Valorization of side streams in the food supply chain

A case study of the adoption of misshapen produce in the Netherlands

Master thesis

Submitted by J. Deckers (Jo), BSc

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First supervisor Dr. B. Kopainsky (Birgit)

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Date ‘s-Hertogenbosch, June 23, 2017

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's-Hertogenbosch, June 23, 2017

Lectori salutem,

The thesis that is in front of you is the end-product of years of learning, developing, and enjoying life. I am grateful for having had the privilege to live in good health, with great people and excellent facilities around me that provided me with all the needs and opportunities to choose my way in this world. This privilege, that so many people on this planet do not have, enabled me to present you this thesis after months of hard work.

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To all, I hope you will enjoy reading this thesis.

Jo Deckers

Abstract

In a context of increasing food insecurity, this thesis introduces a case study that evaluates adoption of misshapen produce by consumers as act to counteract food wastage. Apart from some separate events that report financial benefits, there is little known about what exactly drives adoption of misshapen fruits and vegetables and whether food waste is actually reduced. The potential of this type of valorization of side streams in the food supply chain as business model is assessed by investigating the interplay between human agents and social structures in the social practice of adoption. This interplay is represented in a system dynamics simulation model that is developed and calibrated based on a triangulation of literature, interviews, and observations. In this model, the wide variety of factors that are considered to influence adoption of misshapen produce boil down to a few causal structures that explain the majority of its development. These causal structures connect an acceptance dynamics framework with a supply chain model of vegetable production in the Netherlands. The model is used for testing (combinations of) policies aimed at subsidizing prices, generating food wastage awareness, creating motivation, and developing skills in relation to misshapen produce. It is found that a major constraint in the adoption potential of misshapen produce is the limited supply of misshapen produce, which is a fraction of total fruits and vegetables production. Policy tests over different scenarios in the Dutch food supply chain indicate that the implementation of a subsidy plan for partially reimbursing the price consumers pay for acquiring misshapen produce and the price farmers receive for supplying misshapen produce in combination with a nationwide marketing campaign for generating food wastage awareness uses the full (constrained) adoption potential of misshapen produce. An interesting finding, however, is that adoption of misshapen produce does not reduce food wastage in the food supply chain. Based on the findings from this exploratory research, many directions for further research are given for further exploration of misshapen produce as viable business model and for further development of the concept of adoption dynamics.

Keywords: system dynamics; adoption and diffusion; fresh food supply chain; misshapen produce; food wastage

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PART I: Introduction

The first part of this thesis introduces the background and setting of this research (see Figure 1). In chapter 1 the research setting is presented in terms of problem description and problem definition. Subsequently, the research objectives and research questions this thesis addresses are introduced and the outline of this research is presented. Chapter 2 introduces a core structure in this thesis, namely adoption dynamics. A detailed description of adoption dynamics as combining acceptance dynamics and supply chain dynamics is provided here. The final element of this introductory part is the research design described in chapter 3. The chapter covers the choice of research strategy and research object, the approaches for data collection and analysis, and research ethics.

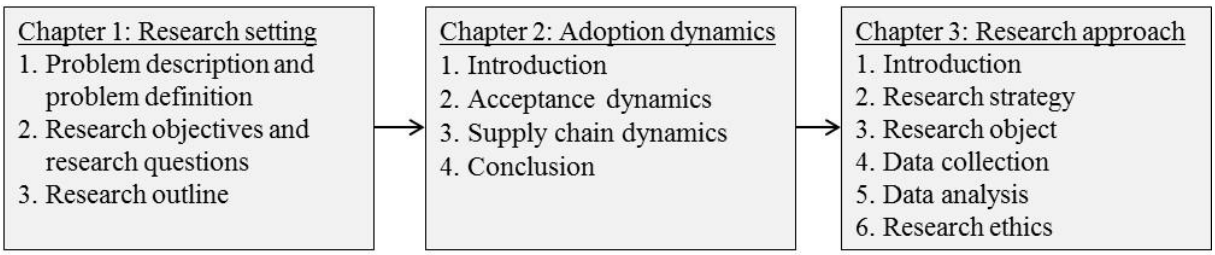


Figure 1: Introduction

1. Research setting

1.1 Problem description and problem definition

Food security is considered to be one of the biggest issues humanity faces. The global demand for food has been increasing and will be increasing over the next decades as a result of continuing growth of population and its affluence (Godfray, Beddington, Crute, Haddad, Lawrence, Muir, Pretty, Robinson, Thomas & Toulmin, 2010). In this respect, it is striking that estimates are that 30 to 40 percent of food is lost to waste (Nellemann, MacDevette, Manders, Eickhout, Svihus, Prins & Kaltenborn, 2009). Many researchers demonstrate the inefficiency of this practice from both an economic and an environmental perspective (e.g. De Hooge, Oostindjer, Aschemann-Witzel, Normann, Mueller Loose & Lengard Almli, 2017) as production of food contributes for one third of all greenhouse gas emissions (Garnett, 2011) and it requires many valuable resources, like water, energy, and land (e.g., Godfray et al., 2010). Hereby, food waste negatively contributes to pressing issues like climate change and water shortage (e.g., Bagherzadeh, Inamura & Jeong, 2014).

Food waste is seen as any food appropriate for human consumption that is removed from the food supply chain to be disposed or recovered (e.g., composted; ploughed in; used for bio-energy production; converted to animal fodder) (FAO, 2014). All food waste is avoidable as it was edible at some point prior to disposal (e.g., slices of bread; fruit; meat) (Bagherzadeh et al., 2014; WRAP, 2009). Whereas in developing countries waste arises mostly upstream from the production and processing stages, in so-called developed countries, waste arises mostly downstream at the retail and consumption stages of the food supply chain (Godfray et al., 2010). In developed countries' downstream stages, many edible products are sorted out due to aesthetic quality standards (Lipinski, Hanson, Lomax, Kitinoja, Waite & Searchinger, 2013). These products are often redirected to different purposes that generate lower value. This valorization of side streams has been one of the major preoccupations of food industries in developed countries.

The problems associated with the themes of food security and food waste are far-ranging. Food waste is presented by the United Nations Food and Agriculture Organization (FAO) as one of the most pressing issues (2014). The FAO (2014) reports that the yearly food wastage volume for agricultural products worldwide is the highest for fruits and vegetables (including roots and tubers), namely 64 percent of total food wastage. Over the last years, this particular product group is considered to have potential for reducing avoidable food waste. In 2014, Intermarché – a retailer with over 1800 supermarkets in France – launched a campaign to start sales of fruits and vegetables of low aesthetic value due to their abnormal shape. The resulting success quickly led other retailers to follow, among which Dutch retailers (e.g., Albert Heijn, 2014). The marketing bureau behind the success story, Marcel Worldwide (2014), reports a financial benefit for consumers, growers, and retailers. Contrary to existing research, De Hooge et al. (2017) signal that there are some indirect suggestions that consumers are interested in adoption of suboptimal food at retailers. There is little known, however, about what drives the adoption of misshapen fruits and vegetables (e.g., Loebnitz, Schuitema & Grunert, 2015). Next to that, there is disagreement about whether adoption of misshapen fruits and vegetables actually reduces food waste as scientists generally perceive food waste as food not being consumed, while producers and processers generally perceive food waste as food not generating economic value.

For these reasons, adoption of fruits and vegetables (hereafter: adoption of produce) that would otherwise be wasted due to aesthetic standards in a developed country (the Netherlands) is the focus in this research. From recent findings it is clear that consumers are interested in adopting misshapen fruits and vegetables (e.g., De Hooge et al., 2017) and that the supply chain is able to organize the provision of misshapen fruits and vegetables (e.g., Marcel Worldwide, 2014). Still, apart from some separate events, there is no formal indication of a trend

in adoption of misshapen fruits and vegetables. Therefore, the assumption in this thesis is that the adoption of misshapen fruits and vegetables currently is in equilibrium, but that there is potential for an increase in adoption.

1.2 Research objectives and research questions

The primary objective of this research is to elicit the drivers of adoption of misshapen produce in the Netherlands. This objective is achieved by analyzing the causal relationships between product characteristics (e.g., price), consumer characteristics (e.g., food wastage awareness), and adoption of misshapen produce as well as analyzing the causal relationships between operations in the fresh food supply chain and adoption of misshapen produce.

The secondary objective of this research is to develop robust policies that stimulate adoption of misshapen produce in the Netherlands. Policies are robust if their effectiveness is not sensitive to minor variations in the policies' context. This objective is reached by analyzing the structure and behavior of the system as representation of reality as well as developing and testing multiple policies aimed at reducing food waste.

The research is primarily theory-oriented in its aims to contribute to the understanding of adoption of misshapen produce by testing adoption policies in a dynamic framework. In this thesis, a system dynamics model that represents socio-technical and socio-economic aspects of the adoption of misshapen produce is developed and calibrated by a triangulation of the methods literature review, interviews, and conjoint analysis. For reaching the research objectives, the research question to be addressed is:

Which processes drive adoption of misshapen produce in the Netherlands?

For answering this research question, answers to these sub-questions are to be found:

a. *Which product characteristics causally relate with adoption of misshapen produce?*
b. *Which consumer characteristics causally relate with adoption of misshapen produce?*
c. *Which operations in the fresh food supply chain causally relate with adoption of misshapen produce?*
d. *Which components of adoption of misshapen produce causally relate with operations in the fresh food supply chain?*
e. *Which robust policies stimulate adoption of misshapen produce?*

1.3 Research outline

This thesis consists of four parts that each represent main steps in the research project. Part I introduces the background and context of this project. Chapter 1 introduced the research setting in terms of problem introduction. In the following chapter, adoption dynamics – a concept at the core of this research – is introduced. Chapter 3 describes and substantiates the chosen research approach.

Part II describes the collection and analysis of data for model development and model calibration. First, the theoretical framework is introduced in chapter 4 in terms of the theoretical background related to adoption of produce. Chapter 5 complements the findings from chapter 4 with results from interviews. These findings serve as the basis for the conceptual framework that is introduced in chapter 6.

Central in the third part of this thesis is the simulation model. After a report on the validation of the model in chapter 7, results from the model in terms of structure and behavior are provided in chapter 8. Based on these results, chapter 9 describes the development and testing of policies for the design of a robust policy for stimulating adoption of misshapen produce.

In part IV, the thesis reflects on the process and outcomes from this research. Chapter 10 facilitates the discussion of limitations and outcomes, followed by a conclusion in chapter 11. The research outline as described above is summarized in Figure 2.

