

## Original Research Paper

## Understanding the protein transition: The rise of plant-based meat substitutes

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## ARTICLE INFO

## Keywords:

Technological innovation system  
Food  
Users  
Norms  
Plant-based proteins  
Sustainability transition

## ABSTRACT

Even though the food system is responsible for a significant part of global greenhouse gas (GHG) emissions and a transition to a sustainable food system is needed, the growing body of literature on sustainability transitions has paid little attention to the food processing sector. We expect transition dynamics in the food processing sector to differ from the typical dynamics portrayed in transitions literature due to particularities in required technological knowledge and government intervention. To better understand dynamics in the food processing sector we apply the Technological Innovations Systems (TIS) framework to an in-depth case study of the plant-based meat substitutes industry in the Netherlands. Results illustrate that, contrary to many other transitions, consumers and changing informal institutions are the driving forces of this process. We show how strengthening cognitive and normative legitimacy can lead to growing markets for sustainable products.

## 1. Introduction

Transitions literature has provided critical insights into the dynamics of systemic change that can lead to sustainable pathways for the economy (Markard et al., 2012). These insights have mainly been based on findings from case studies focusing on low carbon transitions related to energy, mobility and water sectors (Bergek et al., 2015; Markard et al., 2012). Among the strand of food transitions literature, studies primarily explore agriculture, grassroots movements, such as alternative networks for the provision of food, and food consumption practices (Grin, 2012; Hinrichs, 2014; Randelli and Rocchi, 2017; Seyfang, 2006; Spaargaren et al., 2013). Although this literature has developed valuable knowledge relevant to transitions in food systems, it has relatively neglected regime shifts in the food processing industry, including the increasing turn towards substitute products (Bilali, 2019; Mylan et al., 2018).

Over the past decades, the food processing industry has evolved into a dynamic and complex blend of flows of materials, which are combined into durable, standardized food products and are mass distributed to consumers (Spaargaren et al., 2013). Technological innovation is often employed to address pressing sustainability challenges and firms reorient (incrementally) by adjusting inputs and processes to offer new products (Garnett, 2014). It is therefore imperative to develop insights into the mechanisms of endogenous change in the food processing industry in order to contribute to a more comprehensive view of transitions in food systems.

The key question is whether the same mechanisms derived from previous transitions literature also hold for transitions in the food

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<https://doi.org/10.1016/j.eist.2019.09.004>

Received 8 April 2019; Received in revised form 17 July 2019; Accepted 15 September 2019

Available online 08 October 2019

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processing industry. There are a number of reasons why we expect different dynamics. First, technological change in food processing often emerges through a supplier dominated innovation trajectory (Pavitt, 1984; Castellacci, 2008). Advanced knowledge is acquired from different segments of the economy in order to adjust inputs and processes for the development of new products (Pavitt, 1984; Castellacci, 2008). The implication is that we witness hardly any radical technological breakthroughs. Second, there is an almost complete absence of regulatory intervention in the form of favorable taxation schemes for sustainable consumer products. National governments have been reluctant to adopt such regulations due to barriers erected by international regulatory institutions, uncertainties related to the impact of such tools and strong industry opposition (Bødker et al., 2015; Fellmann et al., 2017). Instead, niche consumer markets are supported by conscious individuals who are willing to pay a relatively high price for products with specific characteristics (Akaichi et al., 2019; Hughner et al., 2007).

In this paper, we study the emergence of the plant-based meat substitutes industry in the Netherlands in order to explore how key innovation processes develop in the food processing sector. Plant-based meat substitutes are products that take the place of meat in the human diet and have an appearance, texture and taste similar to meat products. Vegetarian and vegan diets have been practiced for thousands of years (Ruby, 2012). Consequently, despite being perceived as a new trend, plant-based meat substitutes have existed in markets for several decades (Asgar et al., 2010). In recent years, European markets for meat substitutes are experiencing unprecedented growth. Based on data from Euromonitor, in 2016, in Denmark and Germany, the market for meat substitutes showed an annual growth of between 15–20% and in the Netherlands, Sweden and the UK 5–10% (Changing markets foundation, 2018). Due to general awareness of the adverse impacts of meat and dairy production and consumption, several groups of actors, including activists, NGOs and scientists, support the widespread diffusion of meat substitutes. We aim to understand how these developments evolved and which processes and actors were important.

We apply one of the main frameworks in the field of sustainability transitions, the Technological Innovation Systems (TIS) framework due to its use in studying the emergence of novel technologies and products (Bergek et al., 2008a; Hekkert et al., 2007). TIS literature highlights key processes that are needed in well-functioning innovation systems. Dynamics in innovation systems are attributed to interactions between these key processes, leading to virtuous or vicious cycles. These cycles are coined as motors of innovation (Suurs and Hekkert, 2009). However, the motors of sustainable innovation typology is based on case studies from the energy and mobility sectors. Due to the particularities of the food sector, we expect to identify different motors of innovation. Therefore, our research question is shaped as follows: What are the dynamics of the plant-based protein innovation system in the Netherlands and how do they inform the motors of sustainable innovation typology?

## 2. Theoretical background

Transitions literature, has been very influential in analyzing the complex dynamics of systemic change as a response to pressing sustainability challenges. It is comprised by a number of different perspectives, including the multi-level perspective, the technological innovations systems framework, transitions management and strategic niche management (Geels, 2002; Hekkert et al., 2007; Loorbach, 2010; Schot and Geels, 2008). Within transitions literature, the TIS framework explores conditions for the success of emerging sustainable technological fields or products/product groups (Bergek et al., 2008a; Markard and Truffer, 2008). It has therefore been used to provide policy recommendations to support the diffusion of these technologies and products (Hekkert et al., 2007).

A TIS is defined as “a set of networks of actors and institutions that jointly interact in a specific technological field and contribute in the generation, diffusion and utilization of variants of a new technology and/or new product” (Markard and Truffer, 2008, p.611). Therefore, a TIS consists of structural components like actors, networks and institutions (Bergek et al., 2008a; Markard and Truffer, 2008) and the boundaries of the system are set around an emerging technological field or a product/product group (Bergek et al., 2008a; Markard and Truffer, 2008). Complex interactions among the structural components underlie the development process of a TIS (Jacobsson et al., 2004).

TIS actors engage in a wide variety of activities that are enabled and constrained by networks and the institutions in which they are embedded (Bergek et al., 2015). These activities lead to the emergence of key processes – or system functions – during the development of an innovation system (Bergek et al., 2008a; Hekkert et al., 2007). These are entrepreneurial experimentation (F1), knowledge development (F2), knowledge diffusion (F3), guidance of the search (F4), market formation (F5), resource mobilization (F6) and legitimacy creation (F7) (Hekkert et al., 2007). For in-depth description of the seven system functions see Hekkert et al. (2007).

Previous studies have shown that the development process of a TIS goes through a formative phase before it switches to growth and eventually culminates in a mature stage (Bento and Wilson, 2016; Bergek et al., 2008a; Jacobsson et al., 2004). During the start of the formative stage, innovation systems are mainly structured by a variety of ideas and concepts for technological development and a small number of actors participating in knowledge creation (Bento and Wilson, 2016). As the TIS emerges, new entrants partake in entrepreneurial experimentation and bring more knowledge and financial resources in the industry (Bento and Wilson, 2016; Bergek et al., 2008b). Firms and other actors start to form learning and political networks and become involved in institutional alignment strategies (Hellsmark and Jacobsson, 2009; Musiolik et al., 2012). The formative phase changes to a growth phase as the system becomes increasingly structured through a rapidly developing market. Technologies and products form a dominant design, production capacity increases, markets expand and technologies and products become adopted by users (Bento and Wilson, 2016). Finally, TISs in a mature state are highly structured systems that deliver standardized products across mass markets (Bento and Wilson, 2016).

