Faculteit Bedrijfseconomische Wetenschappen

master in de handelswetenschappen

Masterthesis

Developing a value chain from farm to fork for alternative proteins: lessons from the literature on innovation systems

Thomas Vanluchene

Scriptie ingediend tot het behalen van de graad van master in de handelswetenschappen, afstudeerrichting supply chain management

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Prof. dr. Stephan BRUNS

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Voorwoord

U leest nu het onderzoeksrapport "Does Flanders provide a favourable environment for the creation of a value chain related to lab-grown proteins?". Als student Handelswetenschappen, afstudeerrichting Supply Chain aan de Universiteit Hasselt te Diepenbeek, heb ik dit onderwerp gekozen in het kader van de OPO "Masterproef Supply Chain Management".

Ik koos ervoor om dit onderwerp te onderzoeken omdat het een zeer actueel onderwerp is dat mogelijk in de lift zit voor onze maatschappij en omdat mijn kennis over alternatieve eiwitten zeer beperkt was vóór het schrijven van deze thesis. Ik heb veel geleerd over een interessant maar complex onderzoeksonderwerp dat voor mij eigenlijk onbekend terrein was.

In dit onderzoeksrapport bespreek ik de theorie van systeeminnovatie, de belangen van een goede waardeketen en de actoren die een invloed hebben op het succes van deze waardeketen met betrekking tot alternatieve eiwitten in Vlaanderen. Uit het grote aanbod aan alternatieve eiwitten, heb ik gekozen om de transitie naar labo-gekweekte eiwitten in Vlaanderen te onderzoeken.

Ik dank Prof. dr. Stephan BRUNS, Mevr. Rosaly SEVERIJNS en mijn professoren aan de Universiteit Hasselt voor de vele informatie.

Ik wens u veel plezier bij het lezen!

Thomas Vanluchene

Samenvatting

Diverse bronnen zijn het erover eens dat het met de huidige toename van de wereldbevolking niet mogelijk is om iedereen op een verantwoorde manier van eiwitten te blijven voorzien. Niet alleen is de huidige vorm van eiwitconsumptie slecht voor het klimaat, maar ook dierenleed, schaarste aan grondstoffen en gezondheidsproblemen zijn verbonden aan de huidige eiwitconsumptie. Om deze factoren te verbeteren, ligt er een kans om over te stappen op alternatieve eiwitten. Wanneer in deze studie over dierlijke eiwitten wordt gesproken, worden vlees en melkproducten bedoeld. Een voorbeeld van alternatieve eiwitten die deze hedendaagse problemen zou kunnen verhelpen zijn labo-gekweekte eiwitten.

Om een overtuigende overstap naar alternatieve eiwitten te kunnen maken, moeten verschillende aspecten en actoren klaar zijn om de overstap te maken. Dit zijn de bedenkers, onderzoekers, ondernemers, leveranciers van grondstoffen, overheidsinstanties, logistieke dienstverleners, maar ook de consumenten die er belang bij hebben om van de waardeketen van alternatieve eiwitten een succes te maken.

Het doel van deze thesis is om antwoord te geven op de vraag of Vlaanderen al dan niet het potentieel heeft om een gunstige omgeving te vormen voor de creatie van een waardeketen met betrekking tot alternatieve eiwitten. Om hierop een antwoord te vinden wordt de theorie omtrent innovatiesystemen gebruikt en omschreven in de thesis. De volgende onderzoeksvraag werd geformuleerd: "Biedt Vlaanderen een gunstige omgeving voor de creatie van een waardeketen met betrekking tot alternatieve eiwitten?". Omwille van de grote variëteit aan alternatieve eiwitten die op de markt beschikbaar zijn, werd gekozen om te focussen op labo-gekweekte eiwitten.

Om de onderzoeksvraag te beantwoorden is een literatuurstudie uitgevoerd op basis van de theorie van systeeminnovatie. Het onderzoek is daarom opgedeeld in twee onderwerpen. In het eerste deel wordt het nut en de werking van systeeminnovatie besproken en in het tweede deel wordt de theorie toegepast op de praktijk om na te gaan of de waardeketen in Vlaanderen klaar is voor de transitie naar labo-gekweekte eiwitten. De verschillende actoren die in Vlaanderen actief zijn op dit vlak worden besproken, evenals de fases van de waardeketen waarin ze reeds aanwezig zijn. Uit onderzoek blijkt dat heel wat actoren reeds actief zijn in het opzetten van een waardeketen in Vlaanderen met betrekking tot alternatieve eiwitten zoals labo-gekweekt eiwit.

De conclusie van deze thesis is dat een groot deel van de actoren die nodig zijn voor de creatie van de waardeketen rond labo-gekweekte eiwitten aanwezig zijn in Vlaanderen. De producenten van labo-gekweekt vlees en zuivel, alsook onderzoeksteams en consumenten, zijn klaar om de overstap te maken. Innovatie wordt echter afgeremd omdat de nodige regelgeving nog niet klaar is voor de verkoop van labo-eiwit aan consumenten in supermarkten. Laboratorium-gekweekte eiwitten hebben de potentie om deel uit te maken van de eiwitindustrie, maar dit zal in de toekomst een vervolg moeten krijgen, omdat ze op dit moment vanwege de regelgeving niet wereldwijd kunnen worden verkocht. Het verdere verloop van deze thesis is neergeschreven in het Engels. Deze keuze is gemaakt omdat het grootste deel aan informatie omtrent labo-gekweekte eiwitten en de theorie van systeeminnovatie online terug te vinden is in het Engels.

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1 Introduction

The pursuit of a transition from animal to alternative proteins in human food stems from various social trends, such as the prevention of animal suffering, reduction of environmental impact and health considerations. A reduction in meat consumption and/or a switch to alternative proteins would therefore be an effective way of reducing these social problems. In recent years, different techniques to produce alternative proteins have evolved rapidly. Alternative proteins that have become more attractive in terms of meat structure, taste and texture are the results of this evolving technology. Some of these alternative products, based on soy and by-products from the starch industry (potato and wheat) are already produced on a large scale. In addition, growing protein sources such as insects, aquatic plants and lab-grown proteins offer the opportunity for the emergence of new, possibly global, industries (Alexy et al., 2017). It has become clear that the way we produce food today, especially meat, is not sustainable and cannot be sustained until 2030 (Benulic, 2016). Without adjustments to the current production model, increasing animal protein production worldwide is not sufficiently sustainable because of the major climate and environmental impacts and the high demands on increasingly scarce raw materials and land use. (Blonk Consultants, 2018; Vlaamse Overheid, 2021b)

The global awareness that the current way of consuming protein is not sustainable is making universities, companies and government organisations focus on alternative proteins that are more environmentally friendly and healthier. Alternative proteins, vegetables and lab-grown proteins are therefore a hot topic at the moment (Sexton et al., 2019). The production developments of these alternatives offer an opportunity to change the way meat products are produced. Countries worldwide that put systems in place to stimulate and make good use of these growing developments will benefit economically, healthwise and environmentally (Hooper & Hermione, 2021). By 2030, the world's population is expected to reach 8.5 billion (Nations, 2021). Feeding this population the way we know it today is unfeasible, so finding a way to adapt is important. However, in the last 10 years, a lot of progress has been made to decrease meat production.

In 2020, the European Commission released a 'Farm to Fork' strategy for a fair, healthy and environmentally friendly food system. The new plan sets out the desired goals and formulates the actions to be taken for more sustainable food production, consumption, processing and distribution (Mowlds, 2020; Schebesta & J.L. Candel, 2020). The objectives of the 'farm-to-fork' strategy are to mitigate and adapt to climate change by applying positive environmental effects, to ensure food security, to keep food affordable and at the same time to provide economic stability for commodity producers. The strategy also hopes to encourage fair trade (European Commission, 2020c). By 2020, the value of raw materials and consumer products based on plant proteins on the EU market rose to EUR 1 800 million and is expected to continue to rise. The Finnish Government has commissioned a report on sustainability. This study shows that the development of plant proteins and the growing demand for alternative proteins, such as lab-grown proteins, offer great growth opportunities for further research in Europe (European Commission, 2020b; Lampinen, 2020). Europe aims to bring together actors related to alternative proteins in raw material production, food processing, the production industry, and sales. As part of the Climate Food Programme, this objective is launched to support changes in society towards a more sustainable food system (European Commission, 2020a).

According to a recent OVAM study, an adapted diet can help with health and emission problems. This diet includes a halving of meat consumption, combined with an increase in the consumption of lab-grown meat. This scenario leads to a 6% reduction in global greenhouse gas emissions from food consumption. A protein transition that takes into account the type of animal and plant proteins consumed could lead to a greater reduction in the carbon footprint of food consumption (Wim Raes (OVAM) et al., 2020).

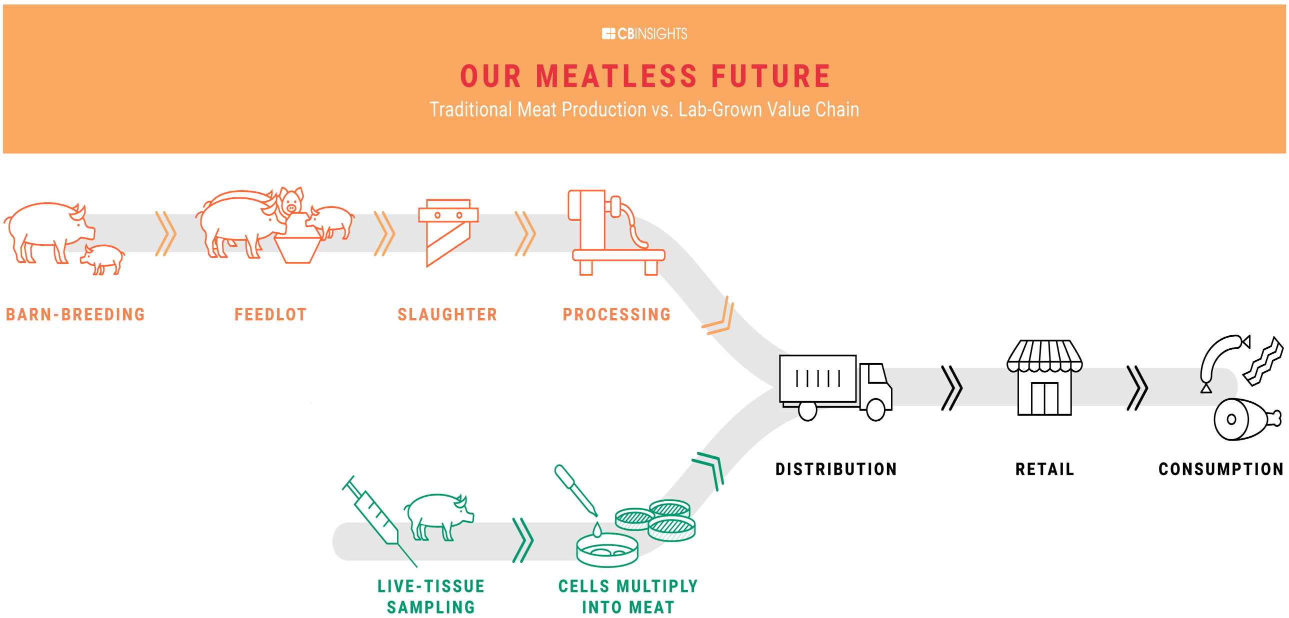

Figure 1. Our meatless future: value chain (CB Insights, 2018).

The value chain of the meatless future is much shorter than that of the meat industry we know today. The processing of alternative proteins is still complicated today, but this will change in the future. With further development and standardisation, the supply chain of alternative proteins, for example lab-grown meat, will be a lot simpler and shorter. This can also be seen in Figure 1. There are two fewer links needed before distribution must be considered. By integrating fewer steps in the value chain, it is easier to understand customer demand, respond quickly to changes and it is better for the environment. Digitalisation and changing customer preferences have shortened product life cycles and customers want products that better meet their personal preferences. Meeting these demands requires a short supply chain. Economic benefits for both the manufacturing company and the end-user can be achieved by eliminating certain links in the chain (CB Insights, 2018; Hagel et al., 2016). A shorter value chain can also have positive consequences for the environment. Shortening the value chain in connection with food will ensure that the welfare of the animals will be improved, organic food will be promoted, less food will be wasted, when developing proteins in a more sustainable way, one can immediately think of using eco-smart packaging and it is possible to create a shorter distance between production and consumption (Smith, 2008; Vitterso et al., 2020).