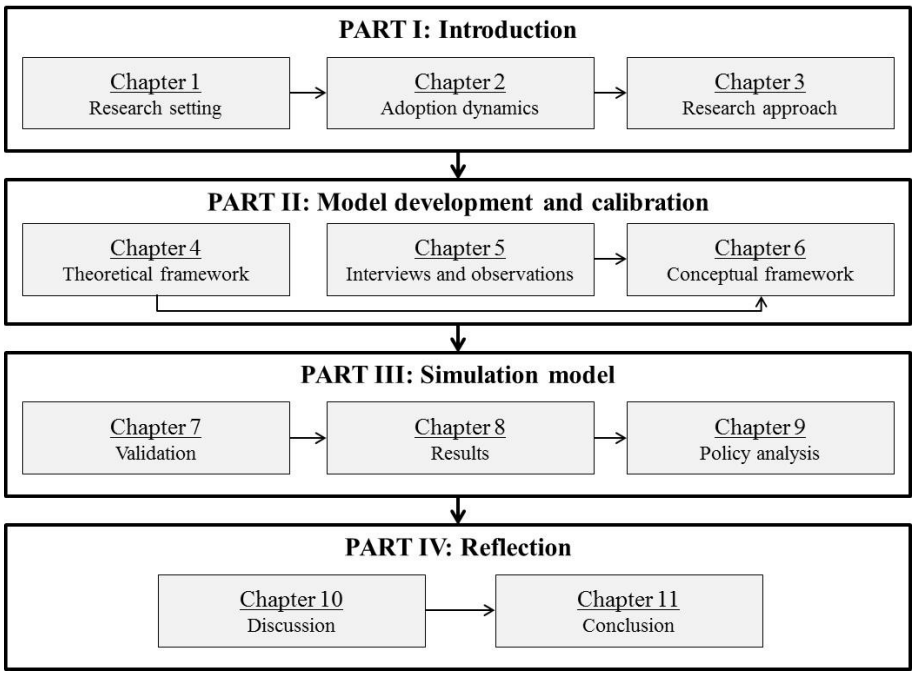


Figure 2: Research outline

2. Adoption dynamics

2.1 Introduction

A core structure in this thesis is the research of a social practice in the context of interactions with both human agents and social structures (see Figure 3). In analyzing so, this research combines an individualist paradigm (e.g., economics; social psychology) with a (technological) system paradigm (e.g., structuralist sociology), thereby adhering a social practice approach (e.g., Sassatelli, 2007; Warde, 2005). Human agents (e.g., consumers), interact in a social practice (e.g., adoption of produce) through their individual lifestyles. Based on their lifestyles they decide to act in a social practice and, in turn, their social practice confirms and shapes their lifestyle. Social structures (e.g., the food supply chain) in terms of a system of provision interact in a social practice as well. The system of provision enables the social practice to take place and, in turn, the act of a social practice changes and forms the system of provision. Spaargaren and Oosterveer (2010) introduce this as an interplay between appropriation and provision taking place in a social practice. On a more practical level, this can be seen as an interplay between agents and objects (Spaargaren & Oosterveer, 2010).

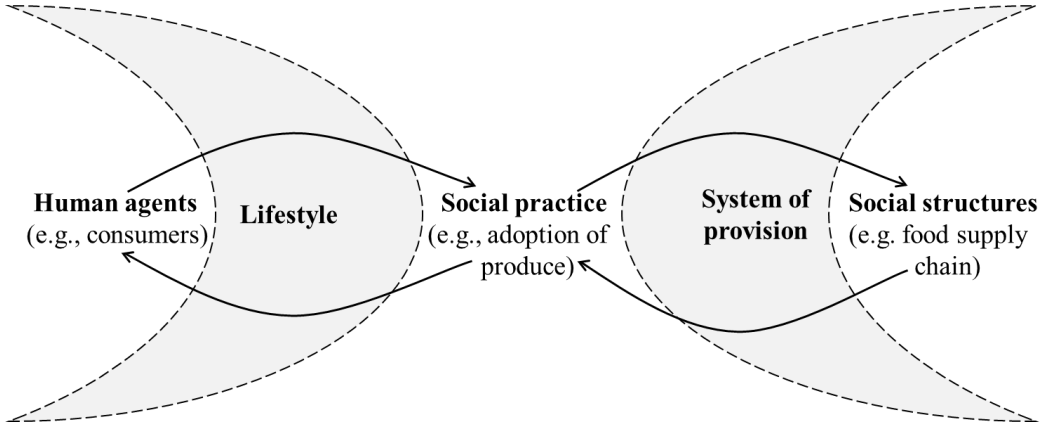


Figure 3: Appropriation and provision within social practices (adapted from Spaargaren & Oosterveer, 2010)

A social practice is a routinized type of behavior. It consists of several interconnected elements, like *" forms of bodily activities, forms of mental activities, 'things and their use', a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge"* (Reckwitz, 2002: p. 49-50). Adoption is thus a social practice in its dependency of both tangible (e.g., associated utility; 'things and their use') and intangible (e.g., mental activities; motivational knowledge) elements. Adoption refers to the processes that govern the utilization of innovations. In this thesis, the interpretation of adoption as addressing both the role of human agents in acceptance dynamics (i.e., modes of appropriation) and the role of social structures in supply chain dynamics (i.e., modes of provision) is called adoption dynamics. These concepts are explained in the paragraphs that follow.

2.2 Acceptance dynamics

Ulli-Beer, Gassmann, Bosshardt and Wokaun (2010) argue that consumers' acceptance is expressed by an act of adoption. This act is constituted by consumer lifestyles, which is a product of consumers' attitude, norms and values, and behavioral control (Ajzen & Fishbein, 1980; Ajzen, 1991). In contrast to the common incremental adjustment process, Ulli-Beer et al. (2010) frame acceptance as a discontinuous social norm-building process in which consumers'

preferences and routines develop. They argue that acceptance of products develops nonlinearly as it is subject to short-term and long-term social processes.

It is often experienced that it is hard to understand to what extend consumers' acceptance is influenced by their decisions (Mathieson, 1991; Dörner, 1980, 1993). For transparency about the assumptions underlying consumers' acceptance as perceived in this thesis, Figure 4 introduces a generic acceptance dynamics structure taken from Ulli-Beer et al. (2010). The generic structure they present introduces a group of adopters and a group of non-adopters, that is balanced by an adoption rate and a frustration rate. This indicates that a change in preferences and routines may cause non-adopters to become adopters and vice versa. In general terms, adoption and frustration is influenced by a product (non-)adopters and the effect of their norm. Etzion (2014) elaborates further on the effect of a norm on (non-)adoption when he indicates that the people's decisions about awareness, motivation, and costs influences people's preferences and routines. In sum, according to Ulli-Beer et al. (2010), acceptance dynamics originates from interactions between two stocks, facilitated by two flows, and involving a time to adjust preferences and routines because of external effects.

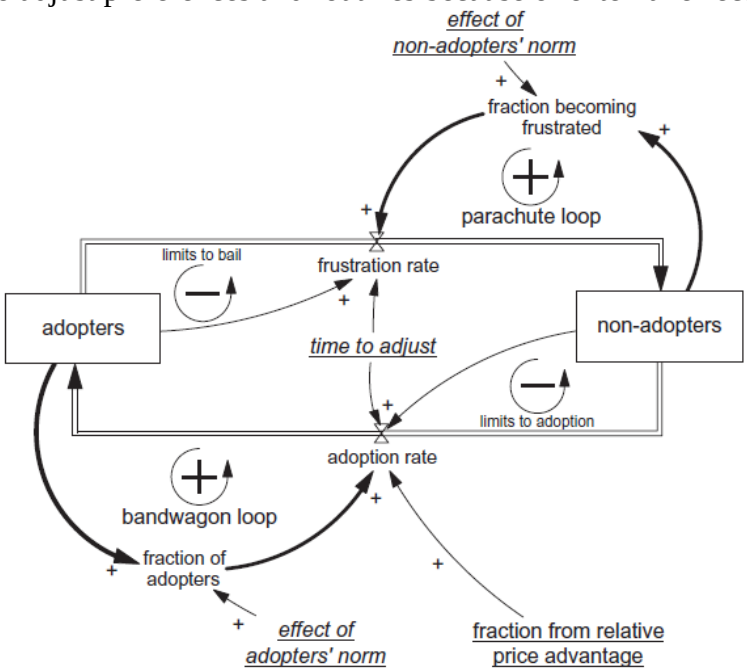


Figure 4: Generic acceptance dynamics structure (Ulli-Beer et al., 2010)

2.3 Supply chain dynamics

A supply chain is a linked set of operations aimed at delivering output to a customer (Krajewski, Ritzman & Malhotra, 2013). To be able to perceive the dynamics originating from stocks and flows in the supply chain, a holistic understanding towards all elements is required. One of the more recent academic contributions for modelling the food supply chain for fresh food is depicted in Figure 5. This figure is taken from a systematic literature review performed by Nakandala, Samaranayake, Lau and Ramanathan (2017) about information flows in the fresh food supply chain. The generic structure they present introduces the main actors in the fresh food supply chain, being agro-suppliers, producers, processors, wholesalers, retailers, food services, export and import houses, logistics partners, knowledge partners, financial partners, and regulatory bodies. These actors can be associated with stocks of materials and substances, like production crops, storage, retailers' supply, and money. Next to that, they introduce various types of flows between actors and stocks, namely material flows, information flows, resource flows, and financial flows.

In sum, according to Nakandala et al. (2017), dynamics in the supply chain originate from interactions between multiple stocks, facilitated by the existence of various flows, and

involving various (lead) times. A missing element in this generic structure that can be found in many Material Flow Analyses of the food supply chain is the role of consumers (e.g., Ju, Osako & Harashina, 2017). The role of consumers introduces the impact of price, quantity demand, and quality demand on the food supply chain (Nakandala, Lau & Zhao, 2016). These information flows relate to consumers' product acceptance.

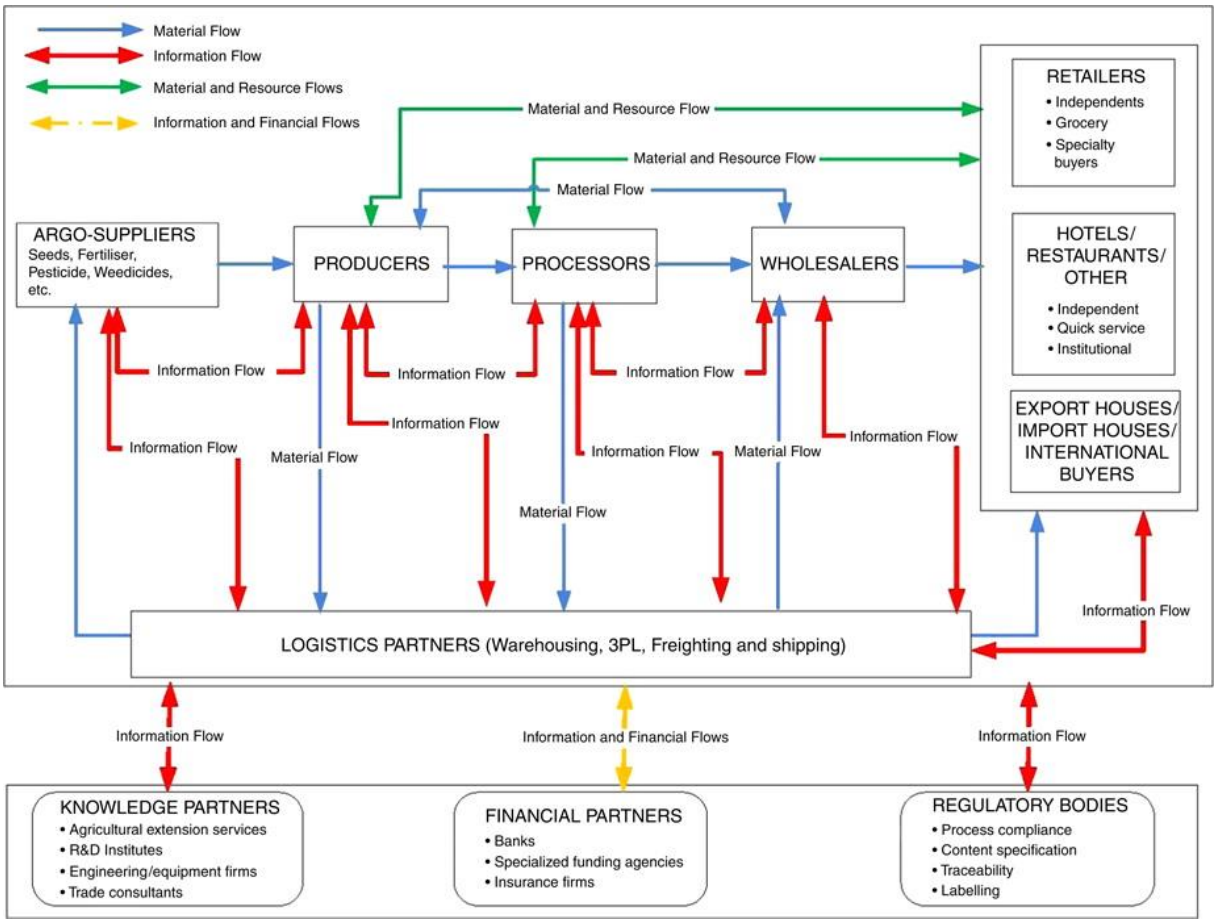


Figure 5: Generic fresh food and vegetable supply chain flows (Nakandala et al., 2017)

2.4 Conclusions

The concepts of adoption as introduced in this chapter can be summarized as an interplay between supply and demand. To describe adoption in technical terms, adoption involves multiple stocks (e.g., storage; consumers' trust), multiple flows (e.g., production rate; adoption rate), multiple causal feedback relations (e.g., demand-based adjustments of supply; adoption-based gaining of skills), multiple varying time delays (e.g., time to grow produce; time to develop trust), and a varying pressure on the system (e.g., supply; adoption). Sterman (2010) states that it is not due to the complexity of components themselves but through the interaction (feedback) among components that complex behavior arises. He introduces system dynamics as an approach that one can take to gain insight into complex systems.