The development of an innovation system is not a linear process. Central to the development process is the notion of feedback

loops, or cumulative causation (Bergek et al., 2008a, 2008b). Feedback is created through the co-evolution of structural components and system functions (Suurs and Hekkert, 2009). Positive feedback contributes to the acceleration of the build-up of a TIS (Suurs and Hekkert, 2009). For example, the introduction of government supported market formation activities, such as tax exemptions, can lead to reinforcing patterns of positive expectations and entrepreneurial experimentation (Suurs and Hekkert, 2009). Negative feedback might result in struggles and decline of the build-up process of a TIS (Suurs et al., 2010). For example, exit of industrial actors can contribute to reinforcing patterns of negative expectations and discouragement of potential new entrants (Suurs et al., 2010).

Suurs (2009) proposes the typology “motors of sustainable innovation”. The typology identifies four patterns of feedback loops – known as motors – which are characterized by the presence of different structural components and system functions. Motors emerge more or less in an order as TISs go through phases of development (Suurs et al., 2010). Feedback loops are described as a sequence of events through which system functions materialize and influence each other, mediated by innovation system actors (Suurs et al., 2010). The Science and Technology Push Motor (STP) is mainly dominated by patterns where research outcomes [F2], positive expectations [F4] and resources mobilisation [F6] reinforce each other. The entrepreneurial motor is triggered by new entrants who partake in more commercially oriented projects [F1] and lobby for resources [F7]. Depending on the outcome of the projects, there is feedback into the dynamics of the system, which incentivizes or discourages [F4] the initiation of more projects [F1]. In the system building motor, entrepreneurs increasingly organize themselves into networks and platforms [F7]. They participate in activities, such as lobbying, that aim to strengthen the industry as a whole. If they are successful, they lead to positive expectations [F4] and increased availability of resources [F6] and in turn, an increased number of new entrants [F1]. Finally, the market motor, is assumed to be triggered by the setting of formal institutional structures that facilitate solid commercial demand [F5] and this contributes to a boost in all system functions.

The typology was advanced through the aggregation of results from case studies within the energy and mobility sectors and particularly in biofuels, hydrogen and fuel cell technologies, automotive natural gas and biomass gasification (Suurs, 2009). However, different industrial sectors follow different innovation patterns (Malerba, 2002). Taxonomies of innovation in different industries (Castellacci, 2008; Pavitt, 1984) have described the characteristics of different sectors and their influence on innovation trajectories. Pavitt (1984) distinguishes between supplier dominated, production intensive (scale intensive and specialized suppliers) and science-based industries. This categorization offers useful insights into the ways in which sectoral characteristics can influence the development of TISs.

Technologies and products in the context of energy and mobility sectors mainly follow innovation patterns that have been observed in industries described as science-based or advanced knowledge providers (Castellacci, 2008; Pavitt, 1984). Firms in science-based sectors mainly rely on the creation of knowledge through in-house R&D and scientific advancements by universities and public research institutes (Pavitt, 1984). Because technologies and products are radical in character, existing technical and institutional structures are not yet aligned with their needs. Therefore, their diffusion also depends on the build-up of new infrastructures and the creation of market niches (Bergek et al., 2008a; Hekkert et al., 2007). Because the risk associated with these technologies and products is high, the government typically needs to take the initiative of creating niche markets by a diverse set of policy instruments, such as favorable taxation for consumer products (Bergek et al., 2008a; Hekkert et al., 2007). Finally, the breakthrough of these technologies and products is intertwined with the formation of new institutions and user practices (Bergek et al., 2008a; Hekkert et al., 2007).

The food processing sector can be characterized as a supplier dominated industry when using the Pavitt taxonomy (Castellacci, 2008; Pavitt, 1984). Several indicators which measure dominant innovation trajectories, including orientation towards process innovation and investment share for the acquisition of advanced machinery and equipment from suppliers, reveal that the food processing sector has a lower technological content relatively to science-based or advanced knowledge providers and a large share of firms with limited ability to develop processes and products internally (Castellacci, 2008; Cuerva et al., 2014; Pavitt, 1984). Therefore, sources of innovation are usually external and lead to incremental improvement of efficiency of processes and quality of products (Castellacci, 2008; Pavitt, 1984). Moreover, contrary to sectors typically studied in TIS literature, in which niche markets are created through supportive government policies, in the food processing sector a wide variety of consumer groups which hold diverging norms support niche markets through their willingness to pay relatively expensive prices (Akaichi et al., 2019; Hughner et al., 2007).

### 3. Method

#### 3.1. Case selection and boundaries

In order to explore the development of TISs in the food processing sector, we selected the case of the plant-based meat substitutes industry in the Netherlands. Already in the 1990's, a few domestic meat substitute firms were active in the Netherlands. More recently, the country has become a frontrunner in plant-based meat substitute innovation. It is home to an industry association, which is composed of 18 firms, including leading firms Vivera and Meatless (Planeet, 2019). The region of Wageningen has developed a food innovation cluster which involves a large number of food firms, global agri-food incumbents and leading knowledge and educational institutions, including Wageningen University and Research. Additionally, plant-based meat substitutes are aligned with social structures to a certain extent. The 2015, the updated Dutch dietary guidelines include plant-based meat substitutes (CR, 2015). Further, the Netherlands is one of the largest and fastest growing national markets for meat substitutes globally (Changing markets foundation, 2018). According to data from the market research agency IRI, in 2017, the total retail turnover of plant-based protein products, including meat substitutes, was estimated at 368 million euros (Distrifood, 2017). Therefore, the case allows for the

analysis of the development of innovation processes over time on both on the supply and demand sides.

We define plant-based meat substitutes as products that take the place of meat in the human diet and have an appearance, texture and taste similar to meat products (Osen et al., 2014). Meat substitute firms depend on inputs which mainly stem from the agricultural commodities and biotechnology industries. These industries depend on several processes, such as plant breeding, protein isolation and functionalization. For the purposes of this paper the focus is kept on the food processing sector, but the analysis considers inter-dependencies that stem from the supply chain of meat substitutes.

### 3.2. Background of case: the meat substitutes industry

The supply chain of plant-based meat substitutes can be described in four broad steps. In the first step, a variety of protein crops are cultivated globally. In the second step, crops are procured and processed into protein ingredients, such as protein concentrates and isolates (Jones, 2016). In the third step, firms in the food sector purchase protein ingredients, formulate and process them into texturized intermediary products for the development of final meat substitutes. In the last step, products reach consumers through retail and food service.

The development of plant-based meat substitutes includes several different food processing technologies to structure raw materials into products that resemble the texture and taste of meat. We conceptualize technological development in the sector by drawing a distinction between first and second generation meat substitutes. First generation meat substitutes have existed in European markets since the 1990's (Aiking et al., 2006). They were mainly based on the intermediate product, Textured Vegetable Protein (TVP)<sup>1</sup>, which is produced with low moisture cooking extrusion (Asgar et al., 2010). The basis of extrusion is a screw system within a barrel. In the barrel, raw materials are compressed, heated to high temperatures and conveyed through a dye/dyes in order to expand into a final shape (Riaz, 2011). The resulting product is further processed for the development of final meat substitutes. Second generation meat substitutes reached European markets in the early 2000s due to advancements in cooking extrusion technology, such as the introduction of high-moisture cooking extrusion, and the deployment of processes from other (food) sectors, such as the utilization of hydrocolloids. Such advancements allowed the development of better performing products in terms of taste and texture and the use of a broader range of raw materials. For example, with high moisture extrusion, resulting products are characterized by well-defined fiber formations that closely resemble meat structures and have enhanced taste sensation (Lin et al., 2000; Yao et al., 2006).