Companies operating in the field of plant proteins, for example soy, currently come closest with their value chain to the operational efficiency and production capacity needed to compete with companies specializing in traditional protein sources. Consequently, the current market of alternative proteins is mainly composed of soy processing companies with a global production of 336 million tons. Due to increasing demand for gluten-free, healthier and more sustainable food by consumers, major players and scientists are setting up production facilities to explore and scale up other areas such as insects and lab-grown protein production. Significantly more investments are being made in all facets of the value chain. The success of these up-and-coming alternatives will depend primarily on product quality, cost and consumer acceptance. The maturity of the value chain to market alternative proteins may also be a decisive factor in the success of the innovations. Alternative protein sources can be produced and built from scratch in such a way that they can close the loop in a circular economy. An aspect that traditional meat production cannot live up to today. The necessary investments, scalability, promotion and encouragement of partnerships within this innovative sector require collaboration between actors at different levels, from universities to companies and government authorities (Belderok, 2021; C.M.M. Lakemond, 2018; MVO, 2021).

Flanders has a tremendous opportunity to lead the way in transforming Europe’s food system by becoming a progressive role model for the future. A new revolution in food has the potential to create healthy food systems that sustain our planet and thereby our society. Existing innovations, knowledge and emerging technologies in Flanders offer opportunities to lead the industry (Margaret Bath, 2018).

The goal of the Flemish government is to accelerate the transition from current proteins to alternative proteins in the next ten years. Thanks to the growing demand for a substitute product for our meat, due to the recognition of the negative effects on the environment, health, etc., there is an economic opportunity for alternative proteins in Flanders (Van Diepen et al., 2018). The analysis by technopolis group and blonk consultants showed that the Flemish academic landscape is internationally competitive and of high quality in the field of protein transition (Blonk Consultants, 2018). This will be discussed later in the study.

There is also potential not only for production in the value chain for Flanders, but also for disease improvement through the introduction and scalable production of this lab-grown protein. At the end of 2021, bird flu was once again discovered in Flanders, which could have major consequences (BELGA, 2021). Because of this contagious disease, all poultry in the region must be kept indoors, where they are kept together in small spaces. The poultry farm where bird flu was discovered must destroy the eggs and poultry (staff, 2020). As a result, a lot of food for people can be lost. Disease problems do not only arise in poultry, but also in swine fever, and because so many animals are crammed together in dense stalls, diseases spread quickly and make many victims. There are vaccines that prevent the disease, but they are not used for economic reasons. Many countries do not accept meat from vaccinated animals because it is not possible to tell whether the animals were sick or had been vaccinated (staff, 2020). In some cases, it even results in human casualties. For example, there is the BSE disease that occurs in farmed cows. Several people have already died from eating contaminated cow meat (staff, 2020). If this type of protein were produced in a secure environment such as an automated laboratory process, these outbreaks of disease would no longer occur (Galusky, 2014; Pascual, 2019).

A study presented during the Inspiration Day: The protein shift, organised by Flanders' FOOD in Bruges (Blonk Consultants, 2018), sketches an objective picture of the Flemish status regarding protein transition. The study showed that there are various opportunities for Flemish businesses in this field. It is also recommended that the chain of cultivation and processing of protein ingredients (science, breeders, growers, processors) be better organised. By improving the security of supply and sales, growers and processors can better respond to the opportunities of a growing market.

Vision 2050, the long-term vision for Flanders, formulates an ambition for a future-proof and sustainable agro-food chain. To achieve this, the food system as we know it today must look for integrated solutions, innovative value chains and system innovations. The Flemish government has set itself the goal of developing a strong and integrated Flemish food policy. On World Food Day 2020, Minister Crevits called on everyone to collaborate on a Flemish food strategy. This will be based on four strategic objectives:

1. Going for a resilient food economy

2. Food connects farmers and citizens

3. Circular and sustainable business for the future

4. Healthy and sustainable food for all

The elaboration of a protein strategy from field to plate is one of the cross-policy areas of the food strategy (Flanders, 2016).

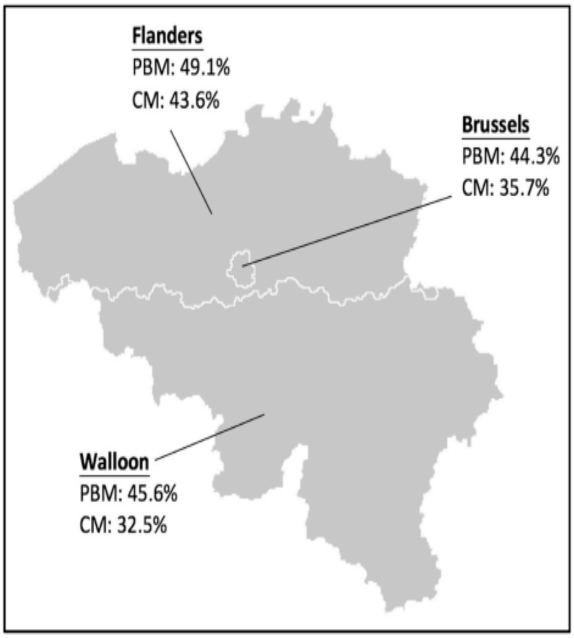

Figure 2. Acceptance of plant-based and cultured meat in different regions of Belgium (Bryant & Sanctorum, 2021).

As described earlier in this thesis, Europe and the entire world are working on the transition, acceptance and production of alternative proteins, Flanders is also investing heavily in these new technologies. Figure 2, a map of Belgium from a study of 2021, shows that Flanders accepts plant-based and lab-grown meat more than Brussels and Wallonia. (Bryant & Sanctorum, 2021).

After crop farming, cattle breeding is the largest industry in the agricultural sector in Flanders. Due to urbanisation and shortage of land, more and more farmers will stop their activities. However, the world's population is growing, so alternative proteins will have to be used to provide all these people with the necessary nutrition. In 2018, the average Flemish person ate 58.4 kg of meat, a drop of 8.32% compared with 2010. 33% of Flemish families do not eat fish or meat at least once a week or eat an alternative source of protein (Belgium, 2019). The reason for the decrease in meat consumption and the increase in alternative products is taste, environment, increasing price of meat, animal welfare and own health (Bryant & Sanctorum, 2021; Vander Putten, 2020).

Because of the combination of these Flemish investments and the acceptance of the new product by Flemish people, the thesis is limited to the value chain of alternative proteins in Flanders, as this combination offers an excellent opportunity for Flemish companies that want to specialise in lab-grown proteins

During the study by Bryant and Sanctorum (2021), participants were questioned about the reasons why they would or would not consider cultured meat in a varied diet. The main reasons they would consider it were social benefits such as animal suffering, environment and world hunger. Personal obstacles such as price, lack of knowledge, unprecedented health consequences and distrust are the biggest challenges that the respondents would have to face. In particular, trust was low in multinationals that would produce alternative proteins with the sole motive of profit. The reason that multinationals would produce cultured meat for profit was one of the biggest factors in rejecting this new technology (Driessen & Korthals, 2012). So, in addition to the related issue of trust, health and price, the concern was whether this might not all be a commercial stunt (Bryant & Sanctorum, 2021; Hocquette, 2016). Innovative ideas such as lab-grown protein have higher (at least different) barriers to acceptance than, say, a new electronic device coming to market, because it involves food and can end up in the daily life of any consumer. Food behaviour is very habitual and it is not easy to change eating habits (Van Der Weele & Driessen, 2013). This is an issue that developers of these food technologies must take seriously if they want to convince consumers.

The thesis sketches an objective and neutral picture of the potential for Flanders regarding the protein transition, with a focus on lab-grown protein.

The aim of the thesis is to provide an answer to the research question: "Does Flanders provide a favourable environment for the creation of a value chain related to lab-grown proteins?". Because there are several alternative proteins, the focus is on a limited sector, being lab-grown protein. It is now possible to grow protein in a laboratory, entirely outside the body of an animal. This is known as lab-grown protein, or cultured protein. The main difference between plant-based protein and lab-grown protein is: plant-based protein is made from plants and should taste like meat, lab-grown protein is animal-based and tastes like the animal products without the environmental impact. The research will investigate whether there are already producers established in Flanders, how government bodies influence the success of the concept, specialised logistics service providers, how far the process has already evolved and is known in Flanders, scientific institutes and how consumers perceive lab-grown protein. This research will be based on the theory of systems innovation, which will be discussed later.

Since the thesis will focus on lab-grown protein, it is necessary to briefly outline what lab-grown protein exactly entails and what the current trends and evolutions are worldwide before focusing on lab-grown protein in Flanders. A much discussed form of lab-grown protein is cultivated meat. A synonym for cultivated meat is cultured meat. Compared to meat made from soybeans, lab-grown meat is real meat with the same structure and cells as those of a cow, pig or chicken. The meat is made by cultivating animal cells directly from the animal. In this way, no animals need to be slaughtered for consumption (Choudhury et al., 2020). The production process to produce cultivated meat is highly technical and scientific. This thesis does not intend to know every scientific process, but a basis is useful for the further course of this research. Muscle tissue is harvested from a living animal in a harmless manner. From the muscle tissue, the muscle fibres and cells (muscle cells and fat cells) are separated. The muscle cells begin to separate and from one muscle cell more than a trillion cells can be grown. These trillion cells naturally fuse together to form a myotube. The myotubes are then brought together to form a whole and begin to grow into one muscle tissue. From one muscle tissue, taken from a living animal, several muscle tissues can thus be grown in a laboratory. When all these muscles are brought together, it is possible to produce exactly the same meat structure as in a living animal (Kadim et al., 2015).

Dutch scientist Mark Post unveiled the first lab-grown hamburger in 2013. It was made from more than 20,000 thin strands of muscle tissue, cost more than $300,000 and took two years to produce. Two years later, the first four cultured meat companies were founded ("De missie van Mark Post," 2021). The first was the Dutch company MOSA Meat, followed by Memphis Meats in California, Aleph Farms in Israel and BlueNalu in San Diego. Since then, the sector has grown to include more than 60 companies on 6 continents each focusing on the production of cultured protein products. Dozens more companies have formed to create technological solutions for the entire value chain (Dent, 2020).

Lab-grown protein is not just meat, lab-grown dairy also belongs to this sector. This product is already more advanced and commercially used worldwide than lab-grown meat. For example, ice cream and cheese produced from milk in which no cow is involved in the production process are already being sold worldwide. There are various options and raw materials available for making lab-grown dairy. Again, the process is highly scientific and technical. The bottom line is that it is possible to recreate the effect that occurs in the stomach of a cow, which converts grass into milk, in a laboratory (Rachel, 2021). The big goal of lab-grown protein is to no longer need to use animals for delicious food and drinks. Society is aware that there is an ecological and also an increasingly ethical problem surrounding the slaughter of animals or the mass breeding of animals to provide food for mankind, but consumers simply like the meat and dairy products we know today and if lab-grown protein products can create the same taste and texture without the involvement of animals, then the innovators are convinced that it can be a success (Rabb, 2021).

Worldwide, there are only a few major players in the field of cultured meat. These companies are located in America, Israel, Singapore, Turkey, Hong Kong, Spain and the Netherlands. However, in 2019, there was a start-up in Belgium that started to make a name for itself in the industry in the field of lab-grown meat. Through a collaboration of three Belgian companies (Peace of Meat, Solina and Nauta pate) and three non-profit organisations (KU Leuven University, Flanders Food and Bio Base Europe Pilot Plant), the Foieture project was launched in Belgium in 2019 to develop lab-grown foie gras. Peace of Meat a Belgian company already active in the lab-grown meat sector at the time declared in December that same year that it was ready to make proof of concept public in 2020. The young start-up’s next plan was to have the first prototype of cultured meat ready in 2022 and to sell their meat on the market in 2023. Thanks to Peace of Meat's potential and the Foieture project, the company received a research grant of EUR 3.6 million. Eva Sommer, the founder of Peace of Meat stated in 2020 that the young company was ready to produce 1kg of meat at a cost of €15 000. It would be impossible to sell the meat on the market at this price, but a production budget had been drawn up and, from that cost price, development, investment and automation of the process meant that Peace of Meat could estimate that it would be able to produce cultured meat at €6/kg by 2023. Two laboratories are going to be built in the port of Antwerp to make these developments a reality. In late 2020, MeaTech, an Israeli company acquired Peace of Meat for 15 million euros and announced in May 2021 that it would build a new large-scale pilot plant in Antwerp by 2022 (De Cleene, 2019). So in 2021, there are already participations and takeovers by cultured meat companies (Detail, 2021; Kroese, 2019). There is a good basis and determination to bring the value chain of alternative proteins in Flanders to a successful result and certainly in the sector of lab-grown protein. For that reason, this thesis will focus on lab-grown proteins when we talk about alternative proteins. It is possible that from time-to-time references are made to other alternative proteins to give an example or to clarify a point of view.

