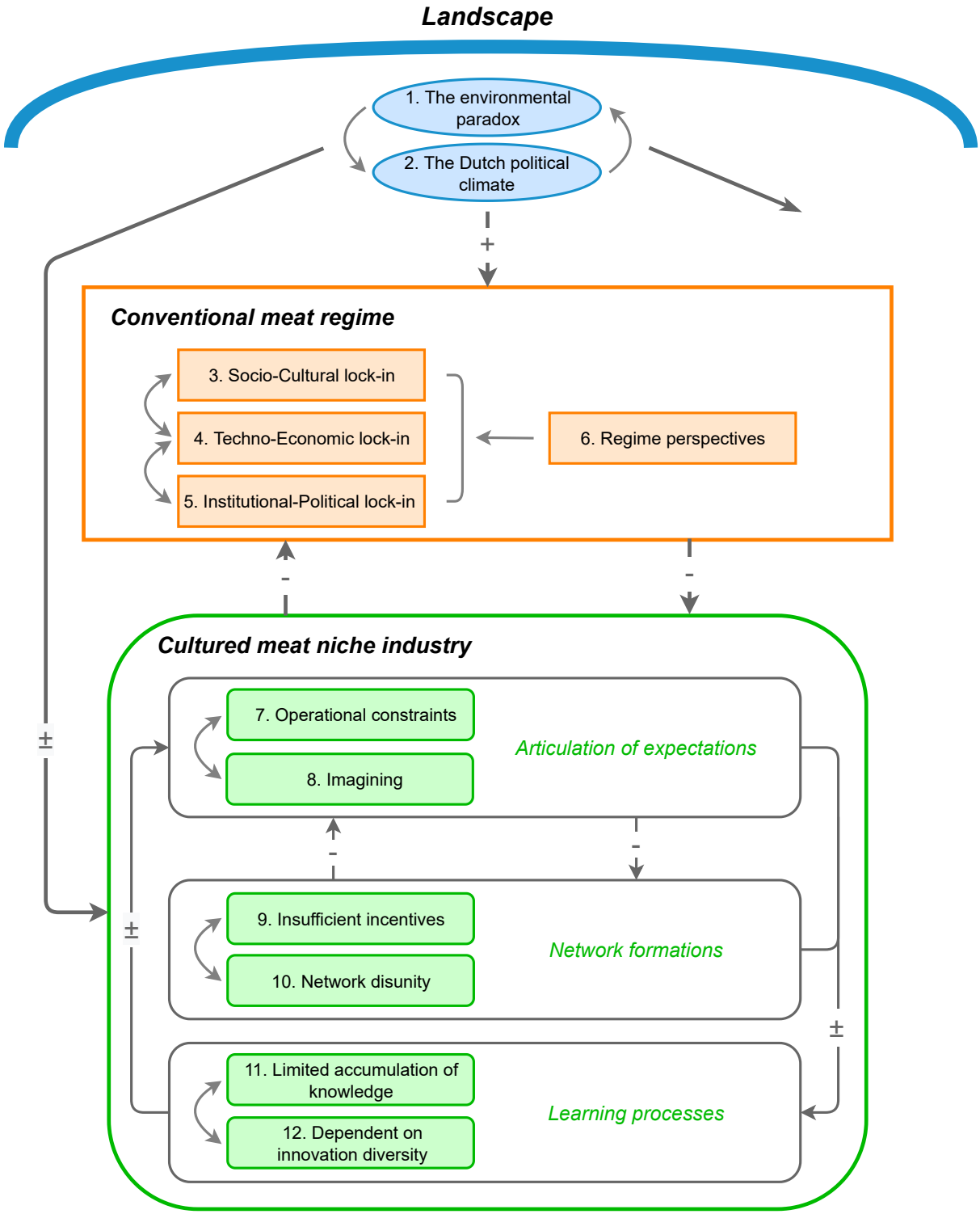

Figure 8. ST-system of meats and its multi-level and multi-barrier interactions

8 Relevance to Management of Technology

The master Management of Technology aims to learn students to recognize technology as resource to achieve objectives in corporate or policy environments. The objectives for example might be to achieve more profit, customer satisfaction or improved services. Besides ways of operating and efficiency, this also could result in the implementation of policies or business models to become for example, a more sustainable organization. Being aware of current and future technological, economic and social developments is of special importance. The master in that respect, depends on multi-disciplinary knowledge and management of technological processes. This is also in line with the activities during this research. The analysis of a niche in a multi-layered ST-system requires in itself a relatively holistic and abstract understanding. In addition, analyzing CM niche processes, to make statements about possible interventions, is in itself about management of technology. Furthermore, the academic theories used, such as the MLP and the Quadruple Helix, have already recurred in the Master courses and SNM with its strategic components in technological context, also seems to fit well. Furthermore, this research provides transition barriers for a particular case. In that respect, it possibly could be compared to a consultancy case, something that many alumni of Management of Technology face in their careers.

9 Reflection

For this thesis project, I analyzed a comprehensive CM industry that involves multiple interesting processes. I have proven that I can work in a disciplined and detailed manner and almost always persevere. During the process, I took the time to truly immerse myself in matters, before jumping to conclusions, e.g. to be able to provide the theoretical chapter of this thesis. Moreover, the understanding of the MLP and SNM also progressed along the way. Furthermore, the interviews where pleasant and easy-going, which possibly also is the result of my social skills. Moreover, quite influential stakeholders participated in the interviews, and proved very willing to contribute and recognized the importance of this research. This resulted in 14 interviews, while my initial aim was to do 10. This combined with the supporting interview questions resulted in interesting and rich data in which I could immerse myself again.