Common raw materials are industrially produced protein ingredients based on plants (oilseeds, cereals, legumes, pulses and aquatic plants) such as soybeans, rapeseed/canola, wheat, rice, oats, peas, beans, lupines and algae. Different raw materials are in different phases of development ranging from experimentation to maturity. Selecting raw materials for product development depends on availability, cost, functional and physiological properties and nutritional value of different products (Smetana et al., 2015; Osen et al., 2014).

### 3.3. Data collection and analysis

The first step of this study was mapping the structural components of the TIS by identifying relevant actors, institutions, technologies and materialities. Data were collected from secondary sources, which were identified online and included news articles, firms and industry associations' websites, policy reports, research reports and scientific literature. In order to identify secondary sources, we used a set of predefined keywords, including *meat substitutes*, *plant-based protein*, *protein transition* and *protein innovation* (translated in Dutch). Then, we followed up on particular leads by adding more keywords, which included names of specific actors, networks, policies and events.

Afterwards, we conducted a qualitative event-history analysis between the years 1990–2017. Empirical data for the event analysis were first collected through the Lexis Nexis Database. Lexis Nexis is a database which collects news, legal and business information from thousands of print and online international and national (including Dutch) news sources. The accuracy of Lexis Nexis Database for this purpose has already been established in previous studies (Negro and Hekkert, 2008; Suurs and Hekkert, 2009). We used the same set of predefined keywords as for the structure analysis. The identified secondary sources were analyzed and events relevant to the development of the industry were organized in a database in chronological order. We also identified more sources, by using the same indicators in Google and three agri-food industry news outlets (distrifood.nl, evmi.nl, foodnavigator.com) and searching through the websites of relevant industrial, governmental and non-governmental organizations. The database contained approximately 450 events. The description of key system functions (Hekkert et al., 2007; Negro and Hekkert, 2008) was used as a heuristic for the identification of events, as well as codes in the database. This process allowed the re-construction of the narrative of the development of the meat substitute industry in the Netherlands and of the development of system functions. In the analysis section, each function was attributed a corresponding reference code: entrepreneurial experimentation [F1], knowledge development [F2], knowledge diffusion [F3], guidance of the search [F4], market formation [F5], resource mobilization [F6] and legitimacy creation [F7].

Following the event-history analysis, we conducted 30 semi-structured in-depth interviews with stakeholders in order to deepen our understanding of innovation dynamics and discuss emerging insights from the event analysis. We interviewed actors across the supply chain of meat substitutes, as well as actors from the government, research and educational institutes, and NGOs. In the

<sup>1</sup> Texturized Vegetable Protein (TVP) is mainly extruded defatted soy flour or flakes and soy concentrates (Asgar et al., 2010)

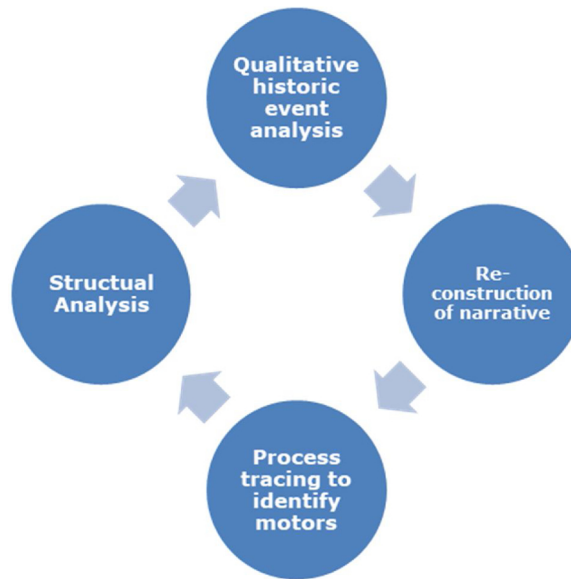


Fig. 1. Illustration of analysis steps adapted from Wieczorek and Hekkert (2012).

interviews, we explored the build-up of the system according to the different interviewees perspectives, their views on milestone developments and the importance of the different system functions. All interviews were recorded and transcribed. These transcripts were coded using the system functions. The interviews took place between June 2017 to February 2018. To encourage an open discussion, all interviewees were granted anonymity. In the analysis section, each actor was attributed a corresponding reference code. Table A1 in the Appendix provides more information about the interviews and the reference code of each interview.

Between February 2017 and January 2018, we updated the database by employing the same method of qualitative event analysis. The coding of the database was verified by a second researcher in order to increase the validity of the study. Minor differences in interpretations were discussed and resolved. The results of the two rounds of event analysis and interviews were compared and analyzed in order to finalize the narrative of the development of the Dutch meat substitute industry. Finally, during December 2018, a small number of important events were added in the database.

We used the method of process tracing to analyze whether motors of sustainable development could be identified. Process tracing is an analytical tool for drawing descriptive and causal inferences from qualitative data that are of a temporal sequence of events (Brady and Collier, 2010). A key step in process tracing is the development of detailed descriptions of key events in several points in time (Brady and Collier, 2010; Bennett, 2010). While it is impossible to present these descriptions in full, their development significantly contributed to understanding unfolding processes and analyzing change. We mainly highlight the findings relevant to understanding the overall dynamics of the innovation system and to show the presence of motors of innovation.

Fig. 1 summarizes the analysis of this paper as a cyclical process of iterative steps. Previous literature has also highlighted the iterative nature of methods employed for the analysis of TISs (Wieczorek and Hekkert, 2012).

## 4. Results

### 4.1. Early formative phase (1990–2006)

#### 4.1.1. TIS development

During the early 1990's, the meat substitutes industry was already comprised of users, a few firms and commercial but low-performing products. European vegetarians and vegans, driven by ethical, cultural or religious factors already consumed early meat substitutes [F5]. In the Netherlands, two international firms Quorn and Tivall dominated the market. A few Dutch firms, including Schouten Europe and Vivera, were established [F1]. They offered a narrow assortment of plant-based meat substitutes, mainly based on traditional preparations, such as tofu, and available intermediary products, such TVP. The market share remained very small because the products did not yet appeal to a wide range of consumers and there was no urgency for a healthy and sustainable agri-food system in public discourses.

Meanwhile, within environmental policy, attention on long-term environmental robustness was emerging, influenced by the publication of the Brundtland Report and the first Dutch National Environmental Policy Plan (Straaten, 1992). In 1993, the Ministry of the Environment initiated the interdepartmental Sustainable Technology Development (STD) program to assess the feasibility of technologies that could contribute in meeting human needs more efficiently (Vergragt and Grootveld, 1994; Weaver et al., 2000). After an initial assessment, meat substitutes were identified as a potential sustainability pathway within the theme of nutrition [F4]. The Novel Protein Foods (NPFs) of the Sustainable Technological Development program was initiated [F6]. It assessed available non-



animal protein sources and processing technologies for the development of the next generation of meat substitutes that could better satisfy consumer expectations [F2] (Quist, 2007). The results illustrated that the substitution of components of assembled or processed end-foods, such as minced meat, was feasible, but still knowledge was needed to manage a satisfactory texture and taste and large-scale production (Quist, 2007). Therefore knowledge development programs continued in the following years.