As you will read further in this study, lab-grown meat faces a serious delay due to regulations. Developments are on the verge of producing on a global scale, but the legislation is not ready to approve this. Only Singapore has already given permission for commercially cultivated meat to be sold in supermarkets.

As mentioned earlier, this thesis focuses on whether Flanders has a positive environment for the creation of a value chain related to lab-grown protein. To research the topic of this thesis and conclude, the theory of innovation systems is used. The theory of innovation systems will be used because lab-grown proteins can be seen as an innovation. The following explains why system innovations can be used for this research and what the concept entails.

Figure 3. Explanation about innovation systems (Innovation, 2018).

System innovation is about using systems thinking to facilitate transformative change within complex frameworks. Figure 3 is a simple representation of this principle. The creation of innovation is about something new and something of value such as alternative proteins in the Flemish region. It is also about its adoption and implementation in society. According to Stephen Shapiro, innovation is about staying relevant (Shapiro, 2002). It is about knowing how the world is changing and adapting to the needs. An innovation system is not about a change in scale, but it is a change in quality. This thesis is not about the change of alternative proteins, but it is about the possible resources that Flanders does or does not have at its disposal to create a favourable environment for the establishment of a value chain related to lab-grown protein. Systems thinking emerges from innovations where organisations work in connections and looks at the system as patterns arising from those partnerships. It focuses on the basic structure of an innovation or industry (Lundvall, 2008). An innovation system is influenced by various actors and institutions within an economy that are directly or indirectly involved in the development, distribution and application of scientific and technological knowledge; these may include universities and developing industry. But also the organisations responsible for coordinating and supporting these processes belong to the network of an innovation system. Since this thesis investigates possible opportunities for the Flemish industry concerning an alternative protein, a market that is at the beginning of its life cycle, it is very appropriate to make use of the innovation system (Dantas, 2008). Later, it will become clear that the producers of lab-grown protein do not want to change the end product as we know it today, they want to change the process by which it is made in order to produce more sustainably. The desire to change the process rather than the end product is in line with the theory of innovation systems that will be explained later. The animal protein will still be the same for the end consumer. The fibres, fat cells and muscle tissues are still animal, they just don't need to die for it. System innovations involve innovative processes that do not only look at an individual company but are implemented together with other chain and network parties. System innovations cannot be brought to a successful conclusion by a single person or organisation. The innovations intervene at the level of the entire chain: from the supply of raw materials up to and including end-use and all related research and experiments. Universities, business organisations, researchers and government agencies work together to make the innovation scalable in the right way. Mapping the differences and similarities between innovation processes within a single company versus chains and networks is an important process. Insight into success and failure factors is crucial for successful system innovations within the food sector (Omta & Visscher, 2003).

To innovate in a common system, it is necessary to understand not only the current form of a system but also all the surrounding factors that may influence the system. It is only with insight that it is possible to know what exists and what might exist. With system innovation, it is not the goal to create something new. All complex systems are a product of a long evolution process. It is only possible to work with this evolution within the system and not to build something from scratch (Niosi, 2011).

Many innovation system approaches have been developed in the last twenty years. Although the core-bases of the different innovation systems are similar, each approach emphasises a different aspect to better suit a particular type of innovation. Innovation systems have been categorised into national innovation systems, regional innovation systems, local innovation systems, technological innovation systems and sectoral innovation systems (Moody, 2016). The technological innovation systems theory is widely used to study the emergence and growth of new technological fields and industries, as in this example, the research whether Flanders has a positive environment for creating a value chain related to alternative proteins, because of the new technologies and uncertainties about the industry. The innovation system theory has the potential to address the development and performance of a technological innovation better than if this type of innovation system were not used. The theory also ensures that no relevant processes are overlooked during the innovation. These frameworks increase the success of an innovation (Markard et al., 2015).

When we take development action, it is important to analyse the value chain of a particular product and first identify the priority problems in the value chain. Then we try to map an innovation system for the specific problem being addressed. By mapping the innovation systems of a particular problem, it is possible to intervene in a more effective way than intervening in something we do not know anything about.

Technological innovation systems have received extra attention in recent years for the study of emerging technologies and especially when it comes to sustainability transitions, simply because these systems are so well aligned with this topic. This approach aims to understand the dynamics of an innovation system built around a specific technology. This approach is interesting for identifying the progress of an innovation system, assessing it and providing recommendations for designing the system to support that innovation. This is why this approach fits so well with the research of this thesis (Markard et al., 2015).

The thesis is divided into three major parts. To start with, the literature study will discuss the theory of innovation systems, followed by a general explanation of a value chain, the three pillars that are important when integrating an innovation, the cycle that a new product goes through before it is launched on the market and the important actors that are active in the field of lab-grown meat. To conclude, the theory is applied to Flanders to answer the research question: "Does Flanders provide a favourable environment for the creation of a value chain related to lab-grown proteins?

2 Methodology

In this part of the thesis, methods of research and the defence of the choice of certain methods will be explained.

In order to come to a conclusion on the research question: "Does Flanders provide a favourable environment for the creation of a value chain related to lab-grown proteins?", this thesis is divided into three main sub-studies.

The literature review will first discuss the theory of innovation systems and how it can be applied to an innovation created in reality. The second part will discuss which factors of the innovation lab-grown protein are already present in Flanders, which aspects are under development and what will be needed in the future for the development of a favourable environment for the creation of a value chain concerning lab-grown protein in Flanders.

The research of this thesis was carried out on the basis of a literature study. No quantitative data was collected through interviews or questionnaires. The results are expressed in words. The data was collected using desk research and literature review. To gain insight into the theory of innovation systems, papers were collected via Google Scholar describing the basic features and citing examples of how this form of research can represent reality. Newspaper articles were also consulted in which the current situation regarding lab-grown protein is explained in more detail. Furthermore, the reports of the Flemish government were looked into in order to collect figures on current projects related to lab-grown protein.

The reason to conduct this research based on the theory of innovation systems is that the characteristics of the theory are closely related to the recent innovation that is lab-grown proteins. Innovation systems see innovation in a more systemic, interactive and evolutionary way. New products and production processes are put into economic and social use through the intervention of different actors as described earlier in the introduction. Since various actors are involved in the success of lab-grown protein innovation, the theoretical steps and philosophies that apply to innovation systems are reflected in reality when discussing the transition to alternative proteins, systems innovations was chosen as the data analysis method for this research.

3 Literature review

The literature review is divided into three major parts. The first part describes the theory of innovation systems. This is important to understand why the choice was made to use this theory to discuss lab-grown proteins in Flanders. This is followed by a more detailed description of what is important when studying the value chain. Here, the value chain is described in general, as well as three pillars that an innovation must comply with in order to be successful. Finally, the focus is on the value chain in Flanders. The different actors that are active are discussed, as well as the phase they are in. To conclude, the opportunities and risks of lab-grown proteins for Flanders are discussed.

3.1 Innovation system

3.1.1 What is the theory on system innovations?

System innovation refers to actors that combine technological, social, institutional, legislative and other forms of innovation to address major societal problems that are systemic in nature (Wanzenböck & Frenken, 2020). These include, for example, mobility problems, climate issue, health and demographic problems or the need for a more sustainable protein source. It is also closely linked to the so-called 'transition policy', which refers to the stimulation, across policy domains and policy levels, of major transitions that would have to take place in order for societal need systems such as the mobility system, production system or health system to make a transition towards greater sustainability. By focusing innovation policy on solutions to major social problems, economic and social added value go hand in hand. After all, the major social challenges are also the very markets of the future to which companies can respond (Vlaamse Overheid, 2017).

Systems theory is often referred to as an "alternative paradigm", so before we can discuss it further, we need to understand what a paradigm is. A paradigm is a model, perspective, or set of ideas that form a worldview underlying the theories and methodology of a particular field (Biggs & Daniela, 2009). A current paradigm is something we are used to at the moment, the way of life as we know it. Paradigm shifts can occur when innovation is implemented and considered the new normal. When a paradigm is changed, the way of thinking about something is changed. An example to outline a paradigm: before the advent of streaming services like Netflix, it was natural for everyone to go to physical shops like Blockbusters and rent or buy a film. Because of a paradigm shift to streaming services, it is unthinkable in 2022 to go to a physical shop and rent or buy a film. Once a new paradigm is established, systems based on a paradigm of the past have no choice but to change strategy. If they do not evolve along with it or adapt their strategy, the systems will hardly, if at all, survive (Horckmans, 2018; Kenton, 2021).

How do system innovations arise? Different types of literature offer interesting ideas, but do not lead to one common conclusion. There are, however, a few things that different sources on innovation systems agree on.

1. The first step of a system innovation is to understand the need for change. Understanding that the current system needs to undergo a certain change. In the case of alternative proteins, for example, the ecological footprint and the increasing world population are important aspects for change (Fraser, 2020).

2. Looking at the current processes as an opportunity or partner rather than as a major competitor increases the likelihood of the innovation's success. Both the new and the current process can benefit from each other's knowledge (Elzen et al., 2004; Gallagher et al., 2012; Godin, 2009).

3. System innovations arise from the cooperation of different initiatives and actors (Elzen et al., 2004; Gallagher et al., 2012; Godin, 2009).

4. System innovations do not only relate to technology, but also to changes in broader dimensions such as regulation, infrastructure, social acceptance and industrial networks (Elzen et al., 2004; Gallagher et al., 2012; Godin, 2009).

The explanation for the development of innovation systems is based on the fact that developments gradually, through innovation, knowledge and growth come together with a problem experienced in society. The success of innovation systems lies in the transition of the innovation and the current system as if the two were merging. The different dimensions provide a structured process approach. However, this approach must be complemented by actors who influence the process. These actors influence the innovation system from the start of the process and work together to produce a final product. This type of approach focuses on how these actors try to add value to transitions, how they create a certain vision and continuously improve it by looking for solutions and learning from their experiences (Elzen et al., 2004; Gallagher et al., 2012; Godin, 2009).

This systems innovation approach does not “solve” problems; it more "dissolves" them. We move from reacting to try and fix problems, to an approach that is about unleashing the systems potential to transform itself into a different state that results in new behaviour and functionality. Technological innovation systems are about innovation in complex systems. Such a system is often a system consisting of different parts, in which different actors take part. All large-scale systems that occur in our economy are adaptive systems; political systems, energy systems, food systems, health systems, etc. When we talk about system innovation, it is in these large-scale complex levels that we are interested. Viewing the world in terms of connections, patterns and how these patterns produce a particular behaviour is called systems thinking. System innovation is a different way of approaching systems because it is innovation in connections and organisations (B. Bonvillian, 2000).

When studying the theory of innovation systems, different words emerge, such as national innovation systems, regional innovation systems, sectoral innovation systems and technological innovation systems. System innovations can be divided into different categories, but the basic principles of the system are always the same.

3.1.2 How are technological innovation systems used?

The whole framework of technological innovation systems is pretty well used in the sustainability systems community and most people who analyse innovation systems are talking about emerging technologies (Altenburg & Pegels, 2012; Urmetzer & Pyka, 2019). It is a way of conducting research that fits well in the whole community of sustainability transitions. The current state of unsustainable ways of doing things in this world is known and everyone agrees that changes need to happen in the socio-technical regimes. Our practices regarding energy, waste, and food simply have to be done in a much more sustainable way and everyone agrees on that (Aiking & de Boer, 2004). Innovation systems does not conceptualise this regime change as such. But it focuses on the way new technologies, new practices and new products emerge and consequently shift socio-technical regimes. The way innovation systems are supposed to work is to replace the current state of how we do things that are not sustainable. These innovations, which are supposed to replace current practices, must go through various stages of a learning curve to the point where they can be incorporated into the regime and thereby change the state of the regime. When an innovation is created, it is assumed to increase in importance over time during the learning curve of the system. As described earlier, the innovation system is not only a technical innovation, but more a socio-technical innovation state. Innovations require many things that determine the success. No single actor is able to innovate successfully on his own. There must be cooperation between different actors for the innovation to succeed. The right conditions must be created by a group of agents who are given the opportunity to participate in the innovation. An innovation system is basically those collectives of actors and institutions that collectively determine the direction and speed of innovation. Actors as mentioned in the text are scientists, industries and universities that research a new system and institutions are those that make the norms and eventual legislation on the systems (Hekkert & Negro, 2009).