System dynamics is one of multiple approaches that are suitable for analyzing the system of adoption. The generic structures introduced in this chapter lay the foundation for an exploratory research for finding out which product characteristics and consumer characteristics influence adoption of misshapen produce through product acceptance. It also provides a way to identify the causal relationship between adoption, demand, and supply of misshapen produce. Through the interaction of these elements, values in this system change over time. Analysis of these developments that originate from the system's structure allow the development and testing of robust policies for stimulating adoption of misshapen produce.

3. Research approach

3.1 Introduction

The previously suggested system dynamics approach allows explicit and consistent representation and testing of dynamic hypotheses (e.g., Sterman, 2000). The associated analyses have been performed with help of a quantified system dynamics model that has been developed and calibrated in Vensim DSS. Together with policy tests, this enabled elicitation of the drivers of adoption of misshapen produce and assessment of adoption of misshapen produce as a viable business model.

The data as input for the model is of both quantitative and qualitative nature and can be the output from any research strategy. Qualitative data lay the foundation for model elements and their causal relationships that may be confirmed by quantitative data. Quantitative data provide direct input to model parameters and allow validation of the model. Both qualitative and quantitative data need to be accessed from multiple levels, ranging from mental data in people's minds to written data in memos and articles and numerical data in reports and databases. Data needs to be valid and reliable to assure the validity and reliability of the output from the model. Subsequently, the maturity of the field of system dynamics allows a structured validation by performing direct structure tests, structural-oriented behavior tests, and behavior pattern tests (Barlas, 1996).

3.2 Research strategy

The concept of adoption dynamics presented previously is detailed in a quantified system dynamics model as part of an exploratory case study research. This choice of research strategy is grounded in a research context of scarce and disperse secondary data about adoption of misshapen produce and food waste. The existence of theoretical frameworks (e.g. acceptance dynamics; Ulli-Beer et al., 2010) made it possible to perform the case study from a more aggregate and holistic perspective. This research as case study helped to formulate recommendations and best practices as input for a further research in this research area. A case study approach allowed the generation of an in-depth understanding of the adoption process within its social, technical, and economic context. Ahrens and Chapman (2004) argue that the natural context of such a process in a specific context is better examined through a qualitatively close engagement instead of a quantitatively distanced research. Still, case studies may involve both quantitative and qualitative data and thereby create a more extensive understanding (Eisenhardt, 1989). This case study is seen as part of an incremental process of theory development (see Repenning, 2003) in which the results and analyses build on past work about the adoption and diffusion of innovations.

3.3 Research object

The case study was the adoption of misshapen produce in the Netherlands. The Dutch food industry that organizes the operation of the food supply chain is one of the largest industries in the Netherlands. The Dutch Federation of Food Industries reports a yearly turnover of the food industry of more than 70 billion euros and employment for about 135.000 people (FNLI, 2016). Relative to other countries, the Netherlands traditionally have a strong competitive food industry in which continuous cost reduction by valorization of side streams (i.e., creating value for streams that are not part of the main product) has been one of the industry's major preoccupations for a long time (Vanhaverbeke, De Rochemont, Meijer & Roijakkers, 2007).

Altogether, the food supply chain organizes the preparation of food and drink products for sales and consumption (Eurofound, 2004). It consists of the sub-sectors shown in Table 1, in which the share of turnover and share of employment indicate the size of that sub-sector. It is

striking to read from Table 1 that the yearly food wastage volume for agricultural products worldwide is the highest for fruits and vegetables (including roots and tubers), namely 64 percent of total food wastage (Lipinski et al., 2013). This is extra interesting as this sub-sector appears to be relatively small given its share in turnover and employment.

Recently, fruits and vegetables are found to have potential for reducing avoidable food waste when they are sold as misshapen produce (e.g., Marcel Worldwide, 2014). Although financial benefits for consumers, growers, and supermarkets are reported, there is little known about what exactly drives the adoption of misshapen produce and whether it actually reduces food wastage (e.g., Loebnitz et al., 2015). Valorization of side streams by adoption of misshapen produce is a relatively new area for improving supply chain efficiency.

Sub-sector	**Share in turnover (%)**	**Share in employment (%)**	**Share in food wastage (%)**
Meat	20	21	4
Drinks	14	10	n/a
Dairy	14	8	8
Bakery and farina	11	32	n/a
Animal feed	7	3	n/a
Fruits and vegetables	6	6	64
Oils and fats	5	1	3
Grain mill and starch	4	2	19
Fish	2	3	2
Various food products	16	14	n/a
Food industry total	**100**	**100**	**100**

Table 1: Sub-sector's share in turnover and employment in the EU and in food wastage globally (adapted from Food Drink Europe, 2014; Lipinski et al., 2013)

3.4 Data collection

Data collection in this research has been triangular as it involved data from a narrative literature review, interviews, and direct observations. Methodological triangulation improves the quality of collected data and thereby assures validity in this research (Vennix, 2011). Data collection in this thesis was performed as a mixed-method approach in which data collected from one source provided direction for data collection from another source. This allowed immediate cross-referencing of collected data and thereby fit the exploratory nature of this research.

3.4.1 Literature data

Secondary data were drawn from a literature review. A literature review enabled better understanding and analysis of the elements in the food system and factors that influence adoption of misshaped produce, thereby enriching the author's mental model of the food system. Reviewed literature included academic articles and books (e.g., sociology; economics; operations management; environment), institutional reports (e.g., Food and Agriculture Organization; United Nations Environment Programme; European Union), policy-makers' memos (e.g., Dutch Ministry of Economic Affairs), and activist' memos (e.g., Kromkommer). This literature was obtained from Internet and in contact with interview respondents. Selection of literature from journals was primarily based on the use of key words (e.g., 'adoption'; 'food supply chain'; 'misshapen produce'; 'fruits and vegetables'). In addition, part of the journal articles are selected by means of backward and forward snowballing (i.e., the use of a paper's reference list to identify additional papers).

3.4.2 Interview data

Primary data from open interviews laid the foundation for an in-depth understanding and the creation of a simulation model. Interviews allow a potentially richer understanding of phenomena (Lee, Collier & Cullen, 2007; Luna-Reyes & Andersen, 2003). Ten respondents with a variety of backgrounds have been interviewed, like scientists from Wageningen University Research, entrepreneurs in fruit and vegetable production, processing and retailing, food waste activists, and policy makers. An overview of the background and expertise of the interview respondents is found in Appendix III. Interview respondents have been contacted via the researcher's private networks and by means of snow-ball sampling. Semi-structured interviews have been conducted to prevent the bias of anticipating the responses from the respondent. This allowed flexibility to adjust to subjects that arise and allows conveying information as being interrelated instead of split-up. Although the interviews were tailored to the professional background of interview respondents, a number of items about the drivers of adoption of misshapen produce structured the interview guide used for the interviews. This allowed insights in the processes and factors that are involved in adoption of misshapen produce. The interview guide with common items for multiple interview respondents is found in Appendix IV.

The interview guide was used for eight of the ten interviews, of which two interviews (S1 and A2) were conducted by phone. The two remaining interviews (A1 and P3) were of informal nature so that it seemed inappropriate to use the interview guide. The six semi-structured face-to-face interviews have been recorded and took 45 minutes on average. The telephone interviews and informal interviews have not been recorded due to practical limitations and took twenty minutes on average. Interviews have been conducted until saturation of exploratory content was reached. Saturation implies that additional data does not lead to new information related to the research questions (Seale, 1999).

3.4.3 Observation data

Observation data from direct observations at the interview site are used for enriching the researchers' interpretation of interview data. The findings from the observations have been integrated with the coded text in the transcripts of the interviews. Therefore, a formal report on observations is not provided. For the purpose of this research, direct observations only were considered to be relevant if they enrich the researchers' understanding of processes in the fresh food supply chain and consumer lifestyles. Therefore, not every interview site (e.g., a plain office building in contrast to a greenhouse) was relevant for collecting observation data. Of the ten respondents that have been interviewed, observations were carried out at four interview sites (V1, C2, P2, and P3). The observations were carried out together with the interview respondent right after the interview and took on average half an hour on average.

3.5 Data analysis

The formal data analysis was performed as a sequenced approach in which the main focus at first was on literature, respectively followed by interviews and observations. It was believed that a sequenced approach for data analysis fosters a thorough understanding of the system.

3.5.1 Literature analysis

Literature that contains conceptual information about adoption of misshapen produce has been summarized and connected in the theoretical framework of this thesis. This has been performed in the form of a narrative literature review, which is summarized in a table that

highlights all causal relationships used for developing the conceptual framework. References to this literature is in line with the AOM reference style (Academy of Management Journal, 2011).

3.5.2 Interview analysis

With permission of the interview respondent, interviews have been tape-recorded and thereby allowed literal transcription. Latest two weeks after the interview took place, the transcript was sent to the interview respondent for confirmation. In those interviews in which literal transcription of the interview was not allowed, a transcript of the most relevant outcomes was made by the researcher. To avoid misinterpretation of these interviews, additional focus was put on verification of the researcher's findings during the interview (e.g., "Do I interpret it correctly that…"; "Is it true that you just mentioned…").

All transcripts are coded using NVivo 11. Coding followed a process of open coding by formulating concise descriptions of responses, axial coding by linking literature-based concepts to the descriptions, and selective coding by identifying relationships between these concepts and their polarity, as suggested by Andersen, Luna-Reyes, Diker, Black, Rich and Andersen (2012) and Turner, Kim and Andersen (2014). An overview of codes used for analyzing the interviews can be found in Appendix V. The findings from the interview analysis are described in the interviews and observations chapter of this thesis and summarized in a table that highlights all causal relationships used for developing the conceptual framework.

3.5.3 Observation analysis

As direct observations facilitated richer interpretation of interview data by the researcher, findings from the observation analysis are intertwined with findings from the interview analysis in the interviews and observations chapter of this thesis. There is no explicit report on the observation analysis.

3.6 Research ethics

This paragraph touches upon the research ethics as prescribed in Denscombe's (2012) guide for research proposals. Every interview respondent in this research participated on a confidential and voluntary basis. No harm is caused to those who participated in this research. Information provision has been performed as transparent and timely as possible within practical boundaries. A copy of the thesis is provided to those interview respondents that indicated interest in the outcomes. Anonymized transcripts and codes are available upon request, but within the limits of confidentiality. This research attempts nothing more than serving society and accomplishing a Master degree.