“The first initiatives have happened in the ‘90s, collaborating with the Wageningen and Amsterdam universities who did an initial analysis. They did research into what would be necessary for the protein transition... it ran for multiple years.” (PE4)

The most notable consequence of the NPF program was the establishment of the subsequent research program Profetas (Protein Foods, Environment, Technology and Society) (Aiking et al., 2006). In 1999, various ministries and academic bodies funded Profetas with 3 million Dutch Guilders (around €1.4 million) [F6] (Aiking et al., 2006). The program delivered knowledge on technological feasibility, sustainability, consumption opportunities and barriers regarding meat substitutes based on a single crop, pea [F2] (Aiking et al., 2006). In terms of technological feasibility, the results were equivocal. They illustrated that research in texturization processes was needed and it could not yet be assessed whether new products would better satisfy consumer preferences [F4] (Vereijken et al., 2006). Although five industrial firms, including incumbent Unilever, were involved in the program, no notable commercially oriented projects followed (Quist, 2007). Due to increased competition in the food sector, one meat substitute firm involved in Profetas, exited the TIS (Quist, 2007).

A few years later, between 1996–2006, crises related to livestock supply chains and increased public concerns over health and safety aspects of food, were driving developments in the TIS. The outbreak of bovine spongiform encephalopathy (BSE) crisis, referred to as mad cow disease, the dioxin crisis<sup>2</sup> and the outbreaks of avian influenza, known as the chicken flue, led to the mass media reporting numerous messages linking meat consumption to health risks (Morabia et al., 1999; Sans et al., 2008; Verbeke et al., 1999). Consequently, consumers increased demand for meat substitutes [F5]. Market research showed an increase in retail sales during particular months of crises and reproduced positive expectations for further growth [F4]. For example, according to data published in the newspaper NRC Handelsblad, during November and December 2000, the retail turnover from meat substitutes of three leading retailers in the Netherlands increased 10% on average (NRC, 2001). Entrepreneurs quickly responded to the increased consumer attention on meat substitutes. This led to the introduction of more meat substitutes by new brands [F1]. Still, the products mainly were based on available inputs and conventional processes [F5].

Positive expectations about future market growth also contributed to additional experimentation [F1]. Two important projects led to the establishment of the firms Meatless and Valess.

Meatless was established by a new entrant originating from the meat processing sector. The crises in the meat sector and the promise of value-added hybrid and vegetarian products incentivized the founder of Meatless to explore the development of plant-based meat substitutes [F4]. Because the range of commercially available intermediate products was limited, the project started by acquiring a process that utilized hydrocolloids for texturizing plant material that had been developed by an agro-industrial incumbent firm [F1]. As a result, in 2005, the firm Meatless introduced textured intermediary products based on wheat and rice that could be further processed into hybrid meat products or meat substitutes [F1]. This proved to be an important breakthrough in the development of the TIS.

Valess was established by the Dutch incumbent dairy cooperative Friesland Campina. Friesland Campina acquired a process for the texturization of dairy protein that had been developed by an individual a few years earlier [F1]. In 2005, the brand Valess was introduced to the Dutch market. Friesland Campina rolled out a €3 million marketing campaign [F6] (De Volkskrant, 2005a). The higher perceived quality of the product in terms of taste and promotion efforts led to further increases in sales of meat substitutes [F5]. Additionally, Valess received the annual award from the food innovation network Food Valley as the “healthy variation for meat” [F4] (Food Valley, 2019). This indicates that the main driver of entrepreneurial experimentation and accordingly the main framing of products was still substitution due to health risks from crises in meat supply chains.

“You have to understand that in 2000, 2002, 2003, there were no thoughts about sustainability and livestock. It was a different world, nobody was thinking about sustainability. We were thinking about healthy food.” (IF11)

The introduction of Valess and rising popularity of meat substitutes also triggered, for the first time, dissent. A dispute started between Friesland Campina and the animal welfare NGO Wakker Dier over the origin of the eggs used [F7] (De Volkskrant, 2005b). Additionally, the Dutch meat information office filed a complain against Valess [F7] because the promotional campaign directly compared the meat substitute with meat (ANP, 2005). The Dutch Nutrition Center issued a statement which clarified that dairy based substitutes do not have the same nutritional value as meat [F7]. The court ruled against Valess, which had to modify information on their website [F7]. This shows that the dominant cognitive institutions were well aligned with meat consumption and not shifting towards plant-based substitutes.

An independent development during this period was the introduction of the EU Novel Food Regulation. In 1997, as a result of efforts to harmonize food laws and pressure stemming from public concerns over uncontrolled imports of genetically modified soy, the European Commission adopted the Novel Food Regulation (Vogel, 2003). The regulation dictates a very expensive and time-consuming authorization procedure for the introduction of foods and ingredients into EU markets, which have not been consumed in EU to a significant extend before 1997. Since it applies to a number of potential raw materials for meat substitutes, it worked as a major barrier for firms to experiment with certain ingredients.

<sup>2</sup> The dioxin crisis refers to media reports in 1999 regarding elevated dioxin levels in poultry, eggs and pork (Verbeke et al., 1999)

#### 4.1.2. Motors of sustainable innovation

During the early formative phase, the emerging norm of meat substitution was crucial for the development of the TIS. Early users, vegetarians and vegan consumers, were the ones who first called attention to the idea of meat substitution and were willing to consume meat substitutes because they resonated with their anti-meat notions [F7]. Therefore, they created niche markets [F5] and incentivized early entrepreneurial experimentation [F1]. In this phase, exogenous influences contributed to positive expectations for the potential of meat substitutes and/or growth in markets, and drove the build-up of the TIS and the development of other system functions.

First, emerging sustainability awareness within a small group of policy makers and scientists led to expectations for the environmental improvement potential of the wider diffusion of meat substitutes [F4]. This led to the introduction of the NPF program [F6][F2]. The NPF program illustrated research pathways for the development of the next generation of meat substitutes that could appeal to a broader range of consumers [F4] and led to further research activities [F2][F3] including the funding of the research program Profetas [F6][F2].

Second, crises in meat supply chains incentivized non-vegetarian and non-vegan consumers to adopt meat substitutes for the first time [F5]. Entrepreneurs saw an opportunity [F4] and experimented with the acquisition and scale-up of processes to develop better performing products [F1]. New products in the market and accompanied marketing efforts reinforced consumer demand [F5].

At that time, meat substitution was not yet a pressing topic in political or public discourses. Important actors that could contribute in strengthening legitimacy for meat substitutes, such as the Dutch Nutrition Center, demonstrated resistance. Consumption of meat substitutes from groups, other than vegetarian and vegans, had been activated due to temporary health concerns. Market growth was unstable and, due to high competition in the food sector, firms exited the TIS. Therefore, feedback creation between functions was limited, the TIS was developing slowly and there is no indication of a presence of a motor of sustainable innovation.

### 4.2. Emerging TIS (2006–2010)

#### 4.2.1. TIS development

From 2006 onwards, the adverse impact of livestock production on sustainability and animal welfare became an important issue in public discourse for the first time. The publication of “Livestock’s Long Shadow” (Steinfeld et al., 2006) from the FAO was a turning point regarding wider awareness of the link between livestock, climate change and environmental degradation. In the Netherlands, the publication was used as a reference from political parties and societal organizations in emerging discourses regarding the sustainability of meat production. Coupled with the introduction of the political party “Party for the Animals” and the release of the documentary, *Meat the Truth* in 2007 narrated by the leader of the party (NGPF, 2019), meat production and consumption became an increasingly contentious issue.

The negative attention on livestock influenced the meat substitute industry in several ways. First, increased urgency in public discourse triggered the legitimization process for meat substitutes. A broader group of actors became involved in the TIS. Apart from NGOs solely focused on vegetarianism, organizations from health, animal welfare and environmental perspectives also started to support meat substitutes [F7]. For example, in 2007, the Dutch Association for Animal Protection gave the highest ranking to meat substitutes in a certification scheme that provided a ranking to meat products according to animal welfare standards (DBFlevoland, 2019) [F7]. In 2011, the environmental NGO Nature & Environment started promoting meat substitutes as part of one of the organizations campaigns [F7].