When such an innovation system and framework is available, innovation will be much easier. It will take much less time and money, but also the risks will be lower to implement an innovation if all actors and institutions are in place (Mazzucato, 2018). If you want to implement radical inventions that are also innovations, then the innovation system is not there yet. Innovation systems are really for innovations that are already at a certain stage of acceptance and understanding by society, industry and institutions. If you can use an innovation system, then there are a lot of assets that you can take advantage of instead of if you could not use the system. There is already skilled labour, well-functioning education systems, legitimacy, markets, knowledge, etc (Spigel & Harrison, 2018). To move from a radical invention to a useful innovation system, the pioneer has to go through some steps that are not easy. The very first one has to carry out the experiments and often pay for them himself. It has to provide the upscaling itself without any other actor supporting it. For example, if you want to build an electric car now, you have the advantage that Elon Musk was the pioneer with Tesla, and as a new builder you can now enjoy the fact that, because of Tesla's success, electric cars are accepted and people believe in the transition from fossil fuel to electricity. If you are the first of a radical invention, this is not possible. As a pioneer, you must also provide your own knowledge and you can not make use of someone else’s knowledge. You are the leader of this new research. This can be positive, but it can also be fatal. You have to shape your own market and prepare the market for what is to come. And an important aspect, a pioneer must create legitimacy and that is not easy. These are a few steps that a radical innovation has to go through before it can make use of the innovation system as a complete plan. Someone who wants to improve or participate in an existing innovation can use all the hard work that has already happened. He just has to use and work out the innovation system in a good way (Bergek, Jacobsson, et al., 2008; Hekkert et al., 2007).

There is the direct influence of all the actors that contribute to the innovation system. These actors are also facilitated by other system functions and those are the engines. It is not only the actors that contribute to the innovation system that influence the success of lab-grown protein. Matters beyond the control of producers can also play an important role in the success of their project. Other innovation systems that are happening at the moment can also influence each other. Sometimes in competition, sometimes complementary with each other. This all affects the innovation system and it determines on the innovation system is well fulfilled (Suurs, 2009).

3.1.3 How can the theory be applied to the research question?

The transversal policy that the Flemish Government has set in motion with its "Vision 2050 - A long-term strategy for Flanders" (Flanders, 2016) is based on system innovation and transition thinking. The Flemish Government has developed a long-term vision for a whole series of major social systems or domains such as food, housing, mobility, knowledge, materials, etc. Within all these domains, Flanders is currently facing major challenges and system innovation is indeed necessary. The EWI (Economy, Science and Innovation) policy domain has an important role to play in this. Within the various priorities, it will be important to make maximum use of the possibilities offered by technological developments and to see opportunities for the companies in Flanders in terms of realising solutions to the challenges we are facing.

These solutions often constitute markets of the future and can even be valorised internationally. Moreover, these economic-technological innovation opportunities must be combined with other forms of innovation such as institutional change, legislative innovation, social innovation, etc. That is why transversality or cooperation with different policy areas is so essential (Vlaamse Overheid, 2016, 2017).

The market for alternative proteins and in particular lab-grown proteins is currently in the early stages of its potential. In the next part of this thesis, it will become clear that in order for this new innovation to be successful, actors such as universities, researchers, companies and government institutions need to work together.

3.1.4 Where do problems arise when working with innovation systems?

An innovation benefits society, industry and governments alike. However, there are some factors that are not always as obvious or as brilliant when it comes to innovation. If a certain process is already being used without any real form of problems, as in this case the protein sector, where there are no too visible current problems, companies are often tempted to leave it as it is. Innovation doesn't have to happen right away, and so companies don't always think it needs to happen instantly. This is certainly the case when several companies have to implement changes together, in which case resistance can arise. Employees have to get used to new systems, government regulations often have to be implemented, the market has to accept the innovations and so on. These types of issues sometimes prevent innovation (Ruud, 2019).

A problematic systems fulfilment may occur. This means that some functions are not fulfilled in an optimal way and it holds back the speed of innovation. The causes of this happening can be found mainly in the basis and structure of the innovation system. Earlier it was discussed that processes have to be met to move from the stage of radical innovation to an innovation system, but if you go one step deeper and look at it, it is always the structure, the basis of the system that is going to hinder the functions of the system. So if you really want to know the causes, you have to go one layer deeper than the processes and focus on the actors, institutions and industries. If you want to intervene in an innovation system, it is best to also focus on these basic structures, rather than going straight for the processes (Negro & Hekkert, 2008; Suurs, 2009).

3.2 The value chain, three pillars and product life cycle

In the second part of the literature review, the value chain in general will be discussed, as well as the three pillars that are important and that the transition to lab-grown proteins must take into account, and the product life cycle will be discussed. These three theories are necessary to understand the further course of the thesis and conclusions.

3.2.1 What are the necessary characteristics for a value chain to succeed?

A set of cooperating players, who work together to satisfy the market demand for specific products or services, is called a value chain. The aim of a value chain is to increase the value of a product or service. The design, production and marketing of goods and services form a flow of activities necessary to create a value stream. A value chain can be executed by one company or by several companies together. As discussed earlier, we will examine the value chain of alternative proteins for Flanders using the theory of innovation systems. Since an innovation system works best when several actors are involved in the process, the focus will be on a value chain managed by a network of actors to create that favourable value chain. For example, a value chain may consist of sector-specific providers, financial providers, research institutes, producers, distributors, government agencies, etc., all working towards the same goal. They form a chain with the goal of satisfying the end consumer's demand (Kaplinsky & Morris, 2001).

To evaluate the value chain of lab-grown protein, the theory called Porter's value chain will be used (Simatupang et al., 2017). Porter's value chain focuses on systems to convert inputs into outputs. Porter has described a number of activities that are common to all businesses. These activities are divided into two types. Primary activities and support activities. This model allows strengths and weaknesses to be identified. Supporting activities are those that support the primary activities. There are different types of support activities, but each individual support activity supports all primary activities.

- The firm infrastructure: The first support activity is the one that covers the entire value chain of an enterprise. It is the overall infrastructure of the enterprise and in the case of this research it is the overall infrastructure of the industry (Horvath, 2001).

- Human resources management: It is important that in order to create an innovation, the right people with the necessary knowledge are involved in the entire process (Lengnick-Hall et al., 2013).

- Procurement: Although these alternative proteins are produced in an animal-friendly way, there is still a need for raw materials, goods and services. Procurement is the activity involved in obtaining these materials and services the company needs to support daily operations (Jenkins, 2021). It will become clear later that the lab-grown protein sector cannot focus on knowledge, materials, etc. only in Flanders. Procurement ensures that partnerships can be formed worldwide.

These activities, carried out at the start of the innovation, will ensure that the primary activities can be carried out successfully. The primary activities are:

- Inbound logistics: refers to the processes related to receiving, storing and distributing inputs sourced by procurement (Pathak & Pathak, 2010).

- Operations: Production are the activities that convert inputs into outputs and contribute to the greatest value added. This is where the final product comes into being (Pathak & Pathak, 2010).

- Outbound logistics: The finished product is packaged, prepared for sale and, if necessary, shipped to a final destination (Svensson, 2002).

- Marketing & sales: These are the processes used to persuade customers to buy lab-grown protein rather than alternatives such as current proteins (Kaplinsky & Morris, 2001).

The remainder of this thesis will discuss which of these activities are already present in the value chain of lab-grown protein and what their contributions are (Feller et al., 2006; Kaplinsky & Morris, 2001; Walsh, 2011).

3.2.2 Three pillars

A favourable environment for the creation of a value chain consists of three major pillars (economic, social and environmental sustainability) that must be met in order to future-proof the product, service or all actors connected to the value chain (Dhahri & Omri, 2018).

The value chain must be economically sustainable. It must be profitable during all activities in the value chain. Economic sustainability can be broken down in to two categories. The first category are individuals, this means that there are adequative family incomes to afford necessities. It means that people are able to afford the necessary things such as food and water every week and not have to search for money to buy these basics. If cultured proteins remain as expensive as they are now, it will be impossible for the average Flemish family to include these alternative proteins in their daily diet. The target audience for cultured proteins will be too small for the company to survive economically. The second category contains countries and organisations. This means that governments must be given sufficient resources to support their citizens. Different flows are needed for a country to be economically stable. Innovation and diversity of industries is very important to contribute to this. Economic stability ensures that countries are able to innovate and invest in new developments such as lab-grown proteins. Relying on one particular industry can be detrimental to a country in times of trouble and therefore it is important for a country to have a diversity of industries. Alternative proteins such as lab-grown protein is an innovation that can help diversify the protein sector in Flanders. Another factor relating to economic sustainability is employment. People are contributing by paying taxes and that results in increased money to the government. And it reduces poverty that will result in less people that rely on social security. If people are not in poverty, they are spending money. This will help economic growth. Lab-grown protein could be a completely new sector in Flanders that could potentially create jobs in various fields Economic growth is another import factor. For a country to grow economically it is necessary to have economic growth. This sustained growth can be measured by GNI and is needed to counteract inflation. The last consideration is trade. Global trade increases economic growth, because countries can sell products that they produce and buy stuff from other countries to again produce more. The trade industry in a country provides employment. Their needs to be a focus on fair trade which means that all people throughout the value chain are paid properly for what they do. Every actor in the value chain has to be paid so that they can make a reasonable profit (D'heur, 2015; Ouhimmou et al., 2021; Soosay et al., 2012).

It must be socially sustainable. This means that a society must be created that can provide for the needs of all its citizens and that this system must be able to be maintained in the future.As with economic sustainability, there are some considerations for social sustainability. It is important that poverty can be reduced and that there is provision for a social protection system in periods of financial crisis. This will ensure that economic growth benefits everyone and that social security can be provided when needed.

Second there is gender equality. This is important to ensure sustainability in the future. There has to be equality in education and employment. It will improve productivity and it contributes to economic sustainability. Another consideration is access to safe and decent working conditions. Therefore, there need to be laws and regulations to ensure safe conditions. To create a favourable environment for a value chain, forced and child labour must be eliminated. This is not a big problem in Flanders, but it remains a huge problem in other areas around the world (Unicef, 2022). Since lab-grown protein has to be produced in highly controlled environments and the tasks that have to be performed within this production expect a certain level of knowledge, the chance of child labour is very small in the beginning. Promotion of political and legal rights is another important consideration. This will ensure equal social opportunities for everyone, so again this is linked with equality. By having these opportunities there will be equal participation in education and employment and it will protect vulnerable groups in society. The last consideration regarding social sustainability is peace and security. Being in a state of peace and security maintains peoples health and wellbeing. It increases productivity, trade and economic growth. It will decrease the economic cost of war and environmental cost of war which has a huge negative impact on the budget of a country (D'heur, 2015; Ouhimmou et al., 2021; Soosay et al., 2012).