PART II: Model development and calibration

As indicated in Figure 6, in the second part of this thesis the building blocks of the simulation model are discussed. First, the current literature about topics introduced in chapter 2 is discussed in the theoretical framework in chapter 4. These topics cover product acceptance as the product of product characteristics and consumer characteristics, the fresh food supply chain, and the market mechanism of supply and demand. The findings from literature are complemented with interview data and observation data discussed in chapter 5. There is reported on this data based on different operations in the supply chain through which fresh produce flow, thereby focusing on production, processing, sales, and eventually consumption. In chapter 6, the overarching conceptual framework is presented which is based on the causal relations and values resulting from the data collection and analysis.

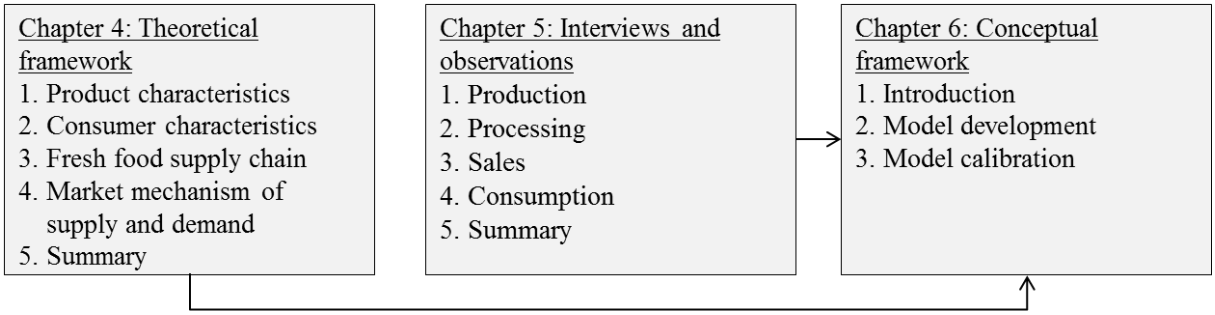


Figure 6: Model development and calibration

4. Theoretical framework

4.1 Product characteristics

Products possess various characteristics on basis of which consumers evaluate a product (Olsen, 1978). In general, product characteristics can be categorized as intrinsic and extrinsic cues. Intrinsic cues of a food product are part of the physical product, like shape, color, and size. These cues can only be changed by changing the product (Akdeniz, Calantone & Voorhees, 2013; Bello Acebrón & Calvo Dopico, 2000). Extrinsic cues are product attributes that are not part of the physical product, like price, labelling, and packaging. They are cues that can be changed without changing the product itself (Akdeniz et al., 2013; Richardson, Dick & Jain, 1994). Altogether, cues communicate information about the product (Olsen, 1978). According to cue utilisation theory, consumers tend to rely on both intrinsic and extrinsic cues to establish the quality of a product (Grunert, 2005). However, Clemente, Dolansky, Mantonakis and White (2013) argue that consumers' evaluation of intrinsic cues can be altered by extrinsic cues. Still, in terms of perceived usefulness, intrinsic cues tend to dominate extrinsic cues (Purohit and Srivastava, 2001). This means that, for example, the size of an eggplant can be more important for a consumer than its associated price, although a lower price partially compensates for a smaller size of the eggplant.

To signal better quality of well-shaped produce relative to misshapen produce retailers tend to set evaluation standards (Loebnitz et al., 2015; Bunn, Feenstra, Lynch, & Sommer, 1990). In fact, until June 2009 such high standards were legally determined by the United Nations Economic Commission for Europe (EU, 2008). Even though these trade norms are less strict now, retailers still tend to offer increasingly more optimal produce. Consumers' reference point towards quality is shaped by this process of produce optimization. As a result, consumers might associate misshapen produce with inferior quality, which may lead them to reject the product (Creusen & Schoormans, 2005). Purohit and Srivastava (2001) explain the development of a consumers' reference point towards a product as a tendency between high-scope cues and low-scope cues. High-scope cues evolve over time, like the reputation of a label and the quality associated with the shape of produce a retailer offers. Low-scope cues are transient and can be changed instantly, like price and packaging. This indicates that, for example, a product with low attractiveness because of its underdeveloped high-scope cues can be made much more attractive by changing to low-scope cues.

There is a variety of findings when it comes to interactions between multiple cues. Consistency theory suggests that corresponding cues (e.g., perfect shape and high price) lead to joint use of cues by consumers (Maheswaran & Chaiken, 1991). Miyazaki, Grewal, and Goodstein (2005) argue that in a pricing domain, contradictory extrinsic cues (e.g., organic label and low price) lead customers to anchor their quality perception on the 'negative' cue only. In this case the consumer would not appreciate the organic label as it is normally associated with a high price. Finally, Purohit and Srivastava (2001) introduce the cue diagnosticity framework that suggests that consumers develop a quality categorization from multiple available cues to determine the quality of food produce.

Wansink (2004) states that shape is a key intrinsic appearance cue. In addition, several researchers report that food appearance highly influences the choice of food and the quality expectations (e.g., Wilkins, Bokaer-Smith & Hilchey, 1996; Steenkamp & Van Trijp, 1996). In this context, Loebnitz et al. (2015) recommend investigation of the way in which price (i.e., extrinsic cue) alters consumers' evaluation of shape (i.e., intrinsic cue). In addition, apart from this context, Kelley (1959) suggests that quantity convenience (i.e., extrinsic cue) may alter consumers' evaluation of shape as well. However, perception of price and quantity convenience does not stand alone as one's perception depends on individual characteristics. For example, Bunkers and Cochrane (1957) find that income may moderate price and thereby

influences the perception of price. In addition, several researchers (e.g., De Hooge et al., 2017) suggest that demographics (e.g., household composition) may moderate consumer preferences (e.g., preferred quantity of produce) and thereby influence the perception of quantity. The reason why quantity of produce may have an effect in the case of adoption of misshapen produce is because – unlike Deng and Srinivasan's (2013) finding that most fresh food produce are offered unpacked – Dutch supermarkets pack misshapen produce in a predetermined quantity (Albert Heijn, 2014). To conclude, findings about product characteristics like those described in this paragraph reflect that product characteristics have an important relation with consumer characteristics in establishing product acceptance.

4.2 Consumer characteristics

The influence of consumer characteristics on product acceptance can be well explained with Social Cognitive Theory (SCT). SCT describes product acceptance as originating from the triadic framework of reciprocal causation between personal determinants, behavioral determinants, and environmental determinants (Bandura, 1986). This means that a change in one determinant affects all determinants that are involved in consumer characteristics, thereby reinforcing or balancing consumer behavior. This framework is relevant as it allows analysis of cognitive processes and consumer behavior in the context of the environment in which behavior takes place. Consumer behavior in the context of consumption is defined by Peter and Olsen (2010) as a dynamic interaction of thoughts, feelings, and actions in consumption processes. These behavioral determinants have a reciprocal causal relationship with personal determinants in terms of cognitive factors like expectations, knowledge, and emotions (Bandura, 2011). Personal determinants in terms of physical characteristics like age, gender, and species, however, are not affected by other determinants. Cognitive factors causally interact with environmental determinants in terms of a social environment that consists of physical aspects like a set-up, instructions, and social persuasion (Bandura, 2011). For example, consumers' beliefs is influenced by the physical appearance of a product and vice versa the set-up in a super market is influenced by what the supermarket knows about consumers' beliefs. Finally, environmental determinants causally interact with behavioral determinants in terms of physical structure and cognitive state (Bandura, 2011). Bandura (1997) notes that although the three types of determinants are reciprocal, their individual strength is moderated by the particular practice, like adoption of produce.

Although this thesis does not deal with every single set of determinants, the SCT framework helps to underline the importance of what is referred to as behavioral determinants and it introduces new concepts originating from the role of both personal and environmental determinants in interaction with behavioral determinants. For example, Bitner (1992) and Bloch (1995) demonstrate that the shape of produce is associated with the quality of that produce so that it infers risks for personal health. Cardello (2004) adds to this by arguing that shape influences the acceptance or rejection of food produce because of perceived quality. Consumers need to trust what they put in their mouth, as food is important for them to stay alive. As consumers are the ones that buy produce, their perception of the benefits and their attitude towards potential risks is key in the acceptance of food produce (Frewer, Fisher, Scholderer & Verbeke, 2005). These perceptions change over time. In addition, as consumers become better informed, their demand for food that has higher nutritional value and that is personal, safe, and affordable has increased (Moors, Boon, Nahuis & Vandeberg, 2008).

The perceived quality of produce is highly influenced by consumers' intentions with the produce (Grunert, 1995). Grunert (1995) argues that one's quality perception depends on two types of knowledge, namely declarative knowledge (i.e., product characteristics) and procedural knowledge (i.e., developing skills). Therefore, for product acceptance, not only product characteristics, but also procedural knowledge is important. The process of skills

development can be perceived as the concept of double loop learning (Argyris & Schön, 1978; 1996) and it involves an endogenous preference and value change. Individual learning improves the consumers' ability to process food produce, thereby developing the skills required for realizing efficiency and, thus, the benefit of misshapen produce. The higher the obtained benefit in terms of quality, the greater the acceptance, thereby reinforcing skills development (Grunert, 1995).

Next to the previously indicated influences on product acceptance that are mostly based on product information that is available to consumers, consumers partially make inferences based on assumptions beyond available information (Kardes, Posavac & Cronley, 2004). An important characteristic that is beyond available information is self-identity. Identity theory states that people tend to shape and express their identity when engaging in specific behavior (Callero, 2003; Stryker & Burke, 2000). Many researchers found an influence of self-identity on consumer food choices (e.g., Bisogni, Connors, Devine & Sobal, 2002; Sparks & Shepherd, 1992) and environmental behavior (e.g., Fielding, McDonald & Louise, 2008; Whitmarsh & O'Neill, 2010). Generally, two theoretical approaches explain pro-environmental behavior. According to the theory of planned behavior (Ajzen, 1991), people engage in cost-benefit analyses such that they choose the option with the highest profit. For other people, values and moral considerations that originate from normative models determine their choice of option. Both approaches indicate that self-identity influences pro-environmental behavior. This influence can be predictive as behaving contrary to one's self-identity creates an internal tension and behaving in line with one's self-identity offers a way to express oneself (Sirgy, 1982). In interaction with one's social context, people develop their self-identity as they determine their position in that context based on their self-identity (Callero, 2003). Self-identity is a broad concept so that consumer evaluation may relate to various identities, including those related to health aspects (Sparks, Conner, James, Shepherd & Povey, 2001), type of food (Bisogni et al., 2002), and the environment (Sparks & Shepherd, 1992). Sparks and Shepherd (1992) argue that people who perceive themselves as pro-environmentalist consider a different trade-off when expressing a purchase intention related to pro-environmental food produce than others. Nordlund and Garvill (2003) take it one step further by stating that one's awareness of an environmental problem determines one's environmental behavior. These statements are supported for the influence of food problem awareness on purchase intention and for the influence of the interaction effect between environmental awareness and food problem awareness on purchase intention (Loebnitz et al., 2015). Problem awareness together with some ascription of responsibility to that problem contributes to a social norm that translates itself into reinforcing behavior (Ulli-Beer et al., 2010). Therefore product acceptance is likely to increase the more consumers perceive a problem and feel responsibility for solving that problem. Product acceptance leads to adoption or diffusion at the consumer’s side (Ulli-Beer et al., 2010). For adoption to take place, however, the food supply chain needs to have adopted misshapen produce as well.

Another aspect in consumer characteristics is routine. A preoccupation of major importance in the food industry is to overcome consumer resistance and prejudice towards new food produce (Meulenberg & Viaene, 2005). The authors state that to reduce diffusion of produce due to non-routine, organizations need to put effort in informing consumers about the positive features of produce that might be perceived suspicious. Again, double loop learning as introduced by Argyris and Schön (1978) is an important process at the consumer side. This process involves an endogenous change by which consumers develop their routine behavior, their skills for processing food, their trust in food, and so forth.