Because these actors were also attempting to convince others to embrace meat substitutes, they contributed to the build-up of knowledge regarding the nutritional value and the environmental impact of meat substitutes. Various assessment studies were conducted [F2] (Blonk et al., 2008; CR, 2011; Pluimers and Blonk, 2011; RIVM, 2011; Westhoek et al., 2011). An important outcome of this was that in 2011, the Health council of the Netherlands (CR) published the “Guidelines for good nutrition, the ecological perspective”, (CR, 2011). The publication led to the conclusion that less animal-based and more plant-based diets would benefit both public health and the environment [F7]. For the first time, it promoted the consumption of plant-based products, including meat substitutes [F7]. Therefore, cognitive and normative legitimacy for the TIS strengthened [F7].

“There was more and more science-based information and support from society, enough support from society as well from the government and NGOs and consumers [...] So, this was a very important milestone, kind of consensus, scientific consensus” (PE7)

Second, contestation and increased awareness regarding the adverse impacts of meat production, as well as increased policy attention on sustainability in general, practically led the ministry of Agriculture, Nature and Food Quality to introduce the Sustainable Food memorandum (LNV, 2009). The promotion of innovation in protein products offered an opportunity to address sustainability issues in the food system although without directly confronting the meat sector and meat production capacity. Therefore, between 2007–2010, the Sustainable Food memorandum [F7] had a focus on protein innovation [F4] (LNV, 2009) and consequently triggered the development of system functions. Table 1 summarizes programs in the context of the memorandum.

Third, increased urgency contributed to growing consumer demand for meat substitutes and renewed positive expectations for market growth [F4][F5]. Established firms, such as Vales, Vivera and Schouten Europe expanded their portfolios [F5]. Retailers became more involved by increasing shelf-space and introducing private labels [F5]. New brands entered the market; for example the plant-based drinks firm Alpro introduced a meat substitutes line [F1].

The enabling political environment significantly benefited entrepreneurial experimentation, particularly in SMEs. For example, in 2006, professionals in TOP BV, a technology provider for the agri-food industry, explored the potential of applying principles of high-moisture extrusion on the development of an intermediary plant-based meat substitute [F1]. The founders of Ojah successfully lobbied for financial resources to fund activities such as a scaling-up tests and the developing a production facility [F7][F6]. The

**Table 1**  
Programs in the context of the memorandum Sustainable Food (LNV, 2009).

Program	System functions	Resources
Innovations in Protein Chains program: broad focus on isolation processes for the introduction of novel protein sources with applications in both feed and food	Knowledge development (F2)	€6 million (F6)
Small Business Innovation Research (SBIR) subsidy scheme with the call replacement of animal proteins	Entrepreneurial experimentation (F1)	€1.7 million (F6)
Protein dialogue program: provided space for stakeholders, such as NGOs, experts and food firms, to discuss the possibilities for plant-based protein production and consumption	Knowledge diffusion (F3)	–

recently established company, Meatless, received project-based subsidies [F6][F1].

“We were struggling to move on, fairly high losses and an uncertain future. You need money for that, ... but the government was also helping to keep us going. And that was especially in the year 2006–2009. That was very important” (IF11)

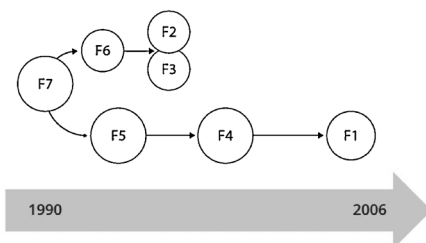
The establishment of innovative firms, and particularly Ojah and Meatless, was a milestone in the diffusion of products referred to as the second generation of meat substitutes. Both firms received a number of innovation awards and recognition [F4]. More importantly, they allowed the entrance of several other firms [F1] in the TIS. This is because many food firms do not develop products internally. They typically acquire products and focus on marketing and sales. Access to higher quality intermediary products allowed end-product firms to supply higher quality meat substitutes in terms of taste and texture. End-product firms employed innovative marketing strategies that draw from the emerging norm of meat substitution. For example, in 2010, the Vegetarian Butcher, which was the launching customer of Ojah, opened its first store with a public event during Animals Day (The vegetarian butcher, n.d.).

#### 4.2.2. Motors of sustainable innovation

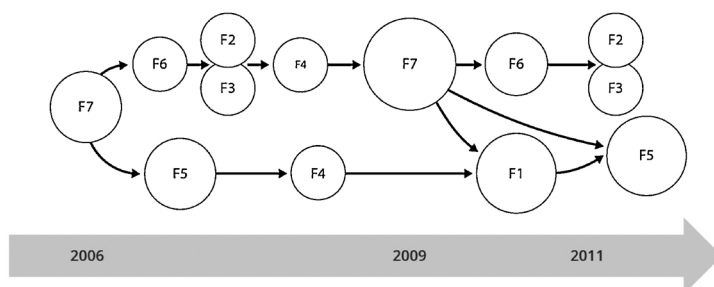
During this period, the main trigger of the development of system functions was normative contestation regarding the adverse impacts of meat and dairy production and consumption, which served as a driving force for the accelerated legitimization of the TIS. Actors which represented perspectives beyond vegetarianism and veganism supported the TIS. Diverse consumer groups started purchasing meat substitutes and contributed to more stable market growth. These developments led to feedback mechanisms, which indicate the emergence of a legitimacy-led motor. The legitimacy motor is characterized by a powerful double feedback loop. Fig. 2 illustrates the interaction between functions during the two phases of development of the TIS and the dynamics of the legitimacy motor during the second phase.

The motor started with a range of actor groups and organizations from various perspectives, including sustainability and health, embracing the norm of meat substitution and advocating for the wider diffusion of meat substitutes [F7]. The attempt of these actors and organizations to convince a critical mass to embrace meat substitutes contributed in the allocation of resources [F6] for the build-up of assessment studies regarding the nutritional value and the environmental impact of products [F2]. Positive results urged more actors and organizations to support the TIS and therefore strengthened its normative and cognitive legitimacy further [F7]. The support of government actors and the inclusion of the promotion of meat substitutes in the governmental agenda led to increased

Phase 1: 1999–2006



Phase 2: 2006–2011



**Fig. 2.** System functions dynamics during the legitimacy motor.



availability of resources. This led to the initiation of knowledge development programs across the supply chain and entrepreneurial projects that aimed to improve the performance of meat substitutes [F6][F2][F3][F1].

At the same time, urgency regarding meat production and consumption positively influenced consumer demand. Apart from vegetarians and vegans, the idea of meat substitution started to resonate with a broader range of consumers [F5]. The growing market led to positive expectations for further growth [F4] and incentivized firms to enter the TIS [F1]. This time, public funding [F6] reduced the risks of experimentation and contributed to the successful establishment of the firms Ojah and Meatless. These firms introduced higher quality intermediate products in the market [F1][F6]. The introduction of intermediary products was a cascading force for entrepreneurship. More end-product firms delivered new, better performing meat substitutes [F1]. Renewed supply and marketing reinforced consumer demand further [F5].

#### 4.3. Towards growth (2011 onwards)

##### 4.3.1. TIS development

Internationally, recognition of the adverse health impacts of meat (over-) consumption was growing. A milestone was the acknowledgment of the link between the consumption of certain processed meat products and cancer from the World Health Organization (WHO) (Bouvard et al., 2015). Also, the livestock sector was becoming more prominent in EU climate mitigation policies. Milestones included the inclusion of agriculture in the EU roadmap towards a low carbon economy and the Paris Agreement (EC, 2011; UNFCCC, 2015).