Finally, the innovation must make a positive contribution to the environment. It is about making sure that nature is used in such a way that the raw materials will still be there in the future and will not disappear. An innovation must contribute to this and not cause more damage than there is at present. The rising world population and rising wealth in China have increased the demand for protein in the form of meat. It is being consumed at a rapid pace and production will not be able to keep up. Lab-grown protein can provide an answer to this. Once production has reached full capacity, it should be possible to supply the world population with sufficient alternative proteins at an affordable price (Whiting, 2020). Consumers are becoming much more aware of sustainability and this is driving consumer behaviour. Consumers want products that are produced and delivered in a safe, ethical and responsible manner. They are putting pressure on retailers and retailers are trying to show that they are contributing to a more sustainable environment. Not only for their own private labels, but also for the brands they work with. This puts a lot of pressure on suppliers further down the value chain. The actors within a value chain feel the pressure to form a circular economy due to the increasing interest in a positive environment. Throughout the entire value chain, it is important not to fall into conflict with environmental sustainability. In relation to the third pillar, there are some considerations to keep in mind. The first one is biodiversity, which in essence mean protection of living things and their ecosystems. This is vital for oxygen, water, food, materials and medicines. All these things primarily come from natural resources. Natural resources is about making sure that the use of finite resources is limited so that there is no overuse of this non replenishable resources. This can be achieved by promoting the use of renewable energies, food and resources. To ensure a sustainable environment waste and pollution need to be removed. Waste can be minimized through biodegradable products, ensure proper disposal of the waste that is produced. These actions will help protect air, water and soil quality. The last component regarding this third pillar is climate change. Throughout the whole value chain it is important to minimize carbon emissions relying on natural resources. When all value chains are able to do this it will be possible to slow down or eventual eliminate the rate of global warming. This needs to happen soon in every value chain around the globe (D'heur, 2015; Ouhimmou et al., 2021; Soosay et al., 2012). These three pillars of sustainability form a favourable environment for the creation of a value chain and all three are equally important for keeping the value chain in balance (D'heur, 2015; Ouhimmou et al., 2021; Soosay et al., 2012).

3.2.3 How is the life cycle of a new value chain completed?

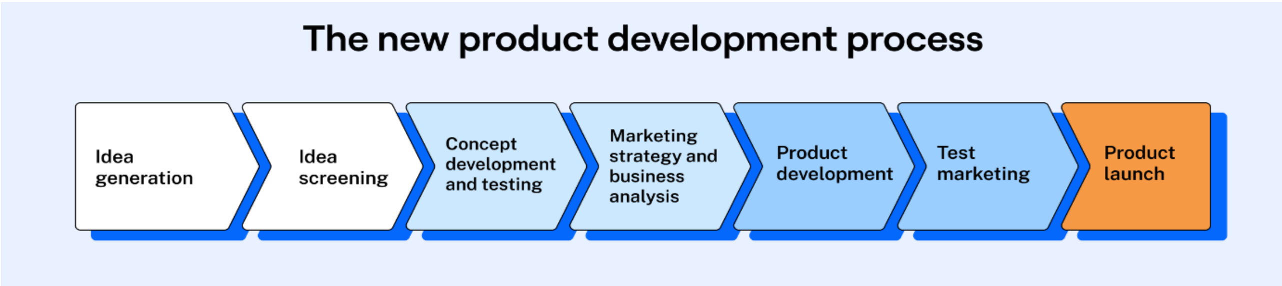

Figure 5. The new product development process (Gastaldello, 2021).

In the context of an innovation and this thesis, the value chain of alternative proteins in Flanders is researched. A brief introduction to this life cycle is important because the remainder of this study will indicate how the different steps in the value chain of lab-grown proteins have already taken place in Flanders and in which phase Flanders currently is (Bessant & Francis, 1997). The development of a product such as lab-grown proteins goes through several steps, as can be seen in Figure 5. As described earlier, the development of a product involves several actors who all make their own contribution to the final product that is brought to market.

New product development is a process that transforms a product or service from a broad idea or concept to a scalable product that can be brought to market. Each company and industry will have a different way of taking a new product from concept to product launch. Depending on the needs of the industry or product, but the basic principles are the same for all new products (Tzokas et al., 2004). The first step are the basics. The company or institution needs to develop a new product strategy. It needs a set of objectives and in which direction it wants to evolve and for that it needs a portfolio of new product ideas and from there it can trace the product ideas to those it wants to market itself (Rochford, 1991). It is the first step that gives meaning to the further course of the value chain. From this starting point, the innovation goes through several steps before being brought to market. A logical second step is to evaluate all generated ideas for suitability and chances of success. Step three in Figure 5 is about concept development and testing. A product concept is the actual product that can be tested and assessed. In the case of lab-grown protein, for example, this is a chicken breast that has been developed on a very small scale and can be tasted. A company that is going to market an innovative idea will develop several samples and test them on a small scale. The idea is to interview different audiences and describe their opinions about the product in order to discover and apply recommendations to the product. The goal of lab-grown proteins is to not notice any difference between the proteins currently used and the new development. Therefore, in this step it is important to know the opinions of consumers. In this way, one can get a better idea of the direction the company will take. Lab-grown protein is truly an innovation, therefore it is important that the product is accepted by the consumer. It was made clear earlier that no matter how good the idea, if the consumer is not prepared to buy the product, the innovation will not be successful (Khurana & Rosenthal, 1998; Roberts & Lattin, 1991). After the company has decided which concept it wants to implement, it is important to do a business analysis. This includes the sales, costs and revenues that can be generated by the innovation. The investment opportunity must be considered and weighed against other ways to spend the money. In this way, it can be determined how much investment is needed and how much the company can earn from the innovation. This is necessary to convince investors of the potential success or to obtain funding from government agencies. Step five is product development. The concept must be turned into a physical product that has the potential to be produced on a large scale. Developing a prototype can take months or years and often requires significant investment to realize (Hart, 2012). Therefore, it is very important to execute the previous steps well so that third-party support can be obtained to support and enable the innovation. Third party support at this stage need not always be financial support. By making the potential of the innovation visible, parties may come forward who can offer operational support to accelerate the process from concept to scalable product. Before the product is brought to market, a marketing test should be conducted. The product and its intended function are tested in a realistic marketing setting to see how the end user responds. This is done on a larger scale than if the different concepts were tested by small audiences. After this step, distribution and commercialisation become reality. This is nothing but the introduction of the product on the market by means of advertisements, sales promotions, etc. With products that are already known to the market, it is as simple as that, but with innovations as ground-breaking as lab-grown protein, legal obligations must first be met and even new laws must be written and approved (Klompmaker, 1976). In the following, you will read about the consequences this has for the pace at which this innovation can develop. After all these steps have been completed, it is important for an innovation to engage in after-sales service, data processing to perform diagnostics and develop performance metrics, and the day-to-day tasks of perfecting the innovation through reporting and analysis. The entire value chain must continue to engage in ongoing education, training, improved supply chain, industry and business development, further technology development and improved innovation support after commercialisation (Bessant & Francis, 1997; Bhuiyan, 2011; Tzokas et al., 2004).

The reason an innovation must strictly follow these steps is to ensure that the process can be more efficient. It will ensure that fewer steps can be forgotten, repetitions occur or mistakes are made. This also means that the innovation can get to market faster and in a cheaper, less risky way. Innovations such as alternative proteins carry a high risk for the actors involved in the entire process, but these same innovations may carry the hope for the future. However, if things go wrong then the actors risk losing money, reputation and potential (Alter, 2008; Bhuiyan, 2011).

3.2.4 Which actors are involved in the problem and what is their contribution or involvement?

As seen in the theory of innovation systems, it is important that different actors who can relate to the innovation work together. To apply the theory to reality, the first step will be to discuss which actors can have an impact on the success of lab-grown protein and then to discuss which parties are already present in Flanders. Actors such as the inventor for the idea of the innovation, researchers, investors, entrepreneur, customers, manufacturers, EU regulations and public authorities are further addressed.

For the value chain of lab-grown proteins to succeed, there are several players in the process who must cooperate and share information with each other. Initially, there is a person or group of people who have an idea for an innovation. Since the creation of lab-grown protein is a highly scientific matter, it is most likely that a group of scientists who are already researching this topic or who have a high level of knowledge in this specific area will be approached. At the beginning of the entire process, everything depends on research and development. It goes without saying that these often-unprecedented innovations require investments in terms of time and money. In order to convince investors to believe in the story, there must be some proof that the idea can become reality. It is for this reason that the innovator must make his idea and vision clear to the scientists in order to motivate them and make them believe in the success of the innovation. Once the scientists have found a way to make proteins in a laboratory as if they were made from an animal, with the same fibre structure, fats, nutrients, etc., it is the innovator's job to get enough resources to keep the process and the scientists' research alive. The innovator can do this with its own resources, third-party investments, loans, grants or partnerships. Either way, he must involve parties that can follow his vision and believe in the idea. In order to collect these funds, the innovator must conduct market research. Are people ready to buy this innovation, are consumers ready for it, what will be the impact on the current system. With lab-grown protein, it is not the intention to change people's eating behaviour, but the process by which the product is created will change. It will therefore have an impact on the current value chain of proteins. The product that many people consume today will still be there through lab-grown meat, but the way it is produced will be different. So it will be necessary for the producers to convince the customers to buy the new product. A great advantage of lab-grown meat is that it has similar characteristics to the original product. With innovations, it is extremely difficult to estimate all of these things because it is unknown territory, but an attempt must be made to enable further steps to be taken in the process. Once the resources are in place and the scientists know exactly how the process will work, the next step is to think about how to turn the scientific aspect into an operational process. Perhaps it is scientifically possible to make one gram of protein in a laboratory, but impossible to produce it on a large scale. After it has become clear that investors, scientists and the entrepreneur believe in the system and are convinced of the possibilities of making the product scalable and selling it to the consumer in sufficient quantities, legislation on innovations must first be approved, adapted or created. When it comes to making alternative proteins, legislation is very strict, because it is about food, human health and the consequences are still unknown (EFSA Panel on Dietetic Products et al., 2016; Hansen & Birkinshaw, 2007; Schauvliege).

According to EU regulations, which also has a decisive role in the innovation, any food that has not been consumed on a global scale before 1997 is a novel food (Europese Commissie, 2020). A novel food falls under the Novel Food regime. This legislation has been in force since 2018 and the process of approving a novel food such as lab-grown protein is complex, time-consuming and expensive. This is not the only barrier lab-grown protein faces. Another constraint for these companies is the requirements for cell-based productions. The end product must be tested by independent parties in laboratories to prove that it is safe and healthy. It is clear that these approval processes slow down the innovation. Singapore, the first and only country to approve the sale of lab-grown meat in supermarkets, has made it clear that the lab-grown protein approval process can be accelerated if regulators change or monitor these stringent requirements in a different way. European regulators are open to considering a more feasible approach. However, because the whole process is new, nothing is happening overnight (EFSA Panel on Dietetic Products et al., 2016; Hermann, 2009).

With the current initiative by the Flemish government to make the way in which food is provided more sustainable, there is certainly an opportunity to make a contribution to accelerating this process. The decision to approve lab-grown protein as a consumer product by the Singapore government has made it clear that there is a lot of interest from the consumer market, production, investors, etc. in being one of the first to take a clear stance on legislation for innovations. The big challenge today is mainly the legislation surrounding this type of food. The science and the production of this topic is there, but the legislation is difficult to define because it is an uncharted area. Once the legislation is in place, manufacturing companies will locate in the countries that approve of lab-grown protein and retailers will be willing to stock and sell this product. It is also the case that cheese made from lab-grown dairy cannot be sold under the name cheese and chicken breast produced in a laboratory cannot be sold as chicken breast. Determining a name for a novel food seems an easy problem to solve, but these are issues that take a long time and delay the approval of new legislation. Because of these delayed procedures, innovations such as lab-grown proteins often develop more slowly than they could (Amelia, 2020; Neslen, 2020).

Once full integration and approvals are in place, there is also room for manufacturers, as an actor, who only produce part of the final product. In Flanders, there is already a company that produces only fat in a laboratory, which is added to the meat fibres later in the process to make a final product. The possibilities for the logistics sector are wide open, because lab-grown protein can take on different shapes and sizes, so the logistics chain for this product can be built up from scratch (Green, 2021).

Flanders already has some important producers in the field of lab-grown protein; you will read more about them in the next section of this study, but it is unlikely that in these innovative changes, only actors from Flanders will play an important role in the success. The players that have an influence on the ultimate success of lab-grown proteins are therefore positioned all over the world. In the section which actors already exist in this sector, it is therefore not possible to focus only on Flanders. It is the cooperation of different bodies, bringing together funds, ideas, innovations, etc. that may ensure that the value chain of lab-grown proteins in Flanders can be successful.

To summarise. Innovators, scientists, producers of raw materials, finished and semi-finished products, government agencies, investors, partnerships and consumers are all needed to make a success of lab-grown protein innovation. The next part of this study will describe in detail which actors are already present in Flanders and what their contribution is to the system.