There were also elements that turn out not quite as well. For example, writing concisely in academic English could sometimes be improved. Furthermore, during immersing into the data, I sometimes got a bit lost which not always resulted in an efficient process. Although I often try to figure out matters myself, I sometimes could have got in touch with the supervisor a bit earlier, for a faster progression. Moreover, occasionally it took some time to figure out what was expected and determine when my outputs where sufficient. This possibly was due to my lacking experience with academic theses and my rather practical background. Furthermore, even though that I created an extensive planning, I therefore also needed to adjust it regularly. That said, I also got very excited by the great response to the interviews. However, that enthusiasm also meant that I needed to process the data of 14 interviews. In terms of practicality and timing it would have been better to incorporate 10 interviews, yet this also would not have resulted in the current rich amount of data. With respect to the data, I found it challenging to address certain barriers to the niche processes, since they were often applicable to multiple processes that also affect each other. Hence, I have changed features of barriers up to the last minute, in both the highlighted transcripts as analysis documents used.

The best lesson I took from this period, is to be more pragmatic at times. In the end, I am the one that need to graduate, and I will not and cannot change the world with this project. Balancing enthusiasm with the bigger picture thus is what I from now on should do.

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Appendix

A.1 Data management plan

To eat or not to eat: Cultured meat and its barriers ahead in transition. The case of the Dutch niche industry.

A Data Management Plan created using DMPonline

Creator: Joris Voogd

Affiliation: Delft University of Technology

Template: TU Delft Data Management Plan template (2021)

Project abstract:

Transitions are generally studied across the levels of *niches* (micro-level), *regimes* (meso-level) and *landscapes* (macro-level). Within this so-called socio-technical system, niche technologies, attempt transitioning to regimes. The cultured meat industry is limited to a few start-ups at the niche level, which are facing barriers to development. Yet, it is not clarified what the barriers seem to be in transition context. It is therefore, unknown how the cultured meat industry could evolve from niche to regime level. The main objective of this study therefore lies in providing insight into the processes that are hampering a transition of cultured meat, i.e. what barriers hampering the shift from cultured meat niche to regime. For this purpose, the *Dutch cultured meat industry* represents this case study and 10 of its stakeholders are interviewed for barrier identification.

ID: 94346

Start date: 15-03-2022

End date: 15-08-2022

Last modified: 18-03-2022

To eat or not to eat: Cultured meat and its barriers ahead in transition. The case of the Dutch niche industry.