4.3 Fresh food supply chain

This research perceives the supply of misshapen produce as a linked chain of processes that altogether constitute adoption and diffusion of misshapen produce. This chain is regulated by an activity called supply chain management. Krajewski, Ritzman and Malhotra (2013) describe supply chain management as *"the synchronization of a firm's processes with those of its suppliers and customers to match the flow of materials, services, and information with customer demand"* (p. 22). In other words, supply and demand are matched by controlling processes like those distinguished by Lipinski et al. (2013) in Figure 7: production, storage and processing, distribution and market, and consumption. Supply chain management in the food supply chain can be challenging and mismatches between supply and demand often occur, resulting in surpluses and shortages over time (Sterman, 2000). The European Court of Auditors (2016) observes that these dynamics translate in fluctuations in supply chain turnover and in supply chain food wastage.

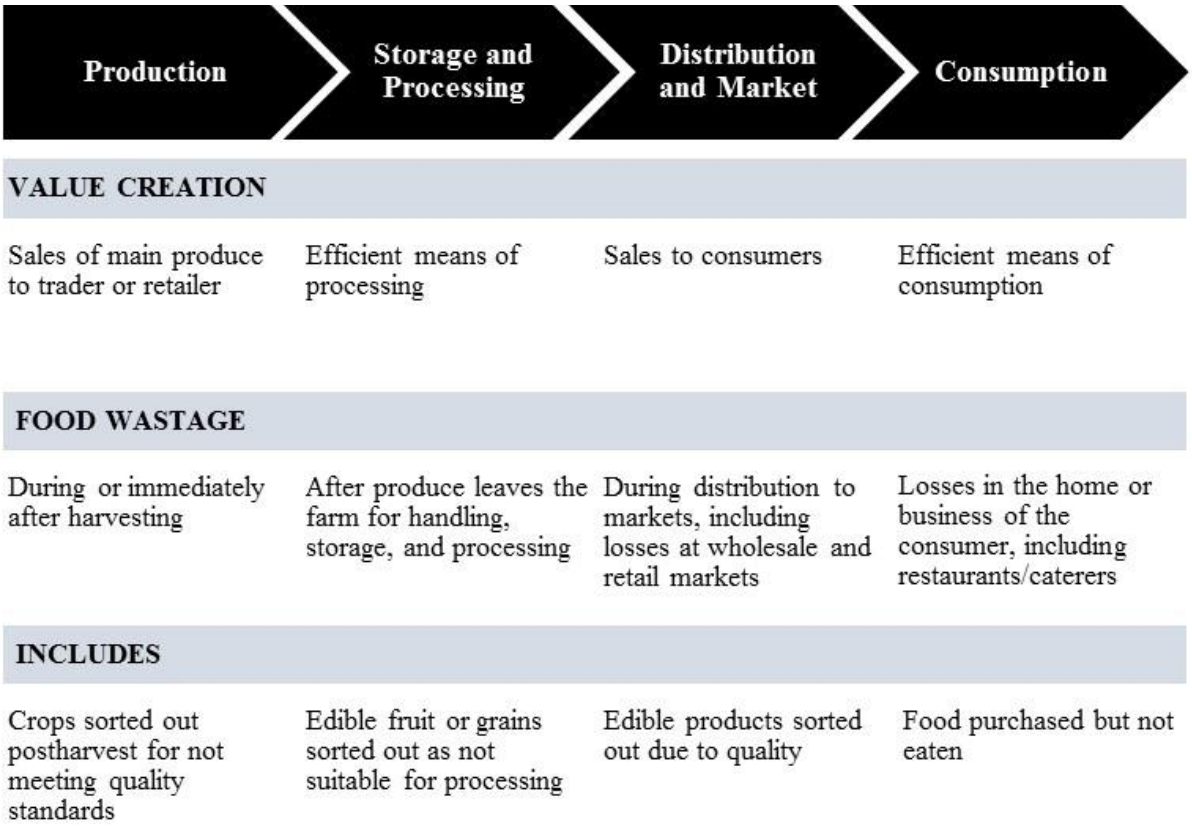


Figure 7: Food wastage along the food supply chain (adapted from multiple sources, including Lipinski et al., 2013)

Supply chain turnover is a product of costs and revenues. Costs include input costs for production, costs for harvesting, costs for processing (e.g., selection; cleaning; quality assessment), costs for storing, costs for distribution to the market, and costs for selling the produce. On the other hand, revenues are generated by the farmer from selling produce to a trader or retailer. A trader or retailer subsequently generates revenues from reselling produce to consumers.

Food wastage is present in all processes in the food supply chain. A part of food wastage is unavoidable as it is unsellable or inedible food (Bagherzadeh et al., 2014). Although culturally and culinary dependent, food like fats, bones and skins of meat, fruit and vegetable peels, and eggshells are generally considered as unavoidable food wastage and is therefore called food loss (WRAP, 2009). On the other side of the spectrum, food that was edible at some point prior

to disposal (e.g., slices of bread; fruit; meat) is called food waste (Bagherzadeh et al., 2014; WRAP, 2009). Godfray et al. (2010) note that in developed countries, waste arises mostly downstream from the retail stage and the consumption stage of the food chain. In these stages, many edible products are sorted out due to aesthetic quality standards (Lipinski et al., 2013). Lipinski et al. (2013) describe food wastage in these processes in more detail in Figure 7. During production and harvesting food is left behind on the field on purpose because of quality standards or overproduction, or because of suboptimal harvesting equipment. In storage and processing, food is wasted and lost because of rot, it is spilled, there is poor order forecasting, or processing is inefficient. During distribution and marketing food is wasted due to aesthetic quality standards and because of strict 'best-before' dates. Finally, in the consumption stage, food is purchased but not eaten or it is sorted out due to aesthetic standards.

Processing food wastage always costs money and only sometimes generates revenue, albeit different per food valorization category. Vanhaverbeke et al. (2007) argue that for an organization's survival in the highly competitive Dutch food industry, it is crucial to increase turnover by activities like valorization of side streams. Valorization of side streams is realized by generating as much revenue as possible for any (part of) produce that flows through the supply chain (Schripsema, Burgh, Sluis & Bos-Brouwers, 2015). This introduces side streams from the food supply chain towards, for example, animal fodder, bio-energy production, and composting next to the flows of main produce that are purposed for human consumption *(Bosatlas, 2014)*. A generalized overview of common valorization practices in the food industry is shown in the food valorization hierarchy that is depicted in Figure 8.

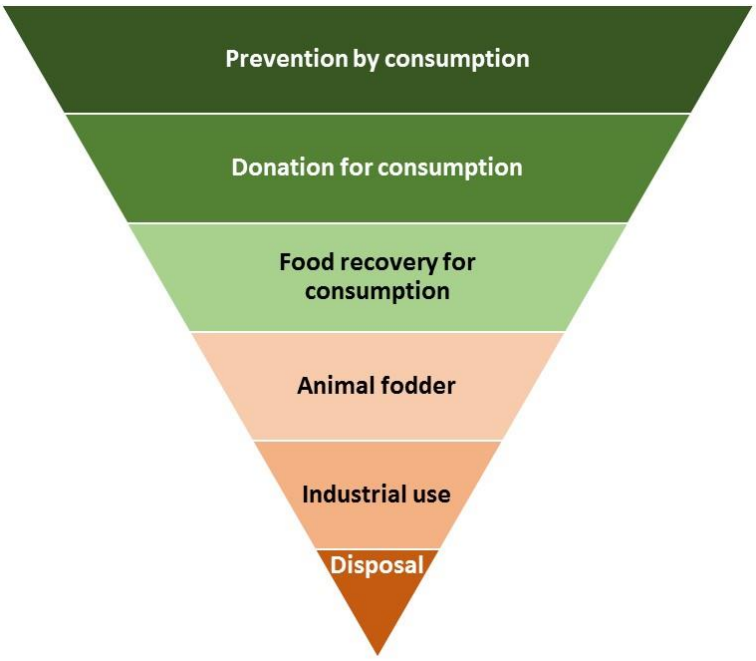


Figure 8: Food valorization hierarchy (adapted from multiple sources, including Bosatlas, 2014)

In the Dutch food industry, valorization in the bottom three categories is split up in animal fodder; fermentation, composting and incineration ('Industrial use' in Figure 8); and landfill ('Disposal' in Figure 8). Over the period 2009 till 2014, the total increase of valorization in these bottom three categories was four percent (Soethoudt, Vollebregt & Burgh, 2016). Figure 9 indicates the absolute development of these means of valorization over the period 2009 till 2014. It is striking to conclude that the lower valued means of valorization is 30 to 40 percent of total food production purposed for human consumption (Nelleman et al., 2009), whereas a part of it could still have been sold to consumers as misshapen produce, donated to beneficiaries, or recovered by alternative processing.

Because misshapen produce were not used to be consumed due to aesthetic quality standards, misshapen produce are not categorized as 'prevention by consumption' (Schripsema et al., 2015). Instead, misshapen produce is often donated to beneficiaries by retailers, recovered as 'cut vegetables' by processers, used as animal fodder by farmers, and used for industrial purposes or disposed as final option for any actor in the food supply chain (Soethoudt et al., 2016). Schripsema et al. (2015) continue that the initiative to sell misshapen produce for human consumption is an attempt to make it fit in the 'prevention by consumption' category.

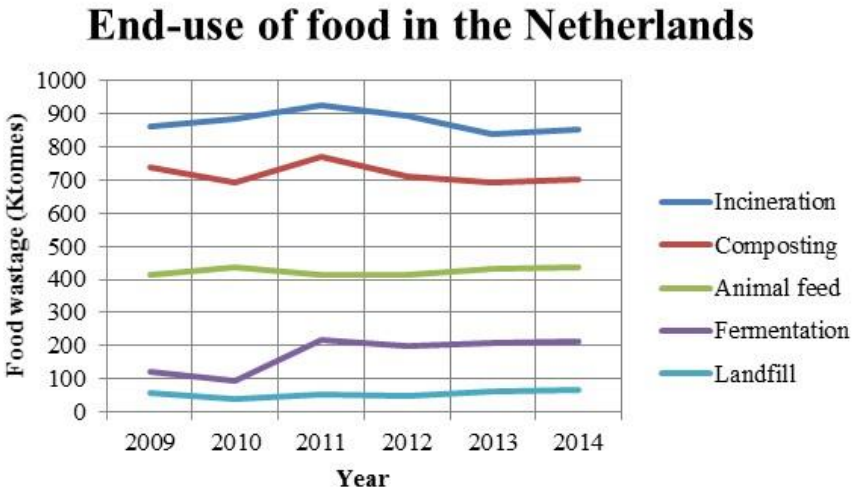


Figure 9: End-use of food produce in the Netherlands over 2009-2014 (adapted from Soethoudt, Vollebregt & Burgh, 2016)

4.4 Market mechanism of supply and demand

The social practice of adoption of produce is framed in this research as the interplay between product acceptance in terms of consumer demand and product provision in terms of farmers' and retailers' supply. To bridge the gap between tangible (e.g., utility aspects; physical flows) and intangible (e.g., social dynamics; information) aspects in this model, a translation to the economic meaning of supply and demand needs to be made. This translation is based on the basic characteristics of the Dutch economy.

The Dutch economy in principle can be seen as a free market economy. This implies that supply and demand are regulated by the market mechanism of supply and demand, which is the natural consequence of economic forces (Smith & Cannan, 2003). This means that supply and demand are balanced out by price as a proxy for all information about a product, including quantity. So that, for example, a large supply of produce in combination with a small demand for produce results in a low price and vice versa.