3.3 Applying the theory to reality for the Flemish economy

3.3.1 Which factors/actors of a favourable environment are already present in Flanders and which are not?

In this section, there will be a review of which actors already exist in Flanders and which ones do not. Moreover, it will be discussed in which phase they currently are in the value chain that was previously mentioned. For each actor, the influence they exert, both positively and negatively, on the three pillars that have already been explained, will also be examined. The actors that will be discussed in detail are the suppliers of raw materials, research institutes, innovators & producers, partnerships, government agencies, consumers and logistics service provider.

3.3.1.1 Suppliers of raw materials

Livestock farmers: The process of lab-grown dairy can mean an opportunity for the many dairy farmers in Flanders. Abroad, animal cells or soy are mainly used to produce milk in an animal-friendly way, but in Flanders the company behind Those Vegan Cowboys wants to make lab-grown dairy products with grass as the basic product. After all, grass grows everywhere and it is a sustainable product that does not require much treatment or pesticides to grow. The only disadvantage of grass is that it requires a lot of space to grow. Farmers who currently raise cattle to produce milk have that space. By using grass, these dairy farmers will still be able to produce milk, but without animals. The place that is now used to keep their cattle and grow grass as food, they will be able to use to grow grass as the basic raw material for lab-grown dairy. Often these dairy farmers have automatic machines and this setting can be used as a production process that converts grass into milk without the intervention of an animal. Currently, there are no farmers who supply grass to a producer of lab-grown milk in Flanders. According to Jaap Korteweg, owner of Those Vegan Cowboys, the idea is that farmers, who will have their own fermenter in the future, can convert their own grass into casein. That casein can then be sold to the company Those Vegan Cowboys. The owners of Those Vegan Cowboys who turn grass into milk in a laboratory suspect they can produce five times more milk from one acre of grass than a cow (Van Dinther, 2021). In this way, the chain can be made shorter and more sustainable, but the dairy farmer is not excluded from the process. The number of dairy farmers in Flanders is decreasing every year because of stricter measures related to the high emission of nitrogen from livestock such as cows and chickens, but once the new way of producing lab-grown protein is approved and scalable, there is a chance that there will be government investment for farmers to convert their current farming process to the innovation system. If this happens, farmers in Flanders will no longer have to worry about strict legislation on nitrogen emissions (Rye, 2020; *Those Vegan Cowboys*, 2021).

Sugar beet farmers: Belgium ranks 16th worldwide in the number of tonnes of cultivated sugar beet. When the number of kg of sugar beet grown per hectare is compared, Belgium ranks 9th. The American company Perfect Day is one of the first production companies that can make lab-grown dairy without animal intervention. Their raw material is vegetable sugar. Sugar beet contains a lot of vegetable sugar and Belgian sugar beet farmers may be able to benefit from this production process in the future. The number of sugar beet growers has been declining in Flanders in recent years, but by using this vegetable sugar in cultivated dairy, there may be an opportunity to increase the sugar beet sector in Flanders again (Loeffler & Ilse, 2018).

Raw materials are of great importance for the creation of lab-grown protein. For example, cells from living animals are needed for cultivated meat and raw materials such as grass and sugar beet are needed for the creation of lab-grown dairy. These matters belong to the secondary and primary part of Porter's theory. Raw materials are both a part of procurement and inbound logistics in the value chain. Flanders currently has all three components available for the innovation. These raw materials are already used in lab-grown protein such as lab-grown dairy. The raw materials are not a new product either. They are existing products which can be optimally used in the creation of lab-grown protein. They are the basis of the innovation, but the raw material product itself does not need to prove anything and its potential is already known.

3.3.1.2 Innovators and producers

Peace of Meat: Peace of Meat is a producer of cultured fat. The company produces fat directly from animal cells without the need of growing or slaughtering live animals. Their objective is to produce 100.000 tons of cultured fat per year which contributes to the Paris Climate targets by 3% and eliminates 2.4mn cows from the food supply chain per year. In 2020, Meat Tech 3D, an Israeli company active in the field of cultured meat, took over the company completely. The activities, however, still continue in Flanders (Gabay, 2020).

Those Vegan Cowboys: Those Vegan Cowboys is a Flemish company based in Ghent near the campus of uGent where they make milk and cheese in a laboratory without the intervention of a cow. Whereas Peace of Meat focuses on the production of cultured meat, Those Vegan Cowboys only produces cultured dairy. The company is a new venture by Dutch entrepreneur Jaap Korteweg, who previously founded the Vegetarian Butcher. He sold the Vegetarian Butcher to Unilever in 2018. Since the entrepreneur was previously a farmer and butcher, he does not have sufficient knowledge to produce milk and cheese in a laboratory. To bring the complicated process to a successful conclusion, he recruited a team, which was active in research for uGent, to help him realise his plan.

Meatech Europe: Meatech Europe is a subsidiary of Meatech 3D, which acquired the Flemish company Peace of Meat in 2020. The Israeli company wants to continue its European production in Antwerp. In the European production plant, they use the technology developed by Peace of Meat.

Tiamat: Tiamat Sciences was founded in 2019 and is currently based in Brussels. The company wants to reduce the cost of lab-grown proteins. They want to do this by producing cell culture medium, growth factors and other building block ingredients more efficiently. These products are currently 80% of the production costs of lab-grown proteins. Tiamat Sciences wants to provide these building blocks to end producers of lab-grown proteins. This way, they can mass produce them at a lower price (Ho, 2020). By reducing these costs, Tiamat Sciences aims to partner with companies such as Peace of Meat and Meatech3D to help them scale up to mass production (Ho, 2020). Tiamat produces and offers key proteins for lab-grown proteins that are ten times cheaper than what is currently available on the market. Using proprietary plant molecular farming platforms, Tiamat makes it possible to produce animal-free proteins. They sell semi-finished products that their customers use to make a finished product in various sectors. These sectors include cellular agriculture and lab-grown meat, but medicine and the production of new vaccines are also possible Tiamat customers (Tiamat, 2021). Dubbed "PlanTech", Tiamat Sciences' solution is created with a customised plant vector and a pathogen that naturally infects plants and then grows its proteins. After a couple of days, the plants can be harvested and proteins extracted and purified to obtain the ingredients needed to grow cultivated meats (Ho, 2020).

Every Flemish company that focuses on this topic hopes to be one of the first in the world to succeed. Being the first to succeed in the field of innovation can create a lot of brand awareness, which can have a positive effect on the growth of the company. But when it comes to innovations, there is still the idea that the cooperation of different factors has a stimulating effect on the success of the project. It is not bad that there is competition in the same sector. If there are more and more companies that can demonstrate the potential of cultured meat, it can speed up various processes.

According to Porter's value chain, the innovators and producers bring the most added value to the final product. These actors ensure that the final product can be created. It is therefore a primary activity that receives support from the secondary activities such as procurement, which in this story are the raw-materials and human resource management, which will be discussed here as research institutes. The innovators and producers belong to the part, operations.

These actors in the value chain, go through the entire process of a new product. They are at the basis of the idea generation, screening and ensure through their production process that the product can be launched on the market. At present, most of these actors are in the phase of product development and test marketing on a very small scale. They are waiting for approvals to be able to sell the product on the market en masse.

3.3.1.3 Research institutes

Ugent: There are several companies in Flanders that are already active in producing, researching or experimenting with alternative proteins and in particular lab-grown protein. Flanders has several successful universities where scientists are researching cells around meat structures. It is for this reason that the Dutch entrepreneur of Those Vegan Cowboys, company producing lab-grown dairy, contacted a group of scientists at uGent who have the necessary knowledge about cell structures related to these protein products. The knowledge that is needed to make the research into lab-grown protein successful is available in Flanders. So it is well known that Flanders has the people and training in microbiological processes, and this also offers an opportunity for the universities and science institutes in Flanders to grow even stronger and expand their knowledge (*Those Vegan Cowboys*, 2021).

KU Leuven: The University KU Leuven has a research institute MTSP (Meat Technology & Science of Protein Rich Foods) that conducts research into all kinds of alternative proteins. The research team has the necessary infrastructure to process all different types of proteins. The research team also provides support to companies engaged in technical innovation and development of high-protein foods. They assist in the development of new products, but also provide their infrastructure for testing potential new ingredients (Loeffler & Ilse, 2018).

Flanders Food: Flanders' FOOD is the innovation platform for the Flemish agri-food industry. They support food companies in initiating, designing and implementing innovations in food products, production systems and new business concepts. Flanders' Food was involved in the Foieture project, which was discussed earlier in this study, with Flanders' Food managing and coordinating the project. They brought different companies together to bring the project to a successful conclusion. Since 2018, Flanders' FOOD has been recognised by the Flemish government, through the Innovation and Enterprise Agency (VLAIO).

As a recognised organisation, Flanders' FOOD receives 3 important roles from the Flemish government: (Food, 2020).

- Central point of contact for companies, social profit organisations, knowledge institutions and authorities, in the strategic domain of the Agro-food Industry within the Flemish innovation system.

- organising cooperation initiatives between all stakeholders in the triple helix with a view to strengthening the competitiveness of the Flemish food industry.

- Managing specific innovation resources (earmarked project budget via VLAIO) to roll out the strategic research and innovation agenda.

Bio Base Europe Pilot Plant: Bio Base Europe Pilot Plant (BBEPP) is an independent process development service provider based in Ghent. They take care of the up-scaling and make proposals for adapted production of biobased products and processes. A broad and flexible spectrum of modular unit operations allows them to translate your bio-based laboratory protocol into a viable industrial process. BBEPP was part of the Foiteture project (BBEU, 2021).

It is an independent open innovation pilot plant and is accessible to companies and research institutes all over the world. The core activity of Bio Base Europe Pilot Plant is to facilitate and accelerate biobased innovations (BioBase4SME, 2020).

When the link is made to Porter's value chain, it can be said that the research institutes are placed in the section of secondary activities that support the primary activities. The institutes discussed in this section bring the necessary knowledge and support to make the primary goal, lab-grown protein, a reality. Specifically, these institutes fall under the human resource management section of Porter's value chain.

The research institutions have an important role to play in the start-up of an innovation. These actors help with the first three steps of the new product development process. They have the most influence during concept development and testing of the product. They ensure that the producers receive sufficient knowledge and information to determine whether the product is economically viable or not.

3.3.1.4 Partnerships

Wild Westland: Wild Westland is a Dutch company that makes and sells cheeses in supermarkets and deli-stores in Belgium and the Netherlands. Recently, they have partnered up with Those Vegan Cowboys. Those Vegan Cowboys makes lab-grown dairy which they sell to Wild Westland to make herb cheeses. These cheeses are already available in supermarkets and deli-stores in Flanders. Wild Westland's goal is to be able to make all its cheeses from milk that does not come from animals by 2036. Together with Those Vegan Cowboys, they hope to achieve this. The cooperation between an end manufacturer and producers of lab-grown proteins in Flanders can give the development of lab-grown proteins a positive boost (Vegan, 2020; Wildwestland, 2020).

3.3.1.5 Government agencies

Agency for Innovation and Enterprise: The public authorities in Flanders also understand the potential success of this innovation. Flanders Investment & Trade, the agency for international business in Flanders, has already been a facilitator in bringing together a company specialising in lab-grown protein from Israel with a Flemish company that can cultivate fats from cells that can later be added to the process. The government agency has made the Israeli company MeaTech 3D realise the benefits of Flanders and provided them with all the necessary information and contacts to move their investment plans to Flanders and cooperate with the Flemish company Peace of Meat. Thanks to the excellent support of Flanders

Investment & Trade, MeaTech easily got its bearings in Flanders. Flanders Investment & Trade introduced the Israeli company to local service providers and several banks. In the end, the foreign company came to the decision to build additional production facilities in Antwerp and chose to work with Peace of Meat and BNP Paribas Fortis. It is possible to convince foreign companies in this sector of the Flemish qualities and to carry out their investments here (Trade, 2021; Vlaanderen, 2020).

European Food Safety Authority (EFSA): The EFSA is the European body responsible for all provisions relating to novel foods. This body determines if lab-grown protein is approved in Europe for sale on the market and to private consumers. For the moment, however, the lengthy regulatory delays are prompting more European companies to look beyond EU borders as they seek to move to market quickly. In this innovation, it is important to bring products to market as quickly as possible in order to reduce production costs. Mosa Meat, for example, is based in the Dutch city of Maastricht and hopes to bring its first cell-grown meat products to market in Europe, according to COO Peter Verstrate. However, he said there is "no doubt" its first offerings will be sold outside Europe because of the long approval procedure (Neslen, 2020).