In the Netherlands, legitimacy for meat substitutes continued to strengthen. In Fig. 3 the analysis of articles in three Dutch newspapers between 1998–2017 illustrates that public discourses were becoming increasingly positive [F7].

A decisive development came in 2015. Building on knowledge developed in the previous years, the Dutch Nutrition Centre revised its official dietary guidelines (CR, 2015). For the first time, the advisable consumption of meat decreased and the guidelines included meat substitutes [F7]. Because the Nutrition Centre is the formal authority for the provision of reliable and independent information regarding food products, embracing meat substitutes was a breakthrough for the institutionalization of products as a pathway to a healthy and sustainable food system.

The activities of the meat substitute industry were also crucial to the growing legitimization of the TIS. Firms started to collaborate in formal associations and networks. In 2012, the 13 key industrial actors of the sector came together in the first industry association, The Planet (Het PLaneet) [F7]. In this case, in order to develop the market for meat substitutes, firms in The Planet did not mainly focus on lobbying in favor of supportive regulations but they sought to further normatively and cognitively associate products with the meat substitution norm. An important example of such strategies was the establishment of the Green Protein Alliance (GPA) in 2016. The GPA is a multi-stakeholder platform comprised of several members and partners including meat substitute firms, the Nutrition Center and the NGO Nature and Environment [F7]. The aim of the GPA was to change the protein consumption balance in the Netherlands from 37:63 to 50:50 protein (plant:animal) by 2025 [F4] (GPA, 2017). The formal association between firms and organizations representing the perspectives of health and sustainability, as well as the commitment to the goal of changing the protein consumption balance and the activities that followed fed back into the legitimization of the TIS [F7].

“Finally, there is also a role for government authorities and NGOs. Let’s call them credible influencers. They have to convey the serious, rational message and educate the public.” (IF12)

“Collaboration on this topic usually also means, that they can [...] and work together with government agencies or semi-government, such as the Dutch Nutrition Centre, which gives them a lot of credibility because the Dutch nutrition center would never work with just one company but they will work together with a number of companies that work together with the government.” (PE3)

Moreover, once again, contestation regarding the adverse health and sustainability impacts of meat production and consumption and strengthened legitimacy for meat substitutes contributed to the renewed enthusiasm in the government to accelerate the protein

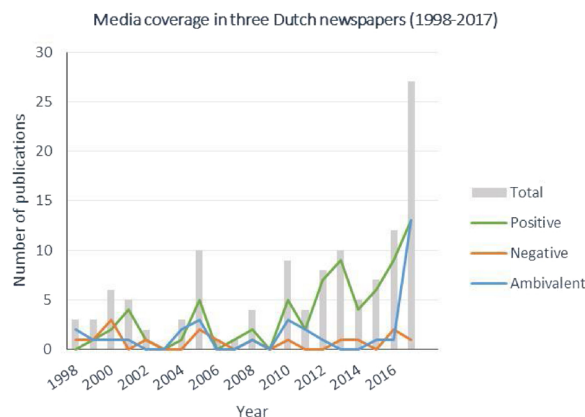


Fig. 3. Media analysis of three Dutch newspapers (De Volkskrant, NRC, Algemeen Dagblad) between 1998–2017.

transition. The publication of the critical report “Towards a Food Policy” (WRR, 2014) from the Netherlands Scientific Council for Government Policy (WRR) heavily criticized the food related regulatory framework and triggered the introduction of the Food Agenda for Safe, Healthy and Sustainable Food (EZ, 2015). The Food Agenda included aims relevant to the meat substitutes industry and was followed by allocation of resources through a number of subsidies and programs for knowledge development and entrepreneurial projects [F6] [F2] [F1].

This period also demonstrates incidences of significant financial resources becoming available directly from users. One example is the successful employment of crowdfunding for research into shear cell technology. Researchers in Wageningen and Delft Universities had been exploring the possibilities of shear cell technology as a manufacturing process for plant-based meat substitutes. Shear cell, or coquette cell, technology offers the benefit of allowing to replicate complete muscular parts of animals, such as chicken breast or beef meat (Krintiras et al., 2016). In collaboration with the founders of the Vegetarian Butcher, a foundation was established which attracted financial resources from crowd funding in order to fund ongoing research [F6]. Another striking example is that in 2015, the Vegetarian Butcher issued a bond loan for consumers to help finance the construction of a new production plant. As a result, the firm managed to raise 2.5 million Euros [F6][F1] (The vegetarian butcher, n.d.). These examples illustrate ways in which users were among the main actors participating in the fulfilment of system functions, as well as the exceptionally strong normative and cognitive legitimacy of the industry. The developments described in these phase led to an overall enabling environment for the TIS.

“And why the time was right, I think within society there was in the Netherlands the Party for the Animals, more and more pressure ..., more and more companies who offer interesting alternatives, there was the report from the WRR, the scientific council for policy, ... that was an important one for this government”(PE6)

Market demand for meat substitutes started becoming an important trend. According to data from the market research agency IRI, the average yearly turnover growth of meat substitutes in Dutch retail stores between 2014–2017 was 8,1% (Distrifood, 2017). For example, the Vegetarian Butcher grew from one store in 2010 to products being present in more than 3000 sales outlets in 14 countries by 2015 [F5]. This led to increasingly positive expectations for the future of the market[F4].

“All signs are green at the moment for us, yeah consumers are very enthusiastic and what is also important is that there are very negative rumors about meat production and that influences people also.” (IF3)

Positive expectations [F4] also contributed to experimentation and knowledge development across the supply chain of meat substitutes [F1][F2]. The growing trend of entrepreneurial experimentation is illustrated in the number of projects that received financial support from 7 Dutch subsidy programs and financial instruments between 2010–2017 (Fig. 4). Successful projects downstream the supply chain led to the introduction of new raw materials, including rapeseed, quinoa and algal ingredients [F1] and renewed technological opportunities. Additionally, firms across the supply chain had started to build learning networks and platforms. Examples include the introduction of the trial facility Green Protein Accelerator for joint development of end-products and the Green Protein Cluster for knowledge sharing between industrial actors [F3].

By 2016, agri-food incumbents had started acquiring successful meat substitute firms around the world (Changing markets foundation, 2018). In 2017, Kerry group acquired Ojah and the following year, Unilever, one of the largest agri-food firms globally, acquired the Vegetarian Butcher (Evmi, 2017, 2018). This indicates that the meat substitutes industry offered interesting opportunities for incumbents and was becoming closely related to the agri-food sector.

“You often see that when small companies give the good example, and show that it is not just the sustainability part, but also the commercial part [...] that actually people can make money then you see that also the bigger companies are interested. And that’s what happening right now, and that is a very good development. It’s not just about sustainability, it is also very commercial” (PE8)

Finally, as a response to the rising popularity of meat substitutes, direct resistance in the form of contestation regarding the naming of meat substitutes and whether they could use animal terms, such as vegetarian chicken or sausage, re-surfaced. In 2017, the Vegetarian Butcher modified the description of a number of products on its website as a response to an investigation from the Dutch Food and Consumer Product Safety Authority (NVWA), which was brought by “complaints” (NRC, 2017). Similar developments in other European countries led European livestock industry groups to begin calling for legal restriction in the labelling of substitute products [F7] (Food Navigator, 2018).