0. Administrative questions

1. Name of data management support staff consulted during the preparation of this plan.

My faculty data steward, Nicolas Dintzner, has reviewed this DMP on 16-03-2022.

2. Date of consultation with support staff.

2022-03-16

I. Data description and collection or re-use of existing data

3. Provide a general description of the type of data you will be working with, including any re-used data:

Type of data	File format(s)	How will data be collected (for re-used data: source and terms of use)?	Purpose of processing	Storage location	Who will have access to the data
Recordings	Audio (mp3)	Online interviews, audio recorded	Data collection for transition barrier identification	One drive	Neelke Doorn, Martijn Wiarda, Geerten van de Kaa, Joris Voogd
Transcripts	Text documents	Transcribing audio recordings	Data analysis	One drive	Neelke Doorn, Martijn Wiarda, Geerten van de Kaa, Joris Voogd
Codes	Text or tabulate documents	Coding spreadsheet	Data reduction and analyzation	One drive	Neelke Doorn, Martijn Wiarda, Geerten van de Kaa, Joris Voogd
Institutional contacts	Text or tabulate documents	Official websites	Digital communication	One drive	Neelke Doorn, Martijn Wiarda, Geerten van de Kaa, Joris Voogd
Respondent list	Text or tabulate documents	Via official websites and institutional contacts	Digital communication	One drive	Neelke Doorn, Martijn Wiarda, Geerten van de Kaa, Joris Voogd

4. How much data storage will you require during the project lifetime?

- < 250 GB

II. Documentation and data quality

5. What documentation will accompany data?

- Methodology of data collection

The methodology of data collection will be documented in my Master thesis.

III. Storage and backup during research process

6. Where will the data (and code, if applicable) be stored and backed-up during the project lifetime?

- OneDrive

IV. Legal and ethical requirements, codes of conduct

7. Does your research involve human subjects or 3rd party datasets collected from human participants?

- Yes

8A. Will you work with personal data? (information about an identified or identifiable natural person)

If you are not sure which option to select, ask your Faculty Data Steward for advice. You can also check with the privacy website or contact the privacy team: privacy-tud@tudelft.nl

- Yes

8B. Will you work with any types of confidential or classified data or code as listed below? (tick all that apply)

If you are not sure which option to select, ask your Faculty Data Steward for advice.

- Yes, I work with other types of confidential or classified data (or code) - please explain below

The interview questions that will be asked are regarded to characteristics of the Dutch cultured meat niche. While Joris Voogd have no intention of explicitly asking about company strategies and it furthermore also is not the focus of the thesis, certain aspects of answers potentially might unveil certain activities of companies. Any sensitive confidential information will be deleted from the transcripts.

9. How will ownership of the data and intellectual property rights to the data be managed?

For projects involving commercially-sensitive research or research involving third parties, seek advice of your Faculty Contract Manager when answering this question. If this is not the case, you can use the example below.

The datasets underlying the published papers will be publicly released following the TU Delft Research Data Framework Policy. During the active phase of research, the project leader from TU Delft will oversee the access rights to data (and other outputs), as well as any requests for access from external parties. They will be released publicly no later than at the time of publication of corresponding research papers.

10. Which personal data will you process? Tick all that apply

- Data collected in Informed Consent form (names and email addresses)
- Signed consent forms
- Names and addresses
- Telephone numbers
- Email addresses and/or other addresses for digital communication

The personal data that I wil collect is only meant to organize the online audio recorded interviews. I am merely interested in the professional expertise of the respondents and not about their personal data.

11. Please list the categories of data subjects

Adults consulted in their professional capacity. The stakeholders will be selected from the following stakeholder groups: Government (such as members of the ministry of economics), Academia, Business and Society (consumer representatives, activists, journalists)

12. Will you be sharing personal data with individuals/organisations outside of the EEA (European Economic Area)?

- No

15. What is the legal ground for personal data processing?

- Informed consent

16. Please describe the informed consent procedure you will follow:

All study participants will be asked for their written consent for taking part in the study and for data processing before the start of the interview.