4.5 Summary

The findings in this theoretical framework are summarized in Table 2. Together with interview data and observation data, this serves as input for the development of the conceptual framework. The identified variables are categorized based on their position in the conceptual framework. Table 2 indicates which elements from literature are included in the model and it indicates the causal relationship including the polarity of the relationship. A '+' indicates that an increase/decrease in cause results in an increase/decrease in effect whereas a '-' indicates that an increase/decrease in cause results in a decrease/increase in effect.

Cause	Effect	Pola-rity	Incl-uded	Data source
ADOPTION AND DIFFUSION				
Acceptance potential misshapen produce	Misshapen produce adoption rate	+		Ulli-Beer et al., 2010
Rejection potential misshapen produce	Misshapen produce diffusion rate	+		Ulli-Beer et al., 2010
MOTIVATION LOOP				
Misshapen produce *adoption/diffusion* rate	Motivation for *misshapen/well-shaped* produce (e.g., consumer evaluation of product appearance)	+		Wilkins et al., 1996; Steenkamp & Van Trijp, 1996; Grunert, 2005; Bitner, 1992; Bloch, 1995
Motivation for *misshapen/well-shaped* produce	Acceptance potential *misshapen/well-shaped* produce	+		Creusen & Schoormans, 2005; Cardello, 2004; Frewer et al., 2005
UTILITY LOOP				
Misshapen produce adoption rate	Skills for processing misshapen produce	+		Argyris & Schön, 1978; 1996; Grunert, 1995; Meulenberg & Viaene, 2005
Skills for processing misshapen produce	Utility misshapen produce	+		Grunert, 1995; Meulenberg & Viaene, 2005
Retailer price *misshapen/well-shaped* produce	Utility *misshapen/well-shaped* produce	-		Olsen, 1978; Grunert, 2005
Consumer income	Impact of retailer price *misshapen/well-shaped* produce on utility *misshapen/well-shaped* produce	+	No	Bunkers & Cochrane, 1957
Utility misshapen produce	Acceptance potential misshapen produce	+		Grunert, 1995; Meulenberg & Viaene, 2005
FOOD WASTAGE AWARENESS LOOP				
Misshapen produce adoption rate	Total food supply chain wastage	+[1]		Loebnitz et al., 2015
Total food supply chain wastage	Perceived total food supply chain wastage	+		Loebnitz et al., 2015
Perceived total food supply chain wastage	Food wastage awareness	+		Nordlund & Garvill, 2003
Food wastage awareness	Acceptance potential misshapen produce	+		Sparks & Shepherd, 1992; Nordlund & Garvill, 2003; Loebnitz et al., 2015; Ulli-Beer et al., 2010

[1] Although adoption of misshapen produce contributes less than adoption of well-shaped produce, adoption of misshapen produce still constitutes food wastage and therefore the causal relationship is positive.

FRESH FOOD SUPPLY CHAIN				
Production rate	Harvest	+	No	Lipinski et al., 2013; European Court of Auditors, 2016
Harvest	Post-harvest sorting rate *well-shaped/side stream* produce	+		Lipinski et al., 2013; European Court of Auditors, 2016
Harvest	Harvest loss rate	+		Lipinski et al., 2013; European Court of Auditors, 2016
Strictness of quality standards	Post-harvest sorting rate well-shaped produce	-	No	Loebnitz et al., 2015; Lipinski et al., 2013; European Court of Auditors, 2016
Strictness of quality standards	Post-harvest sorting rate side stream produce	+	No	Loebnitz et al., 2015; Lipinski et al., 2013; European Court of Auditors, 2016
Post-harvest sorting rate *well-shaped/side stream* produce	Storage and processing *well-shaped/misshapen* produce	+	No	Lipinski et al., 2013; European Court of Auditors, 2016
Post-harvest sorting rate side stream produce	Valorisation rate misshapen produce of side produce	+		Vanhaverbeke et al., 2007; Bosatlas, 2014
Post-harvest sorting rate side stream produce	Alternative valorisation rate	+		Vanhaverbeke et al., 2007; Bosatlas, 2014
Storage and processing *well-shaped/misshapen* produce	Distribution rate *well-shaped/misshapen* produce	+	No	Lipinski et al., 2013; European Court of Auditors, 2016
Storage and processing *well-shaped/misshapen* produce	Storage and processing wastage rate	+		Lipinski et al., 2013; European Court of Auditors, 2016
Distribution rate *well-shaped/misshapen* produce	Market supply *well-shaped/misshapen* produce	+	No	Lipinski et al., 2013; European Court of Auditors, 2016
Market supply *well-shaped/misshapen* produce	Sales rate *well-shaped/misshapen* produce	+		Lipinski et al., 2013; European Court of Auditors, 2016
Market supply *well-shaped/misshapen* produce	Market supply *waste/loss* rate	+		Lipinski et al., 2013; European Court of Auditors, 2016
Sales rate *well-shaped/misshapen* produce	Consumption *well-shaped/misshapen* produce	+	No	Lipinski et al., 2013; European Court of Auditors, 2016
Consumption *well-shaped/misshapen* produce	Consumption wastage rate	+	No	Lipinski et al., 2013; European Court of Auditors, 2016
Misshapen produce *adoption/diffusion* rate	Consumer demand for *well-shaped/misshapen* produce	+		Loebnitz et al., 2015

Consumer demand for *well-shaped/misshapen* produce	Sales rate *well-shaped/misshapen* produce	+		Loebnitz et al., 2015
Sales rate *well-shaped/misshapen* produce	Market supply waste	-		Loebnitz et al., 2015
Market supply *well-shaped/misshapen* produce	Market supply waste	+		Loebnitz et al., 2015
FINANCIAL PERFORMANCE				
Costs (e.g., input costs; processing costs; distribution costs)	Turnover	-		European Court of Auditors, 2016
Revenues (e.g., sales revenues)	Turnover	+		European Court of Auditors, 2016
Wastage rate (e.g., market supply wastage rate)	Costs (e.g., costs for disposal)	+		European Court of Auditors, 2016
MARKET MECHANISM OF SUPPLY AND DEMAND				
Consumer demand for *well-shaped/misshapen* produce	Retailer price *well-shaped/misshapen* produce	+		Smith & Cannan, 2003
Market supply *well-shaped/misshapen* produce	Retailer price *well-shaped/misshapen* produce	-		Smith & Cannan, 2003
CONVENIENCE				
Predetermined product quantity	Product convenience from product quantity	-	No	Olsen, 1978; Grunert, 2005
Consumer household composition	Product convenience from product quantity	+	No	De Hooge et al., 2017
Product shape abnormality	Consumer evaluation of product appearance	-	No	Wansink, 2004

Table 2: Causal relationships based on literature

5. Interviews and observations

5.1 Production

Production is the outset of the food supply chain. In the Netherlands, production of fruits and vegetables can be split up into two major categories, namely agriculture and horticulture. Produce from Dutch agriculture is, amongst other, (sugar)beets, grain, potatoes, onions, and carrots. Produce from Dutch horticulture is much more diverse. Whereas open ground horticulture is limited to production of, amongst other, leek, apples, cauliflower, cherries, and beans, greenhouse farming is almost limitless in the variety of fruits and vegetables that can be produced. Because of the controllable environment in greenhouses, produce like cucumber, strawberries, paprika, grapes, and tomatoes can be harvested all year long.

Agricultural production and open ground horticulture are strongly influenced by the rhythm of seasons. Whereas in many parts of the world harvest can take place two times a year, the Dutch open ground farming allows only one harvest a year. Albeit highly dependent on the product, most open ground production starts with planting in April and ends with harvest around September. After harvest, the produce is mostly stored at either the farmer or a trader. Spread over the year the produce is sold to downstream parts of the food supply chain, until there is a new harvest in the next year. One aspect that has a major impact on open ground production is the weather. Dependent on the product, bad weather conditions like hail and rain can quickly cause a complete harvest to be subject to, for example, rot, outside damaging, premature germination, or a combination of all. Thereby, weather conditions primarily regulate the amount of produce that is selected as main product, side streams, or wastage.

Greenhouse farming is much less constrained by seasons as the environment in greenhouses can be controlled. Production mostly takes place from January until November and greenhouses are cleaned in December when the amount of sunlight is lowest. Harvest can take place three times a year. Storage at the farmer is only for one day until it is transported to a trader, processor, or directly to a retailer. In greenhouses, the weather has a major impact as well, albeit in the sense of sunlight. The more sunlight, the higher the quantity and quality of produce. This may cause overproduction, thereby regulating the amount of produce that is selected as main product, side streams, or wastage as well.

5.1.1 The concept of provision in production

The core objective for farmers is to make sure that as much main produce as possible finds its way to the next part of the food supply chain in good quality so that their harvest generates the highest revenue possible. However, misshapen produce has always existed as side stream of production and it is not a farmer's choice to grow misshapen produce. In the more vulnerable environment of open ground farming the side stream of misshapen produce is much bigger than in the more controlled environment of greenhouse farming. Originally seen, the main product generates a revenue, while side streams and wastage generate costs. In order to generate revenue out of side streams as well, the food industry in the Netherlands has become highly experienced in valorization of side streams. The aim is to find the highest value possible for every part of a product. It is through provision by the whole fresh food supply chain that misshapen produce can generate a higher value when used for consumption than when used for different, lower valued ends.

Appropriation by consumers and provision by retailers can be constrained when farmers do not become involved in the concept of provision. The main driver for farmers to become involved in the concept of provision is the economic value it could generate. Farmers consider an economic trade-off between selling misshapen produce to retailers or selling misshapen

produce for lower means of valorization. The first generates more revenue, but could negatively affect the sales price for well-shaped produce, while the second generates less revenue, but will not negatively affect the sales price for well-shaped produce. The outcome from the calculations they make highly influences a farmer's decision of whether to offer their side stream of misshapen produce next to their main produce, or to offer it for other ends, like animal fodder, fermentation, or simple disposal. In a worst case scenario, the revenues from selling misshapen produce do not compensate for loss of revenues from selling well-shaped produce and the farmer is worse off than not having sold the misshapen produce.

Another driver for farmers to become involved in the concept of provision of misshapen produce is because of the awareness of food wastage they create themselves. Farmers are aware of the fact that they not get back the economic value they have put into their produce if they need to dispose it. Therefore, provision of misshapen produce offers a way to generate more value from a side stream which otherwise generates a very low value.

5.1.2 Food wastage in production

There are instances in which the demand for produce is so low relative to the supply of produce that prices drop to an extent that it becomes more interesting to use it for fermentation rather than to sell it. In case of a failed production, the most essential question for farmers is how to get rid of the harvest at the lowest costs. Food wastage that is saved by using it for animal fodder is not considered to be wastage from an economic perspective, but it is considered to be wastage from the perspective of nutritional value for human consumption. Next to economic incentives, governmental subsidies, legislation, and corporate social responsibility prerequisites encourage farmers to seek for opportunities to become more efficient with food that would otherwise be disposed.

5.2 Processing

After harvesting, there is a wide range of processing activities possible before the product is sold for consumption. First of all, it is important that fresh produce is delivered properly to avoid financial loss. In the majority of the food industry, processing fruits and vegetables involves practices like cleaning, peeling, and cutting, sometimes followed up by combining the product together with other products (e.g., grain for bread; carrots for soup). Fruits and vegetables for the market of fresh produce, however, undergo a different, much less intensive processing. The operation of processing fresh produce can be split up into processes of selection, cleaning, packing, quality assurance, and transportation.

Based on the interviews and observations, in this thesis it is assumed that produce is categorized into three categories: well-shaped produce, misshapen produce, and disposed produce. The norms by which produce is selected depends on the purpose of the product. Produce that is processed for a different kind of food product (e.g., sugar beet) is mostly subject to industry norms when they are processed by machines. Produce for the market of fresh produce (e.g., cucumber), however, is mostly subject to consumer norms, like aesthetics. Selection is partially performed by machines on the basis of, for example, size, shape, and weight and partially by humans on the basis of aesthetics. Estimates are that in greenhouse production, at least 95 percent of produce is selected as well-shaped product and 5 percent is either sold as side stream or is disposed. These numbers slightly differ per product and per greenhouse.