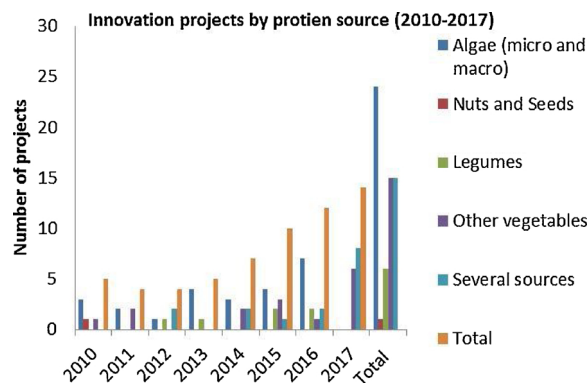


Fig. 4. Number of projects that received financial support from 7 subsidy programs and fiscal instruments in the Netherlands (2010–2017) adapted from (Hielkema et al., 2018).

#### 4.3.2. Motors of sustainable innovation

This period indicates that the system was moving towards the growth phase. The TIS was becoming closely tied to the food sector and the market was growing rapidly. Rapid entry rates and the increasing trend of incumbents acquiring meat substitute firms indicates that the system was driven by the market motor in which the growing market pulls the strong fulfillment of all system functions.

At the same time, the activities of the meat substitute industry played an important role in these developments. Firms organized in networks and associations. Relevant patterns of activities and/or events that followed have been coined as the system building motor (Suurs, 2009). For example, firms initiated the Green Protein Cluster [F3]. They managed to draw in the (financial) support of the local governments [F7][F6] and this incentivized more new entrants [F1]. A distinctive aspect of the case in terms of the system building motor is that activities that aimed at the development of the market mainly aimed at further strengthening normative and cognitive legitimacy for the sector by becoming formally associated with independent organizations from health and sustainability perspectives.

Fig. 5 summarizes the chronological development of the plant-based meat substitutes TIS in the Netherlands.

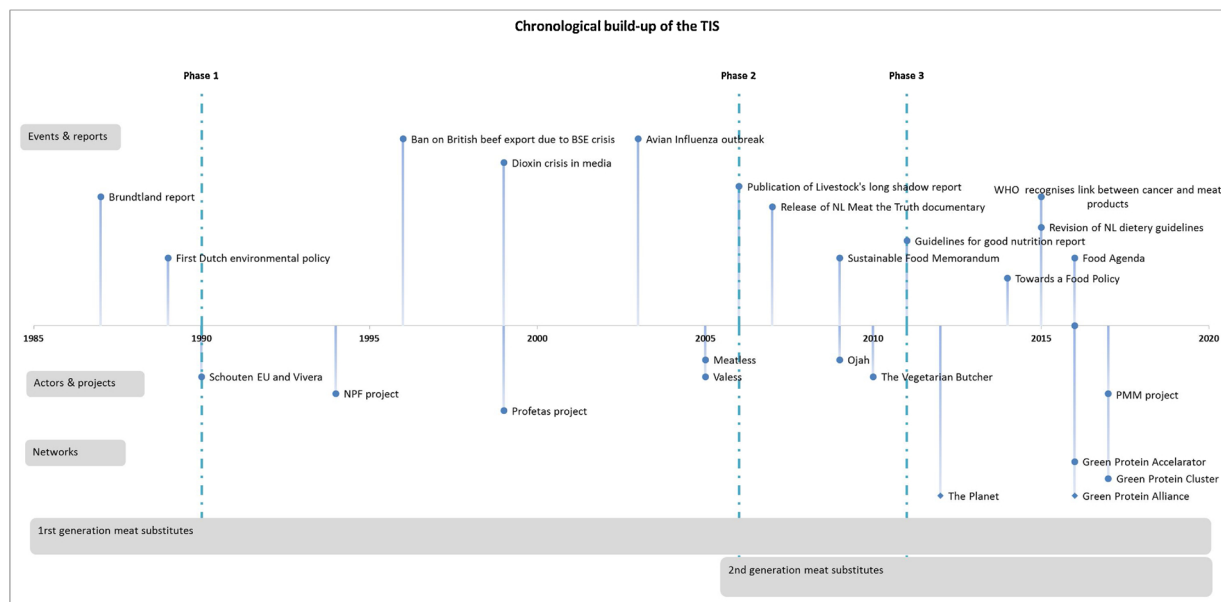


Fig. 5. Summary of the key events during the development of the plant-based meat substitutes TIS in the Netherlands.<sup>3, 4</sup>

## 5. Discussion and conclusion

The case illustrates the crucial role of users and emerging norms for the build-up of TISs in the food sector. The role of such groups of actors, coined as 'norm-entrepreneurs', has been discussed in political change literature (Finnemore and Sikkink, 1998). Norm entrepreneurs first call attention to specific issues and challenge the appropriateness of alternative norms and behaviors (Finnemore and Sikkink, 1998). In this case, the role of vegetarians and vegans was pivotal in challenging the appropriateness of meat consumption and initiating normative contestation. Moreover, because of their strong notions against meat consumption, they also supported the consumption of meat substitute products. This way, they first triggered the emergence of the meat substitute TIS by creating markets in which consumers were willing to pay expensive prices for early meat substitutes. Already before the 1990's, they had incentivized a small number of firms to enter the TIS. For many decades, the TIS was composed of norms, users, niche markets, a few firms and low-performing products. This early market and the presence of profitable firms would become a key component for other actors to move in later phases.

During the early formative phase, mainly exogenous influences contributed to the development of system functions. Crises in meat supply chains were important in triggering temporary health concerns and in turn patterns of increased consumer demand, positive expectations for market growth and entrepreneurial experimentation with new inputs and processes. However, at the time, the structuration of the TIS was low; important actors did not yet support it and therefore functional fulfillment was unstable and relatively independent. In the second phase, increased awareness regarding adverse impacts on the climate, the environment and animal welfare led to amplified normative contestation around meat in public discourses. This changed the way meat substitution was understood. As the frame of meat substitution evolved from altruistic and ethical considerations to broader sustainability considerations, it resonated with more actor groups and organizations. Accordingly, more actors accumulated in the meat substitutes

<sup>3</sup> Fig. 5 is not a comprehensive depiction of all relevant events, but an illustration of the key events discussed in the results section.

<sup>4</sup> Fig. 5 illustrates the (approximate) year/date of the establishment of firms.

TIS. This led to a growing degree of normative and cognitive legitimacy and accelerated the build-up of the TIS.

The types of interactions between functions that were observed during the second period have not been described in the motors of sustainable innovation typology of [Suurs \(2009\)](#). Therefore, in this paper, we introduce the legitimacy motor. The core dynamics of the motors are characterized by a double feedback loop.

The motor starts with groups of actors and/or organizations, including NGOs and independent organizations, which embrace an emerging norm and support the promotion of products with certain characteristics because they resonate with this norm [F7]. Therefore, they start to shape normative and cognitive legitimacy for the TIS. The attempt of these actors and organizations to convince a critical mass to also support the TIS contributes to the development of assessment studies [F2]. Positive results urge more actors and organizations to partake in the TIS and therefore strengthens normative and cognitive legitimacy further [F7]. When government actors become involved, they contribute financial funds through subsidy programs to facilitate the improvement of the performance of products. This leads to initiation of entrepreneurial and knowledge development projects.

At the same time, growing legitimacy for products positively influences market growth. The growing market leads to positive expectations for further growth [F4] and incentivizes the initiation of more projects [F1]. Availability of public funding reduces the risks of experimentation and contributes to the successful results of projects. Firms introduce higher quality products in the market. Renewed supply and marketing reinforce consumer demand further.

The legitimacy motor contradicts the motors of sustainable innovation typology ([Suurs, 2009](#)) in terms of the structural build-up of the TIS and the sequence that different system functions emerge. The motor started with users and societal organizations who drove the fulfillment of cognitive and normative legitimacy and created niche markets. This early cognitive and normative legitimacy, as well as the presence of markets amplified the involvement of policy makers, knowledge institutions and entrepreneurs in resource mobilization, knowledge development and entrepreneurial experimentation processes. In that respect, contrary to the motors of sustainable innovation typology, societal contestation and actors, including users and NGOs, provided an early “incubation ground” for industrial innovation.