This could also be a disadvantage for Flanders. If the EFSA continues to postpone approvals and cannot reach a decision, there is a chance that the current Flemish companies active in the lab-grown protein sector will move abroad, such as Singapore for example.

In the story of lab-grown protein, the government agencies have the final step to fulfil before the product can be sold on the market. The last step is to approve all legislation and, if necessary, to form new laws about novelty food in connection with these lab-grown proteins. The only country where government agencies have approved lab-grown proteins for sale is Singapore, but this is not yet the case in Flanders.

3.3.1.6 Consumers

A major drawback to consumers' willingness to buy lab-grown proteins is the low level of product awareness. Alternative plant-based proteins are better known to consumers than lab-grown proteins. There have already been several studies on the willingness to buy this alternative protein in Europe. A study by Food Navigator (2021) shows that readiness among consumers strongly depends on age. They state that people over 55 have a greater reluctance to buy the new product. A major challenge for producers will therefore be to convince this category of consumers of the new product (Southey, 2021).

There are currently not very many studies in Belgium on consumers' willingness to buy cultured meat, but if we are to believe the statistics from the USA, only 1/3 of people are willing to buy lab-grown meat (Pakseresht et al., 2022). To some extent, this is due to the deterrent name of lab-grown meat and the current price of buying it. As the product will grow in the market and the meat can be produced on a large scale, lab-grown meat products believe that it is possible to sell the new product on the market for €6/kg. The problem that lab-grown meat has a negative name can be solved by marketing the product under another name. The name of the new product will be determined by legislative bodies. No decisions have yet been taken in Flanders on the legal name of the product.

In general, it is often difficult for innovations to be immediately accepted by consumers. The fact that this innovation is food-related does not help to speed up the acceptance process. Food neophobia is seen as a barrier to consumer acceptance of meat substitutes (Bierlaire et al., 2001; Pakseresht et al., 2022).

3.3.1.7 Logistics service providers

Port of Antwerp: The port of Antwerp is a very important import port for Europe. It is certainly an important import destination for perishables. The port is very flexible and has good inland connections, which makes it an attractive port for various shippers from all over the world. The Israeli company MeaTech 3D, which took over the Flemish company Peace of Meat in 2020, has built a laboratory in the port of Antwerp where they want to produce cultured fat (Broens & Cardinaels, 2021).

Port-centric logistics: Flanders also has a bonus point in terms of logistics, being successful in the field of lab-grown meat. Because these alternative proteins are so focused on animal welfare and their carbon footprint, the pressure will be high for logistics service providers that they too start doing business in an ecological way and organize their supply chain in a sustainable manner. A new trend in logistics is port-centric logistics. Port-Centric Logistics refers to the services offered when goods arrive at a seaport. It is seen as an alternative to inland depots and smaller regional storage sites. It enables a user of this new system to store goods at the port and reduce the number of handling operations in the supply chain. This can save time and money. Port-centric logistics is increasingly seen as a way for companies to streamline their supply chain and reduce their environmental impact, as the chain is made smaller and tighter. This contributes to why the transition to lab-grown proteins would be made (Galea-Pace, 2020). And let the Flemish seaports be the perfect environment to carry out this port-centric logistics.

Logistics service providers are the final part of the primary activities in Porter's value chain. The product is handled by these actors, shipped and delivered to the right partner. The outbound logistics will ensure that all actors within the value chain can be connected.

In a development cycle of a new product, the logistics service providers come into the spotlight both at the first and last moment. They do not have a role in the design or development of the product, but in the supply of raw materials, lab necessities, etc. These actors also ensure that the product can reach the end consumer and that the raw materials or semi-finished products end up with the right parties in the value chain.

3.3.2 Key challenges and the risks of using innovation systems, applied to lab-grown protein.

Systems innovation is a theory that ties in closely with the research on whether Flanders has a positive environment for the creation of a value chain related to lab-grown protein, because it focuses on what already exists in the innovation, what is to come and what outside actors can influence its success. However, there are several challenges associated with innovations. There are five key challenges: directionality, experimentation, demand articulation, policy-learning and -coordination and policy implications (Malerba, 2007; Martin, 2016).

When we talk about innovation, we often think about improving existing processes or developing processes that can make our lives easier, but innovation can also mean disrupting or replacing existing processes, technologies or business models. This means that there are often winners and losers in innovation systems. In the past, innovations have increased productivity and contributed to economic growth, while jobs that used to be done by human labour have been automated and digitised. Often, companies that contribute to these innovation systems are willing to retrain the current workforce to cope with the innovation systems, but often the workforce is not ready or willing to participate in the new development and they are dismissed. This is one of the examples of the downsides of innovation systems. This part of the research deals with disruptive goals, operational failures and unintended consequences of bad innovations (Illanes et al., 2018; Twerenbold, 2017).

3.3.2.1 Directionality

The first challenge points to the need not only to generate innovations as effectively and efficiently as possible, but also to contribute to a change in the system without causing additional damage in other areas. This was discussed earlier in the section on the three pillars, where economy, social and sustainability must change evenly to avoid extremes. Innovations are not, by definition, desirable. It is not always a good thing for a government to stimulate one particular sector and at the same time harm society. In innovation systems, you must always keep the broader aspect in mind in order not to lose the helicopter view. In order not to lose that directionality of innovation, it is recommended to establish a vision and to implement policy instruments that are in line with that established vision (Hekkert et al., 2020). Different methods can be used to solve a social problem. Continuing to encourage current meat consumption, for instance the "Become a Beefatarian" campaign of the EU. Contradicting their other objectives of reducing meat consumption has negative consequences for the climate and there are clear studies showing that it is impossible to continue feeding the ever-increasing population in the way we know today (Campbell, 2020). Lab-grown protein could solve these problems, but on the other hand, government agencies do not know what health consequences this new product will have in the future and what will happen to all current livestock farmers. So it turns out that when these different paths are taken, there are not only positive points associated with each direction, but also negative ones. Moreover, they cannot always be used hand in hand. Following one path might exclude another. Deciding which direction to take, which vision to follow to ensure that directional innovation is achieved, is often very difficult (Schlaile et al., 2017; Wesseling & Meijerhof, 2021).

3.3.2.2 Experimentation

This points to the need to test new technologies. Not only to focus on laboratory tests and establishing demonstration plants, but also on business models and the use of technologies in practice. The point is to reduce uncertainty. It improves learning about factors that make niche technologies successful. This challenge is not about trying something new, but is more systematic. A test is done in order to learn something or to discover if something works or is accurate. Experimentation is crucial during the innovation process and to turn innovations into economic activities (Lindholm-Dahlstrand et al., 2019). Innovation systems will stagnate without experimentation. Only when new technologies are selected, commercialised and scaled up can the system develop into economic activity. The pure form of new knowledge alone will not automatically lead to economic growth without successful experimentation (Bergek, Hekkert, et al., 2008; Schlaile et al., 2017).

In the past, enough tests have been carried out to conclude that it is possible to produce on a large scale, but an assumption can turn out to be completely different in reality (Loeffler & Ilse, 2018). It may well be that when lab-grown protein is produced on a global scale, limitations will be discovered. This test phase can only be carried out if several countries give permission for lab-grown protein to be sold on the free market. Singapore can be taken as an example to test whether large-scale production is possible, but only 5.6 million people live in that state. Not much of a challenge if you compare this with a world population of 7.9 billion (Loeffler & Ilse, 2018).

3.3.2.3 Demand articulation

This focuses on the fact that sustainable technologies must meet market demand and be accepted by society if the innovation is to have any impact at all. Demand articulation is not only about the measures taken to introduce a certain innovation into society, but it is also about understanding and learning from what the end-users need. Learning about how the end consumer will use the innovative technologies in reality is also very important. In current systems, customers often know what they want and how they will apply it in their daily lives (Galli & Teubal, 1997). Actors and institutions can take full advantage of this. Systems that are capable of being successful over a long period of time must therefore be both market-oriented and market-driven. Innovation systems are no different, but new systems cannot benefit from end-users specifying what and how they want to use something new, because often they do not even know they need the new system. It is therefore often many times more difficult for innovation systems to identify these wishes and needs (Kodama & Shibata, 2015; Weber & Rohracher, 2012).

Various studies are already being conducted into the acceptance of cultured protein. 65% of meat-eating consumers would be prepared to try lab-grown protein, but only 32% would be prepared to eat it regularly (Bryant & Barnett, 2018, 2020). Consumers are currently somewhat sceptical because they are unfamiliar with the product and do not know what effects it has on health. They are, however, convinced of the positive consequences for the climate and animal welfare (Verbeke et al., 2015).

3.3.2.4 Policy-learning and -coordination

It is about learning whether policies work or not, but also when the consequences of policies are desirable or undesirable. The role of the policymaker is associated with greater responsibility when the policy has a clear direction. It is more important to actively secure the social benefits of innovation policies when they set a very clear direction (Borrás, 2011). If a policy is set to boost biodiversity, it should ensure that it does not have very negative consequences in terms of food prices, land degradation, etc. If a new policy is put in place, it should not create another problem due to using these new technologies (Hall, 2007).

Policy coordination emphasises that transitions between different social systems are complex. These transitions from one system to another affect more systems than one would think. (Zabala-Iturriagagoitia et al., 2007).

When introducing lab-grown proteins, the aim is to create a positive evolution. It should not be the case that the transition is started in order to use fewer living animals because they emit a lot of CO_2 and that, on the other hand, the production companies that make lab-grown proteins will emit just as much. Then the problem will only be shifted and not solved. It is also important that a solution is provided for all farmers. With lab-grown dairy, there is a good chance that the activity of these farmers could be shifted from being livestock farmers to growers of sugar beet or grasses that serve as raw materials. It cannot be the intention that the advent of lab-grown proteins will put current livestock farmers out of work, otherwise there will be a negative effect in the current system.

3.3.2.5 Systemic risk

The risk of failure of an entire system rather than an individual component. It is a product of how the parts in the entire system function and interact to cause a systemic crisis. Systemic risk increases as a result of the increased connectivity between different actors. In an innovation system, actors from different domains work together and therefore difficulties can occur at different levels. The interdependence of huge global networks has led to an exponential increase in systemic risk. Systemic risks come in many forms: financial, environmental, technological, socio-political, etc. The risks can increase in size, scope and frequency due to the misuse of innovation systems (Propson, 2021).

As is mentioned continuously, in innovations it is extremely important that to make the system successful. This can be a positive contribution, but it can also mean that if one actor does not evolve with the rest, the others will also lag behind. The chain is only as strong as its weakest link. In the case of lab-grown protein, this is currently the intensive procedures to obtain approvals in connection with novel foods and regularisations that must create legislation concerning lab-grown protein. The producers and scientists cannot start up a production process that can produce lab-grown protein at a competitive price if it is forbidden to sell this new form of protein globally.

3.3.2.6 Cultural resistance to change

The adoption of innovation systems by social groups can be a long and difficult process. It is important to know that social reactions may arise that slow down the spread of innovations. There is a small chance that society will hold back innovations, but they can create difficulties that slow down the whole process. Detecting or reducing resistance to innovation can be a complex process that takes time and has high costs, but at the same time understanding the process can be important for the success of the innovation system. Reasons such as distrust, ignorance of the innovation systems, not knowing the effects of the innovation or misunderstanding the new system are all things that can cause cultural resistance to change (Dibrov, 2015). It is therefore clear that, in creating an innovation system, all the actors involved want to avoid, overcome or tackle this resistance. To do this, the institutions and actors must respond to various factors. The content of the new system must be convincing and must not contradict the objectives of the innovation. It is important to emphasise the advantages of the new system and to be transparent about any disadvantages so as not to create suspicion among the end consumer. The change should feel like an individual's choice to accept it or not; the consumer should not feel that the change is being imposed on him. All actors together must ensure that the end-user believes that the innovation system is an addition or improvement to the current system and that there will be no unpleasant consequences for using the system (Bauer, 1991; Laidoune et al., 2021).

This will be a major challenge in the field of lab-grown protein. The production companies and government bodies will have to be able to convince consumers of the positive effects of the innovation. The way in which proteins have been consumed for years will be broken and, from the start, the intention will be to have current proteins and lab-grown protein blend in side by side so that the transition is not too big for consumers and so that consumers do not reject the innovation that is lab-grown protein.