The moment at which selection takes place differs per product. Some farmers select out a product that does not meet the norms during production to prevent that it uses energy that can better be used for products that do meet the norms. A part of open ground produce (e.g., red beet) is selected while being harvested, leaving produce that does not meet the norms on the land. It costs less money to let this produce be composted and ploughed in on the land than

trying to find a market for this produce. Another part of open ground produce (e.g., potato) is selected when it is taken from storage to be sold to a processor or retailer. Greenhouse produce, in general, is selected directly after harvesting, before they are packed and transported for quality assurance.

Even though the product essentially may be the same, misshapen produce generally undergoes a different logistic processing line than well-shaped produce. One of the reasons is that misshapen produce is generally more blemished (e.g., ingrown sand) and less strictly selected (i.e., leaves of plants may be part of this flow). Quality assurance differs as well per product. In general, inspection of rot, product class, temperature, and labelling play a role. Produce that fits the quality standards can be used for human consumption, but produce that does not fit the standards can still generate revenue when used for other ends, like animal fodder. Transportation works the same for every fresh product. The only thing that differs is the labelling on the package indicating the good that is in the box. Regardless of the type of product, fresh produce needs to be transported, sold, and consumed as fast as possible to guarantee freshness of the product. These processes of cleaning, packing, quality assurance, and transporting cost money. Altogether these costs are part of the trade-off between offering side streams or not.

5.2.1 The concept of provision in processing

Processors do not consciously choose to become involved in the concept of provision, but they simply process produce based on retailer's demand. Costs for processing become lower when the quantity of produce to be processed becomes higher. A higher amount of misshapen produce thus makes it more interesting to process them. Still, it is hard to say how much value a side stream generates relative to the main product. Most often the value of a side stream other than selling it as misshapen produce is less than half of the value of the well-shaped product, but exceptions exist. If the revenue is too low relative to the associated costs, it is not interesting to set up a side stream.

5.2.2 Food wastage in processing

Especially food processers try to avoid transparency about their food wastage, although almost every operation in the processing stage can be associated with a certain amount of wastage. It ranges from leaves and roots to peels and ingrown sand. Dependent on the purpose of the product, wastage can be from 0,5 percent (e.g., tomato) up to 20 percent (e.g., pumpkin) of the product. Still, since every product that is lost or wasted has a direct negative influence on turnover, processing practices are organized in such an optimal way that food loss and waste is as low as possible.

5.3 Sales

Based on the interviews and observations, in this thesis three types of suppliers to consumers are distinguished, being the regular retailers (e.g., Albert Heijn), trendy suppliers (i.e., suppliers that focus on selling unique produce), and internationally-oriented suppliers (i.e., suppliers that focus on selling to people non-domestic background). These three types are referred to as 'retailers'. Retailers are generally perceived as the organizers of the food supply chain. Retailers have direct contact with consumers and are therefore essential in perceiving consumer demand. They organize the upstream parts of the supply chain in such a way that consumer demand is satisfied as well as possible and that every part of the supply chain receives a satisfactory revenue. Next to that, retailers have the task to inform consumers about the product in terms of quality and health. Product characteristics like price, packaging, labelling, et cetera communicate this information to consumers.

5.3.1 The concept of provision in sales

Retailers' decision to become involved in the concept of provision originates from the trade-off between using shelf-space for misshapen produce or for well-shaped produce. Shelf-space for selling misshapen produce might generate lower revenue than shelf-space for selling other produce, but at the same time, this might attract a type of consumer that otherwise would not have visited that retailer. Also in the case that the side stream of misshapen produce generates neither a direct nor an indirect revenue, retailers may still decide to use this shelf space with the aim of communicating a sense of corporate social responsibility. The supply of misshapen produce as side stream is a means of differentiation of consumer groups on the basis of consumers' norms and values towards food. Retailers closely follow trends and thus realize that consumers demand retailers to take responsibility for the environment.

The concept of provision in sales is complex as misshapen produce tends to substitute well-shaped produce. Consumer demand in terms of quantity is unlikely to increase whereas supply does increase. This would cause a retailer to receive a relatively lower revenue from a same supply of produce. If the surplus of well-shaped produce would be sold at the retailer, price would decrease. Therefore alternatives need to be considered, like increasing the export of well-shaped produce or decreasing the total production size.

5.3.2 Food wastage in sales

Unsold food is often considered to be waste. Retailers have always been looking for ways to reduce food wastage as it directly causes financial loss. Therefore, they have set up multiple logistics to generate value from this waste. For example, unsold fruits and vegetables are collected and redistributed to people who are in urgent need of food because they do not have the resources to buy it themselves. Even though this side stream mostly generates costs because of logistics, it generates a non-monetary social value as well.

5.4 Consumption

The final stage in the food supply chain is consumption of produce. Before consumption takes place, consumers make a decision about which product to buy. As there is a wide variety of offered produce, consumers are free to choose the product they think fits them best. Their trade-off is based on a number of product characteristics and consumer characteristics. Primary product characteristics of fresh produce have a lot to do with aesthetics, like shape, color, size, means of presentation, availability, and freshness. There is a realistic chance that produce of low aesthetic value is of lower quality than produce of high aesthetic value. For example, misshapen produce is more potent to rot, ingrown sand, and inside damaging. As food is one of the few things people actually put into their body, the perceived quality and associated health of a product is important to consumers. However, a consumer can make a decision based on the outside without having an idea about what is on the inside.

Also more factual product characteristics communicate information about a product that helps a consumer to make a decision. Plain information about the way the product has been produced and processed are part of this, but also price is important for indicating the quality and reliability of a product. For example, consumers expect organic produce to be more expensive just like they expect misshapen produce to cost less. Next to price, also the quantity of produce that is offered in a predetermined package influences the attractiveness to buy a specific type of food. Consumers who frequently go for grocery shopping or who have a small family size are the least interested in large quantities.

If product characteristics would have been the only aspects on basis of which consumers make decisions, retailers would not offer such a wide variety of produce for a wide variety of

prices. This indicates that there is an influence of consumer characteristics as well. Consumer characteristics originate from a wide variety of lifestyle categories. Each category contains a specific set of social characteristics. Consumers often engage in multiple lifestyles and thereby create a unique set of social characteristics for themselves. The way in which a lifestyle expresses itself may differ a lot per theme. For example, a consumer that engages in a 'green' lifestyle in food consumption does not necessarily engage in a 'green' lifestyle in travelling. Both the lifestyle shapes the practice and the practice shapes the lifestyle. In this way, lifestyles and social characteristics are ways to express one's identity (e.g., vegetarian; vegan; fast food).

Directly related to lifestyles is consumers' environmental awareness and food wastage awareness. People are becoming more aware of environmental issues and of food waste because of many initiatives that have been launched. Consumers are generally willing to pay a little bit more if they have the impression that it positively contributes to the issue. However, if a consumer is truly aware of these issues, aspects like price would not play a role, which it obviously does in reality. Next to that, it is difficult for consumers to judge what is good or bad for the environment in the long run as this can be counterintuitive. The impact of environmental awareness and food wastage awareness on decisions consumers make it hard to assess, but it is clear that consumers trigger other consumers to think about their consumption behavior.

Less directly, but still of importance are consumer characteristics like routinized behavior, skills, and convenience. Routine is an important aspect in decisions consumers make. Consumers have a tendency to question the quality of a product that appears to be different than the standard they are used to. If a consumer would be asked to reconsider routinized behavior, (s)he would most likely realize that well-shaped produce essentially is not different from misshapen produce. Consuming food produce that is not part of a routine usually requires additional skills, thereby reducing convenience. It is important to note that some consumers do and other consumers do not appreciate routines. Some consumers like their skills to be challenged and others do not. Therefore it is hard to draw a general conclusion.

5.4.1 The concept of appropriation in consumption

The way in which misshapen produce is framed is important for a consumers' decision to become involved in the concept of appropriation. It needs to be clear that misshapen produce is not equal to waste as this may be associated negatively. At the same time, to foster environmental awareness and food wastage awareness, it needs to be clear that appropriating misshapen produce reduces food waste and improves the environment. Some consumers conclude that misshapen produce that otherwise would be wasted costs much less. Other consumers decide to appropriate misshapen produce because it makes them feel better about themselves while others are actually concerned with these issues.

5.4.2 Food wastage in consumption

Food wastage is highest in the consumption stage of the food supply chain. It seems inevitable to avoid food wastage in consumption as it is part of individual consumer behavior. It would require an increase in awareness of food waste for consumers to change their consumption behavior and accept consumption of suboptimal produce.

5.5 Summary

The findings from the interviews and observations are summarized in Table 3. Together with literature data, this serves as input for the development of the conceptual framework. The identified variables are categorized based on their position in the simulation model. Table 3

indicates which elements from the interviews and observations are included in the model and it indicates the causal relationship including the polarity of the relationship. A '+' indicates that an increase/decrease in cause results in an increase/decrease in effect whereas a '-' indicates that an increase/decrease in cause results in a decrease/increase in effect. The abbreviations in the 'data source' column stand for the respondent's primary expertise in the food supply chain: production (P), processing (V), retailing (S), consumption (C), and general (A). In comparison to the literature, interviews and observations generated additional information about the trade-off farmers make for determining the means of valorization, about farmers' determination of price, and about consumers' evaluation of product quality. In addition, whereas literature mostly is about 'acceptance' of products, interviews were mostly about 'adoption' of products.

Cause	Effect	Polarity	Included	Data source
MOTIVATION LOOP				
Motivation for *misshapen/well-shaped* produce (i.e., evaluation of aesthetics; routine; convenience; market share; identity)	Misshapen produce *adoption/diffusion* rate	+		V1; C1; C2; S1
Misshapen produce *adoption/diffusion* rate	Motivation for *misshapen/well-shaped* produce (i.e., evaluation of aesthetics; routine; convenience; market share; identity)	+		V1; C1; C2; S1
UTILITY LOOP				
Skills for processing misshapen produce	Yield misshapen produce	+		C1; C2
Yield *misshapen/well-shaped* produce	Utility *misshapen/well-shaped* produce	+		C1; C2
Retailer price *misshapen/well-shaped* product	Utility *misshapen/well-shaped* produce	-		C1; C2; S1
Utility well-shaped produce	Misshapen produce adoption rate	-		C1; C2
Utility misshapen produce	Misshapen produce adoption rate	+		C1; C2
Misshapen produce adoption rate	Skills for processing misshapen produce	+		C1; C2
FOOD WASTAGE AWARENESS LOOP				
Market supply *misshapen/well-shaped* product price	*Food wastage/environmental* awareness	+		V1; C1; C2
Food wastage/environmental awareness	Misshapen produce adoption rate	+		V1; C1; C2