The dynamics of the legitimacy motor could potentially apply to other supplier dominated industries and producers of consumer goods, particularly because large scale individual collective action as a response to sustainability challenges becomes a more important trend ([Bennett, 2012](#)). However, we suggest that the successful realization of consumer demand as a driver in the early build-up of the TIS is closely related to the concept of customer benefit ([Kammerer, 2009](#); [Horbach et al., 2012](#)). The rationale of the customer benefit concept is that “green” products that have private benefits for consumers will generate stronger consumer demand and create incentives for firms to introduce innovations ([Kammerer, 2009](#)). Our analysis illustrates that meat substitutes have had strong perceived customer benefits linked to health. Growing legitimacy for meat substitute products is determined to a large extent by perceptions that substituting meat consumption is beneficial for personal health. Due to this added-value, consumers are more willing to pay a high price for low-performing products and as a result firms are more motivated to introduce innovations. Therefore, we argue that the legitimacy motor is more likely to be observed in industries which offer consumer goods with perceived private benefits.

Technological change and the development of higher performing products was crucial for appealing to potential user groups beyond dedicated vegetarians and vegans and ultimately achieving market expansion. The impact of the legitimacy motor on the availability of public resources significantly contributed to offsetting the risk of experimentation, particularly in SMEs. It was very important for the successful introduction of new intermediary products. Because a large share of food firms does not develop products internally, this was a key precondition for the breakthrough of the second generation of meat substitutes. Therefore, although intervention in the form of hard regulations was missing, policy was still pivotal for the development of the TIS.

We argue that governmental actors chose to support innovation in meat substitutes partly because it was an opportunity to address pressure without directly challenging the meat sector. In general, the promotion of innovation is politically more feasible than the promotion of reducing consumption or decreasing production capacity of established sectors. Therefore, on the one hand, it offers a leeway for surpassing political lock-ins but on the other it can also become an averting strategy and inhibit the rapid development of transitions.

During the third phase of the development of the TIS, the market started to drive the fulfillment of system functions, indicating the presence of the market motor. Since the market had been triggered by normative and cognitive legitimacy, politics remained important, which is in contrast to [Suurs \(2009\)](#), who argue that legitimacy and political activities lose their importance with the emergence of the market motor. Therefore, the third phase also indicates the emergence of the system building motor, in which actors attempt to strengthen the TIS. In this case, they aimed at supporting the legitimation process for meat substitutes. Indeed, as recent TIS literature has demonstrated, the legitimation process of a TIS is not just the direct consequence of accumulation of actors in a system, but also the result of deliberate actors’ strategies ([Binz et al., 2016](#); [Kukk et al., 2016](#)). The case illustrates an interesting strategy that aimed at developing the market. Meat substitute firms initiated formal associations with NGOs and organizations from health and sustainability perspectives. This way, they managed to further strengthen cognitive and normative links between meat substitutes and the emerging norm of meat substitution by earning the official endorsement of independent organizations.

Direct resistance to the TIS was connected with the emerging norm of meat substitution. During the early formative phase, when the need to substitute meat consumption was highly contested, important actors, such as the Dutch Nutrition center opposed the meat substitutes industry. As the norm of meat substitution and meat substitute products were becoming more institutionalized, the same actors started to support the TIS. Additionally, in line with [Mylan et al. \(2018\)](#) who studied the diffusion of plant-based milk in the UK, this case illustrates that farmers are more locked-in to livestock production and therefore, contrary to manufacturing firms as the TIS was growing, they opposed it directly.

The aforementioned observations confirm that the growth of the meat substitute industry is an example of endogenous enactment in transitions. Early transitions literature was mostly focused on the efforts of new entrants who struggled against incumbent firms to introduce radical innovations, which necessitated fundamental changes in organizations, technologies, infrastructures, markets, regulations and user practices ([Geels, 2002](#); [Loorbach, 2010](#)). More recent studies also acknowledge the important role of incumbent firms and

incremental reorientation, which can contribute to the enhancement of the performance of the system (Geels et al., 2016). Indeed, this case illustrates an example of push and pull factors for the reorientation of the food processing industry and possible levers for sustainability transitions. Nevertheless, the directionality of these processes and their contribution to sustainability should be examined with caution.

To sum up, this case illustrates that, contrary to TISs in the energy and mobility sectors even during the formative phase, TISs can be composed of firms, niche-markets and commercial products. Second, it highlights the crucial role of users in the food sector, who hold norms about appropriate behavior and consequently provide niche markets and trigger early innovation processes. Third, it shows how the gradual institutionalization of norms can lead to growing normative and cognitive legitimacy for TISs and contribute in the acceleration of its build-up in the absence of supportive tax schemes for sustainable consumer products. Overall, it emphasizes the role of users and cognitive and normative institutions as leverage for sustainability in the food sector and possibly in other supplier dominated industries which manufacture consumer goods.

Future research could further unpack the relationship between emerging norms and the legitimation process of TISs. Such research could investigate the political context in which TISs develop, why and how particular norms emerge and which conditions are important for them to be embraced by different actors. Moreover, future research could more closely investigate the system building activities of actors. Although this paper indicates interesting examples, its aim is to explain the dynamics on the system level. Therefore, it does not systematically analyze micro-activities. An interesting research avenue would be to explore the discourses of a broad variety of actor groups and how they change as a TIS develops.

### Declaration of Competing Interest

None.

### Acknowledgement

This research has received funding from the European Union Horizon 2020 research and innovation programme under grant agreement no 730053 (REINVENT). We would like to thank the reviewers for their constructive feedback. We would also like to thank all contributing interviewees for partaking in this research. Finally, we wish to thank Arielle de Jong and Gijs Leeuwen for their valuable research assistance.

### Appendix A

**Table A1**  
Information about interviews.

Type of organization	Interview details	Code
Consultancy	Interview conducted in person in October 2017	PE1
Consultancy	Interview conducted in person in November 2017	PE2
Consultancy	Interview conducted in person in June 2017	PE3
Farm	Interview conducted in person in November 2017	IF1
Firm	Interview conducted in person in October 2017	IF2
Firm	Interview conducted via Skype in October 2017	IF3
Firm	Interview conducted in person in October 2017	IF4
Firm	Interview conducted via Skype in October 2017	IF5
Firm	Interview conducted in person in October 2017	IF6
Firm	Interview conducted via Skype in November 2017	IF7
Firm	Interview conducted in person in November 2017	IF8
Firm	Interview conducted in person in November 2017	IF9
Firm	Interview conducted in person in November 2017	IF10
Firm	Interview conducted in person in November 2017	IF11
Firm	Interview conducted in person in November 2017	IF12
Firm	Interview conducted in person in December 2017	IF13
Government	Interview conducted in person in November 2017	PE4
Government	Interview conducted in person in February 2018	PE5
Government	Interview conducted in person in July 2017	PE6
Government	Interview conducted in person in September 2017	PE7
Industry organization	Interview conducted in person in December 2017	IO1
Industry organization	Interview conducted via telephone in June 2017	IO2
NGO	Interview conducted in person in June 2017	NGO1
NGO	Interview conducted in person in June 2017	NGO2
NGO	Interview conducted in person in November 2017	NGO3
NGO	Interview conducted in person in November 2017	NGO4
Research	Interview conducted in person in September 2017	R1
Research	Interview via telephone in November 2017	R2
Research	Interview conducted in person in December 2017	R3
Independent Expert	Interview conducted via telephone in December 2017	PE8



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