17. Where will you store the signed consent forms?

- Same storage solutions as explained in question 6

18. Does the processing of the personal data result in a high risk to the data subjects?

If the processing of the personal data results in a high risk to the data subjects, it is required to perform a Data Protection Impact Assessment (DPIA). In order to determine if there is a high risk for the data subjects, please check if any of the options below that are applicable to the processing of the personal data during your research (check all that apply).
If two or more of the options listed below apply, you will have to complete the DPIA. Please get in touch with the privacy team: privacy-tud@tudelft.nl to receive support with DPIA.
If only one of the options listed below applies, your project might need a DPIA. Please get in touch with the privacy team: privacy-tud@tudelft.nl to get advice as to whether DPIA is necessary.
If you have any additional comments, please add them in the box below.

- None of the above applies

22. What will happen with personal research data after the end of the research

project?

- Anonymised or aggregated data will be shared with others
- Personal research data will be destroyed after the end of the research project

For the potential purpose of future use, all personal research data will kept for a maximum of 3 months after the thesis period for potential follow up studies. After this period, all personal research data will be destroyed. In the case of a follow up, the participants are asked for their consent.

23. How long will (pseudonymised) personal data be stored for?

- Other - please state the duration and explain the rationale below

Only up to 3 moths after graduation/the thesis period on the same one drive storage location.

24. What is the purpose of sharing personal data?

- Other - please explain below

I have no intention of sharing any personal data. Only temporary for the potential of future use.

25. Will your study participants be asked for their consent for data sharing?

- Yes, in consent form - please explain below what you will do with data from participants who did not consent to data sharing

Participants cannot participate without consent. The content form furthermore, will mention a potential follow up study and will inform the participants that they will have to consent again in the case of a follow up study.

V. Data sharing and long-term preservation

27. Apart from personal data mentioned in question 22, will any other data be publicly shared?

- I do not work with any data other than personal data

29. How will you share research data (and code), including the one mentioned in question 22?

- My data will be shared in a different way - please explain below

Aggregated information and the interview codebook will be included in my master thesis that wil be uploaded tot the TU Delft master thesis repository

30. How much of your data will be shared in a research data repository?

- < 100 GB

31. When will the data (or code) be shared?

- As soon as corresponding results (papers, theses, reports) are published

32. Under what licence will be the data/code released?

- CC BY

The data will be present in the master thesis.

VI. Data management responsibilities and resources

33. Is TU Delft the lead institution for this project?

- Yes, the only institution involved

34. If you leave TU Delft (or are unavailable), who is going to be responsible for the data resulting from this project?

Prof. Neelke Doorn: N.doorn@tudelft.nl

35. What resources (for example financial and time) will be dedicated to data management and ensuring that data will be FAIR (Findable, Accessible, Interoperable, Re-usable)?

4TU.ResearchData is able to archive 1TB of data per researcher per year free of charge for all TU Delft researchers. We do not expect to exceed this and therefore there are no additional costs of long term preservation.

A.2 Interview questions

Topic	#	Question
Welkom		
Informed Consent		
Korte toelichting op transities + introductie Nederlandse Industrie		
Respondent		Kunt u uzelf introduceren en vertellen wat uw verantwoordelijkheden zijn?
		In hoeverre ben je/u betrokken bij kweekvlees ontwikkelingen?
Landscapes	1	Wat zijn belangrijke trends op globaal/nationaal niveau, die invloed hebben op (kweek)vleesproductie en consumptie?
Regimes	2	Wat veroorzaakt dat een groot deel van de Nederlandse maatschappij toegewijd is aan de productie en consumptie van conventioneel vlees?
	3	Welke factoren verklaren en versterken deze toewijding?
	4	Wie zijn de belangrijkste actoren/partijen die bijdragen aan de ontwikkeling van kweekvlees?
Articulation of expectations	5	In hoeverre heerst er tussen deze actoren een gelijkgestemde visie op de rol die kweekvlees binnen 10 jaar zal krijgen in de maatschappij?
	6	Wat is jouw/uw verwachting van de rol die kweekvlees binnen 10 jaar zal krijgen in de maatschappij?
	7	Wat zijn factoren die deze verwachtingen (negatief) kunnen beïnvloeden?