3.3.2.7 Research and development investments

Whenever there is any mention of an innovation in the media and thus in the mainstream spotlight, it is often about innovations that are on the verge of success. They are often stories of successful research and getting society ready for the innovation to become part of everyday life. Those few innovations that are put in the spotlight are only a small part of all the local social innovations that are being created every day between actors such as universities, industries and government institutions. Most remain local and are short-lived. The emphasis on potential success and scale is vital when implementing an innovation system. The lack of global recognition and the impossibility of stimulating economies of scale in innovation systems makes it impossible to attract further funding for the project. The costs associated with the research and development of innovations such as lab-grown protein are often so high that scalability is crucial to their survival and to make the new system attractive to society (Franceković et al., 2021). If the innovation is so advanced and accepted by society, but no one can afford it because the unit production cost is so high, it will never be able to evolve into a standardised system. This is where lab-grown meat currently stands. The cost price of one kilo of meat is not affordable. Therefore, the recognition of investors, the interest of other companies to join the system or subsidies from government agencies are necessary for the continued existence of the innovation system (Brandsen et al., 2016).

Companies such as GAIA are currently working to make lab-grown proteins known to the end consumer so that they know the environmental benefits and contribute to animal welfare. Lab-grown proteins have also been mentioned in the past on the radio station Radio 2 and in the VRT news. This ensures that the product is in the spotlight. When investors see that there is a future in lab-grown proteins and consumers are prepared to buy the product en masse, the willingness of investors to invest in the production process will also increase. This will speed up the process.

3.3.2.8 Existing systems

Any innovation based on innovation systems theory assumes the improvement or transformation of an existing system. At first, existing systems and new systems run side by side until an opportunity arises to replace the existing system with the innovation.

Once lab-grown milk protein and lab-grown meat can be sold in supermarkets, for the first few years it will simply be sold alongside the current products that we are all familiar with. As discussed earlier, the aim of Those Vegan Cowboys is to make milk from grass without the intervention of cows. The company knows that in doing so they are putting the work of dairy farmers at risk. However, it is not their intention to work against the dairy farmers, but rather to work together. The land that is freed up by growing fewer dairy cows could be used to plant high-quality grass that can be used as raw material for lab-grown dairy. The barns used to store the cows could be used as innovative laboratories to produce the milk. So, the current work of dairy farmers will not disappear, but it might change.

The implementation of lab-grown proteins therefore not only has an impact on how the consumer will consume his nutrients, but also on the underlying activities. It is therefore important, as seen earlier with innovation systems, to consider all the things that the new system will trigger. If we were to focus solely on the ecological aspect of the value chain in relation to proteins in Flanders, then it is very clear that alternative proteins such as lab-grown protein are head and shoulders above the current method of protein production, but as previously read, it is important to comply with all three pillars (ecological, economic, social) and keep them in balance. Before an innovation such as lab-grown protein is implemented on a large scale, so the key challenges are to see what the effects of the new value chain will be on the current system and whether it contributes to all three pillars in the same amount.

3.3.3 Benefits of creating the lab-grown protein value chain in Flanders.

Meat production and meat consumption as we know it today often entails consequences that are already known. There are disadvantages such as the environmental impact, health, safety problems, etc. Often, these negative effects can be avoided or reduced by using alternative proteins. In the next part of this research, the potential advantages of lab-grown protein for Flanders are discussed.

Environmental impact: Farmers who raise cattle for both meat and milk production account for 6% of the total greenhouse gas emissions in Flanders (Peiren, 2020). This percentage does not include the pollution from meat processing plants. The introduction of lab-grown protein could mean a reduction in methane emissions for Flanders compared to conventional meat production by livestock farmers. According to a study by Oxford University (Oxford, 2011), lab-grown proteins could reduce greenhouse gas emissions by 96%. Reduction of meat consumption could also lead to a more efficient use of land and water (Rust et al., 2020). Flanders has launched an action plan to generate 40% less CO2 emissions by 2030. The government wants to achieve this mainly by using electric vehicles and by making houses more energy efficient. The transition to lab-grown proteins would be a good alternative to support and stimulate CO2 reduction, since cattle are responsible for 6% of the CO2 production in Flanders (Vlaamse Overheid, 2021a).

Health and safety: In farm animals, there is a risk of outbreaks of diseases such as bird flu, and diseases in pigs and cows. The production of cell-based meat is carried out in a controlled environment, preventing possible contamination during the slaughter of the animals. In addition, the production of lab-grown proteins will be more strictly controlled, as production will take place in closed facilities and several checks will be carried out before the proteins are sold on the market (Davies, 2021). As previously discussed in this study, there are regular outbreaks in Flanders that originate from farmed cattle. By producing lab-grown meat, fewer farm animals will be needed in Flanders and the risk of infections will decrease. This is positive for the animals, but also for consumers, who have less chance of contracting infections such as salmonella.

Nutritional content: The nutritional quality and vitamins in farmed meat can be adjusted or modified by changing the ingredients of the culture medium. The mother cell is the basis, but several additional supplements can be added that are not possible in conventional meat. It is thus possible to regulate the content of saturated fatty acids and polyunsaturated fatty acids. Thus, it will be possible to replace saturated fats with Omega-3 vitamins that can give a positive boost to human health (Chriki & Hocquette, 2020).

Animal rights: A major potential advantage of cultured meat over conventional production is the fact that it does not require the slaughter of animals. Each mother cell used for the production of cultured meat can multiply an enormous number of times, and each donor animal has billions of these mother cells in its body. Thus, the number of animals needed for the production of cultured meat will be much smaller than the number of animals slaughtered today (Rorheim et al., 2016).

Opportunities for market expansion: It is the intention of producers to be able to offer cultured meat cheaper than conventional slaughtered meat by 2030. This is because it is predicted that the production of cultured meat will prove to be significantly more cost-effective on a large scale than normal production methods. As a result, more consumers will be able to buy meat products with a higher nutritional and calorific density than many staple foods currently offer. Producers, in turn, will be able to benefit from the increased demand for meat. With higher revenues, they will have more resources available to implement new innovations in the market (Watson, 2021). Due to the rising price of meat, more and more people are starting to eliminate meat from their diet. According to dieticians, this is not the best solution. Meat contains vitamins C and zinc, which are necessary for the human body. Lab-grown protein could offer a solution here. The produced meat will contain the same vitamins as normal meat and the cost should be much lower in the future due to mass production. This could ensure that everyone can afford and consume meat in healthy sizes so that all the vitamins can be absorbed by the body (Rafferty, 2022).

4 Conclusion and discussion

This study aimed to answer the question: "Does Flanders provide a favourable environment for the creation of a value chain related to lab-grown proteins?" To answer this question, a literature study was carried out based on the theory of system innovations. The research examines whether the necessary actors are already active or are emerging to make a successful value chain for lab-grown protein.

This study examined innovation systems theory to demonstrate its importance and similarities to the research question. The transition from conventional proteins to lab-grown protein is currently an innovation that is at a certain stage and has already undergone some steps. By examining the theory regarding innovation systems, it is possible to understand what is important when undergoing an innovation and what actors may have an influence. The second section discusses general aspects related to a value chain. A value chain has several aspects that are each fulfilled by a different actor. Each actor contributes a value to the final process. In the second part it also became clear that when implementing an innovation, it is important to pay attention to the three pillars. All three pillars are important and each pillar should have an equal impact. The third and final part of this thesis zooms in on the current situation of the value chain concerning lab-grown protein in Flanders. It is discovered that there are already several actors active in Flanders and that each actor is at a different stage of innovation. It also becomes clear that every actor has to be ready for the transition before one can speak of an innovative success.

Research has shown that the use of the theory of system innovation is an ideal match to provide the guidelines for this research question. The similarities between the theory and the emerging innovation of lab-grown protein are sufficiently great to make use of it. The main similarity between system innovation and the creation of a value chain for an innovation such as lab-grown protein is the cooperation of different actors in the market. There must be an awareness throughout the entire value chain that there is a need for change. An existing system is in need of change for a process that improves on several things. These are improvements for the environment, the economy and socially. This is also referred to as the three pillars.

Research has shown that the value chain of alternative proteins consists of various actors that can bring about the evolution of the product. The entire process is created by the actor who realises that there is a need for change. These are often innovators or inventors who think about a possible improvement of a current process. Due to the high complexity of lab-grown protein, these innovators need to collaborate with research teams to find out if it is possible to grow proteins in a laboratory. The conclusion of this research is that it is currently possible to produce both meat and dairy products without the need to slaughter animals. These production teams are currently active in Flanders. The necessary resources to produce the product on a larger scale are available both at home and abroad. There are already Flemish investors and foreign companies that will contribute financially to the Flemish production of lab-grown protein. Consumers in Flanders are also becoming increasingly aware that their current protein consumption is not feasible and that there is a need for a better alternative.

This literature study suspects that the main reason that lab-grown protein is not yet being produced on a large scale in Flanders is the government. Because of the lack of legislation and regulations concerning novel foods, it is not yet possible to sell lab-grown meat to consumers in a supermarket. This, of course, means that producers do not have the cash flow to finance production and this holds back innovation. Another challenge to calling lab-grown protein a success in the future will be to convince consumers of the product. Currently, it is very expensive to make lab-grown protein due to the small production quantity. The production quantity will only increase if customers are willing to buy the product. Once consumers have included the product in their daily diet, it will be possible for producers to sell lab-grown meat for €6/kg, for example. A major challenge ahead is to market the product in such a way that customers have no problem buying it. Problems at the moment are the willingness of the customer to buy the product and the price of the product.

As became clear in this study, there are also many dangers associated with the transition to lab-grown proteins. One of the main risks is that the innovation will bring disadvantages that were not present in the past. Jobs will be created by the new production environments, but there is a chance that current farmers will lose their income from raising animals. Of course, it is not the intention that livestock farmers in Flanders will run into problems as a result of the transition. For the transition to succeed, an alternative must be provided for these professions.

The results showed that many actors are already actively engaged in the search and production of lab-grown protein. There is certainly potential for the creation of a value chain in Flanders concerning lab-grown protein. All the necessary actors are ready to take lab-grown protein to the next level once the legislation is implemented and lab-grown protein can be sold in supermarkets.

This is a topic that must be followed up in the future and once the product is freely available in supermarkets, a clear answer can be given to the question of whether Flanders is ready for a transition to lab-grown protein or not. At the moment, it looks as if the value chain in Flanders is ready to launch the transition.

4.1 Limitations and implications for future research

This section indicates the limitations of the study, as well as suggestions for further research.

A first limitation of this research is the recent development of lab-grown proteins. At the time of writing, there are only a few scientific articles available on lab-grown proteins. As a result, there is a lot of speculation online about the future of lab-grown proteins and few, if any, scientific studies have been conducted on the value chain of lab-grown proteins. Most articles focus on the process from stem cell to end product, but there are hardly any scientific articles discussing its value chain and certainly not in Flanders.

Furthermore, this master's thesis has mainly focused on the actors currently active in Flanders in the field of lab-grown proteins and has not investigated the actual chances of success of the value chain in Flanders. Therefore, research should be conducted into the willingness of consumers in Flanders to make the transition to lab-grown proteins. An interview could also be organised with producers to find out how they see the future and how they want to increase the pressure so that the government authorities adapt the legislation concerning novel foods. At the moment, there is mostly speculation online, but little researched data. In subsequent research, it is advisable to examine each actor in Flanders in detail and possibly carry out field research. The disadvantage of this sector is the strict production rules, which makes it difficult to obtain a company visit.

Apart from the above limitations, this master thesis is likely to contribute to the existing literature on lab-grown proteins. This research has both a social value and a value for the supply chain management course. This thesis has value for society, because it shows the process of a successful transition to lab-grown proteins that can reduce CO2 emissions, animal suffering and raw material shortages. This research also has an added value for supply chain education, because the transition to lab-grown proteins can create a completely new value and supply chain that has not yet been fully established. The supply chain from producer to end consumer with regard to proteins may look completely different in the future.

This thesis can support future research in understanding what is important in a transition to innovations and the current state of affairs in Flanders regarding the transition to lab-grown proteins. This is necessary to conduct further research in the future on the different actors active in this sector.

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