Network Formation (and stability)	8	Wat beperkt, of mist in, de formatie van een samenwerkend industrieel kweekvlees netwerk?
	9	Welke factoren verklaren de beperkingen uit vraag 8, en maken daarmee het netwerk instabieler?
Learning processes	10	In welke staat van ontwikkeling bevindt de kennis over kweekvlees zich, wanneer er gekeken wordt naar de volgende leerdimensies:
	11	Waar is, relatief gezien, nog weinig kennis van?
	12	Welke factoren belemmeren het verkrijgen van kennis op deze gebieden?
Shielding/protection	13	In hoeverre is de Nederlandse kweekvlees industrie klaar voor de commerciële markt?
	14	Wat zijn de belangrijkste factoren die een commerciële marktintroductie belemmeren?
Snowballing	15	Zou u/je nog andere betrokkenen kunnen aandragen die mogelijk mee zouden willen doen aan dit onderzoek?
Documenten met info over barrieres	16	Kunt u documenten aandragen die dit onderzoek zouden kunnen aanvullen? > transitie barrieres

A.3 Quadruple Helix elements and interactions

Academic research

The helix of academic research involves all knowledge-based institutions and stakeholders that are affiliated to universities. Universities, are predominantly the core institutions of a knowledge-based society (Carayannis & Campbell, 2012). In this regard, their main responsibility involves generating and transferring knowledge through research and teaching. The different vehicles of knowledge it produces in this regard, enables knowledge spill-overs into other communities. An additional functionality of the university helix lies in its contribution to economic development. Applied science hereby increasingly requires strong ties with business and governments, to create an infrastructure for the transfer of knowledge. The formation of spin-off initiatives, academic laboratories, patents and other intellectual properties for example, could be seen as products of this cooperation (Etzkowitz & Leydesdorff, 2000). Hence this entrepreneurial behaviour of universities results in taking over some of the functions of the other helixes. As a result, the educated actors at universities, are also able to provide the knowledge necessary for innovations that contribute to economic development.

Business

The business helix involves different company and institutional stakeholders that can be accounted for wealth creation (Arnkil et al., 2010). This requires a high demand for knowledge from universities and, not to mention, a good entrepreneurial climate to provide opportunities for the development of innovations. Strategic alliances for this purpose, can be established with academic institutes or scale-up incubator projects. In addition to close cooperation with universities for new knowledge carriers or cooperative projects, the facilitating and financial resources of governments are also particularly important in the business helix. The provision of industry clusters and subsidies by governments may, for example, contribute business stakeholders in their growth. Furthermore, the demands from society are also crucial as they represent consumers and other target groups for innovations. These groups carry certain perceptions that business innovations potentially could address.

Government

The government consists of stakeholders that determine and implement policy and regulations. It has in that respect, an important role in the dynamics and policy regarding the interacting helixes. The facilitating functions of government stakeholders furthermore, contributes to cooperation and employment in between society, academic research and business. For example, the provision of infrastructures and spatial industry clusters, represented by all of the helixes, ensures a convergence of supply and demand for knowledge and innovations. In addition, interference through financial measures e.g. subsidies, could provide promising start-ups or research programs the resources necessary for development or scale-up possibilities. Nevertheless, the core of the Quadruple helix does not assume a particularly enhanced role of the government. As the following helix descriptions will prove, arrangements for alliances between different industry helixes namely also emerge due to other cross communications (Etzkowitz & Leydesdorff, 2000).

Society

The society or media-based and culture-based public, in a sense is considered as an overarching helix. It contextualizes and potentially declares typical movements of behaviour in the other helixes (Carayannis & Campbell, 2012). This is possibly due to the involvement of cultures, values, media and creative industries in societies. Cultures and values for instance, guide certain worldviews that possibly may influence national innovation systems. The media and the creative industries in turn, may

contribute by reflecting on current technologies or envision future development directions. Hence, art and communication can be assumed as important drivers for needs and perceptions that foster new innovations (Carayannis & Campbell, 2012). Potential members of the society helix in that respect, involves movements and NGO's that represent worldviews or defending certain rights. In addition, artists, journalists and consumer representatives may also be involved.

A.4 Thematic analysis approach

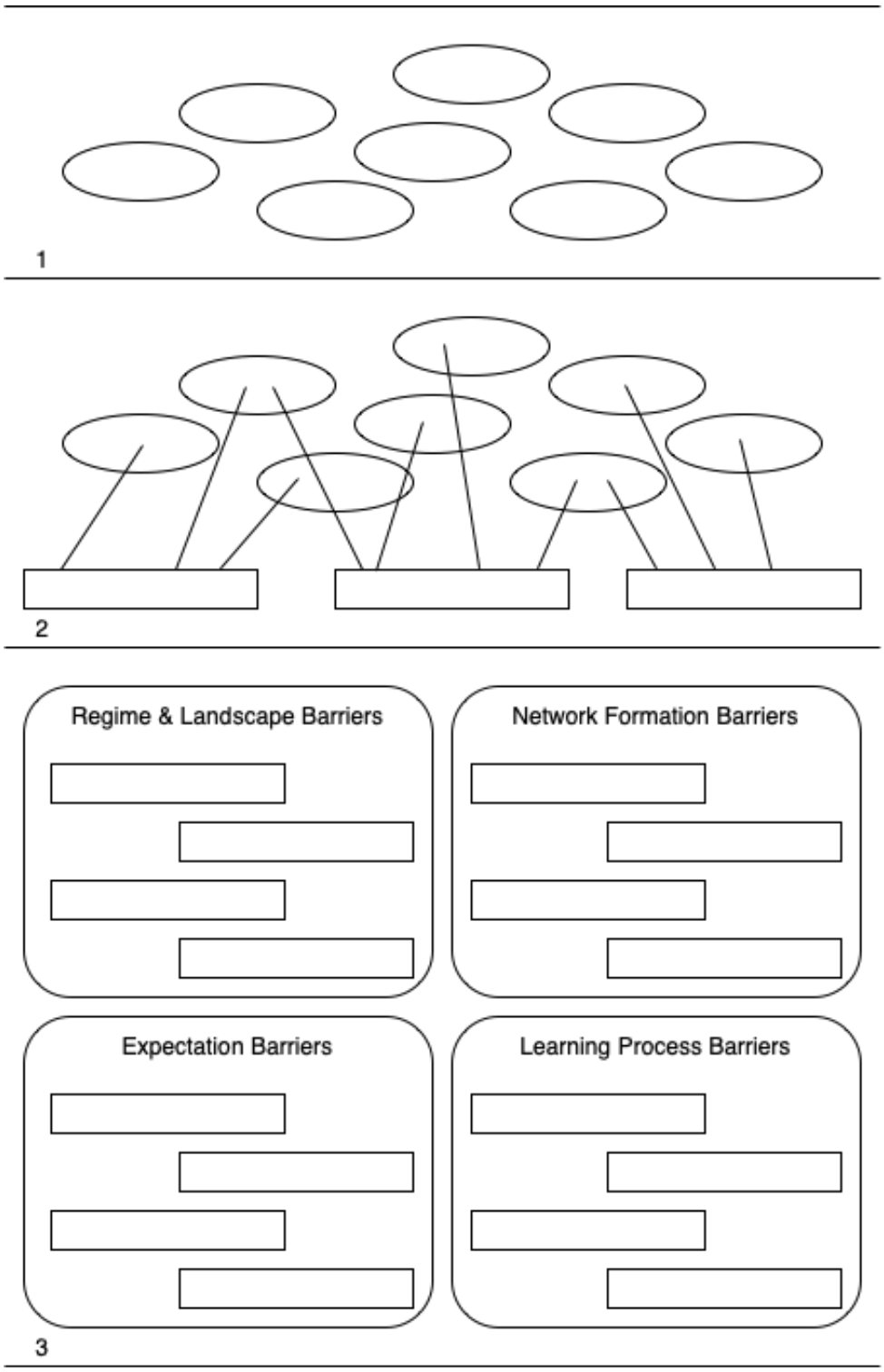

Figure 9. Thematic Analysis; from 1 codes; to 2 themes; to categories.