FRESH FOOD SUPPLY CHAIN				
Production rate	Harvest	+	No	P2; V1; P1; P3
Harvest	Post-harvest sorting rate well-shaped produce	+		P2; V1; P1; P3; V1; S1
Harvest	Post-harvest sorting rate side stream produce	+		P2; V1; P1; C2; P3
Harvest	Harvest loss rate	+		P2; V1; P1; C2; P3
Control over production environment	Fraction well-shaped produce	+	No	P2; P3
Fraction well-shaped produce	Post-harvest sorting rate well-shaped produce	+		P2; V1; P1
Fraction side stream produce	Post-harvest sorting rate side stream produce	+		P2; V1; P1; C2
Fraction harvest loss	Harvest loss rate	+		P2; V1; P1; C2
Post-harvest sorting rate *well-shaped/misshapen* produce	Storage and processing *well-shaped/misshapen* produce	+	No	P2; V1; P1; P3
Storage and processing *well-shaped/misshapen* produce	Distribution rate *well-shaped/misshapen* produce	+	No	P2; V1; P1; P3
Storage and processing *well-shaped/misshapen* produce	Storage and processing wastage rate	+		P2; V1; P1; P3
Fraction storage and processing wastage *well-shaped/misshapen* produce	Storage and processing wastage rate	+		P2; V1; P1
Distribution rate *well-shaped/misshapen* produce	Market supply *well-shaped/misshapen* produce	+	No	P2; V1; S1
Market supply *well-shaped/misshapen* produce	Sales rate *well-shaped/misshapen* produce	+		P2; V1; S1; MM
Market supply *well-shaped/misshapen* produce	Market supply *loss/waste* rate	+		P1; S1
Fraction market supply loss	Market supply loss rate	+		C1; S1
Market share *misshapen/well-shaped* produce	Consumer demand for *misshapen/well-shaped* produce	+		C1
Consumer demand for *well-shaped/misshapen* produce	Sales rate *well-shaped/misshapen* produce	+		C1
Consumer demand for *well-shaped/misshapen* produce	Market supply waste rate	-		C1

Sales rate *well-shaped/misshapen* produce	Consumption *well-shaped/misshapen* produce	+	No	P2; V1; C1; S1
Consumption *well-shaped/misshapen* produce	Consumption wastage rate	+	No	P1
FINANCIAL PERFORMANCE				
Harvest	Farmer costs (i.e., production and harvesting costs)	+		P2; V1; P1
Harvest loss rate	Farmer costs (i.e., wastage costs)	+		P2; P1
Storage and processing wastage rate	Farmer costs (i.e., wastage costs)	+		P2; V1; P1
Storage and processing *well-shaped/misshapen* produce	Marginal costs for processing *well-shaped/misshapen* produce	-	No	P2; P3
Distribution rate *well-shaped/misshapen* produce	Farmer revenues (i.e., farmer product revenues)	+		P2; P3
Farmer price *well-shaped/misshapen* produce	Farmer revenues (i.e., product sales)	+		P2; P3
Farmer price *well-shaped/misshapen* produce	Retailer costs (i.e., cost price)	+		V1; C2
Market supply *loss/waste* rate	Retailer costs (i.e., wastage costs)	+		C1; S1
Retailer price *well-shaped/misshapen* produce	Retailer revenues (i.e., product sales)	+		V1; C2
FARMER VALORIZATION TRADE-OFF				
Farmer price of well-shaped produce	Relative farmer price misshapen produce	-		P2; V1; P3
Farmer price of misshapen produce	Relative farmer price misshapen produce	+		P2; V1; P3
Relative price misshapen produce	Valorization rate misshapen produce	+		P2; V1; P3
Relative price misshapen produce	Alternative valorization rate	+		P2; V1; P3
Post-harvest sorting rate side stream produce	Food waste awareness of farmer	+		P2; V1
Food waste awareness of farmer	Alternative valorization rate	-		P2; V1; P1
CONSUMERS EVALUATION				
Evaluation of aesthetics (e.g., shape; color; size)	Perceived quality *misshapen/well-shaped* product	+	No	C1

Retailer price *misshapen/well-shaped* product	Perceived quality *misshapen/well-shaped* product	+	No	C1; S1
Perceived quality *misshapen/well-shaped* product	Associated health *misshapen/well-shaped* product	+	No	C1
Associated health *misshapen/well-shaped* product	Misshapen produce *adoption/diffusion* rate	+	No	C1
CONVENIENCE				
Quantity convenience	Misshapen produce *adoption/diffusion* rate	+	No	C1; C2; S1

Table 3: Causal relationships based on interviews and observations

6. Conceptual framework

6.1 Introduction

This research is founded in a dynamic conceptual framework. This means that relationships involve causality, feedback and delay structures, model boundaries, and a unit of time. The conceptual framework is based on data collected from literature, interviews, and observations. The core structures introduced in this chapter cover the adoption of misshapen produce (e.g., Loebnitz et al., 2015), the acceptance dynamics framework (Ulli-Beer et al., 2010), the design of the food supply chain (Lipinski et al., 2013), and the market mechanism of supply and demand (Smith & Cannan, 2003).

In this case study, the focus is set on one intrinsic, high-scope cue, namely shape. It is hypothesized that acceptance of produce based on shape is explained with help of the cue diagnosticity framework introduced by Purohit and Srivastava (2001) and the triadic SCT framework introduced by Bandura (1986). The diagnosticity framework suggests that extrinsic cues like price alter consumers' evaluation of intrinsic cues like shape. The triadic SCT framework suggests that consumers' decisions are formed by the reciprocal causation between personal determinants, behavioral determinants, and environmental determinants. In addition, Etzion's (2014) note on the effect of awareness, motivation, and costs on preferences and routines lies at the heart of the conceptual framework. Thereby, the conceptual framework introduced in this chapter combines tangible (e.g., utility aspects) and intangible (e.g., social dynamics) aspects of adoption and diffusion of misshapen produce. In Appendix I, a figure of the complete simulation model is given.

6.2 Model development

Adoption and diffusion of misshapen produce is shaped by consumers' evaluation of the shape of produce and consumers' actions on these evaluations. This is conceptualized in Figure 10 as an adoption structure with a stock of non-adopters' share, a stock of adopters' share, an adoption rate connecting non-adopters to adopters, and a disadoption rate connecting adopters to non-adopters. This mechanism is self-balancing. Fresh produce of (extremely) abnormal shape (e.g., Loebnitz et al., 2015) are counted as misshapen produce. Consumers' evaluation of misshapen produce is the primary moderator in this mechanism, influencing both adoption and disadoption. It contributes to a social norm-building process that is based on concepts like aesthetics, convenience, and availability. Thereby, motivation development is a reinforcing process that is both influenced by and influences (non-)adoption. The associated feedback loops are indicated in orange as R1 and R2.

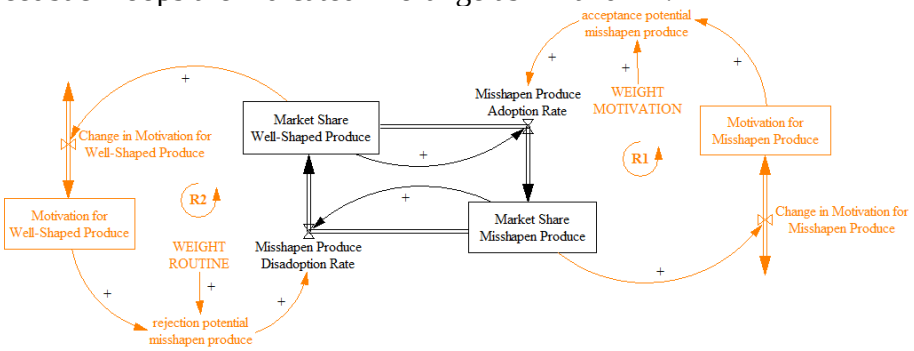


Figure 10: Core structure of adoption, diffusion, and motivation

Adoption is also determined by utility evaluations of product characteristics. The relative utility of misshapen produce as conceptualized in Figure 11 depends on the utility of misshapen produce compared to the utility of well-shaped produce. Utility is determined by

the yield one gets out of a product. Consumers need to develop processing skills to get the most optimal yield out of misshapen produce. These skills are obtained from prior adoption of misshapen produce. Thereby, skills development is a reinforcing process that is both influenced by and influences adoption. The associated feedback loop is indicated in dark blue as R3. In addition, utility is determined by the price one pays for a product. An increase in adoption causes an increase in demand. An increase in demand relative to supply causes an increase in price. An increase in price decreases utility and thus adoption, thereby balancing the price setting mechanism. The associated feedback loops for misshapen and well-shaped produce are indicated in pale blue as respectively B1, B2, B3, and B4.

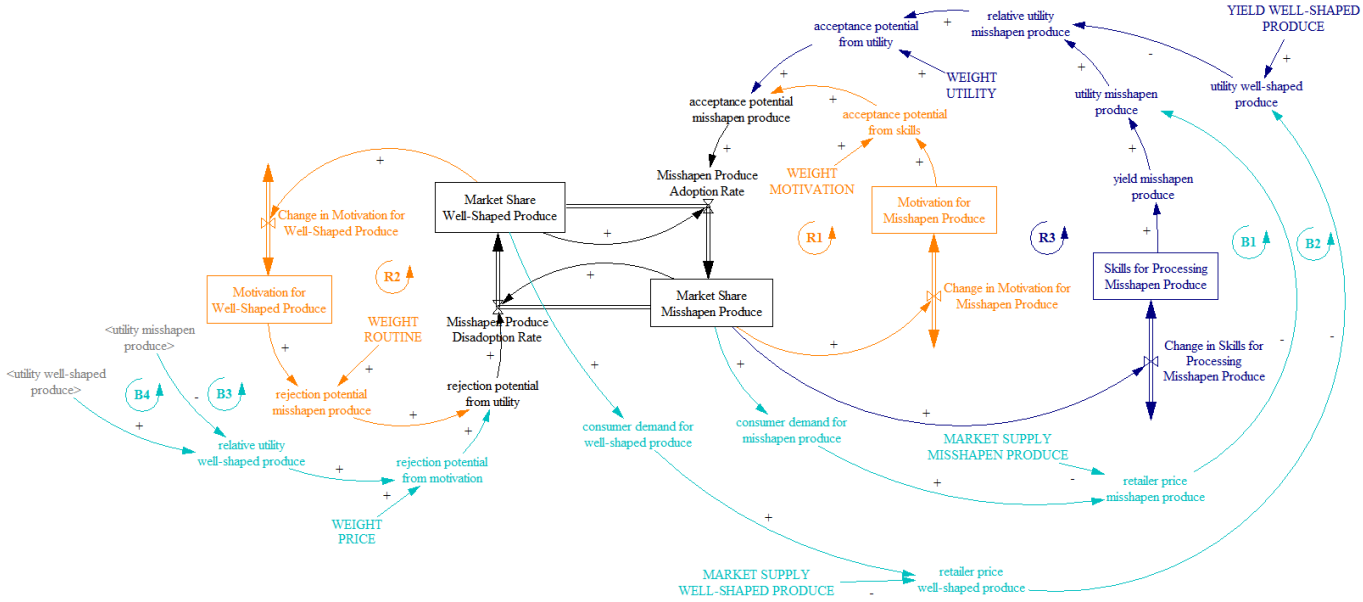


Figure 11: Skills development process and price setting

Furthermore, adoption is influenced by a social process of awareness development. In the case of misshapen produce, awareness originates from consumers' perception of food wastage in the food supply chain. The belief is that adoption of produce reduces food wastage. An increase in adoption causes an increase in demand and thus sales. An increase in sales relative to supply reduces waste at the retailer and thus reduces total food supply chain wastage. A reduction in wastage subsequently reduces the perceived wastage and thereby wastage awareness. This balancing feedback loop of awareness development is indicated in brown as B5 for total food supply chain wastage related to misshapen produce.

The similar social process of awareness development is found for market supply waste of well-shaped produce. A potential increase in adoption if misshapen produce causes a decrease in sales of well-shaped produce and thereby an increase of market supply waste of well-shaped produce. This creates a stimulus for consumers to buy well-shaped produce again, thereby constituting to a balancing feedback loop indicated in brown as B6.

In addition to the core structure described up and until this point, it is hypothesized that the fresh food supply chain influences market supply of both misshapen and well-shaped produce. Thereby, the supply chain has an indirect effect on adoption and diffusion. Market supply is regulated by a trade-off farmers make to provide misshapen produce or to use it for alternative means of valorization. This trade-off is primarily based on a financial calculation. The higher the price of misshapen produce relative to well-shaped produce, the more interesting it is for a farmer to provide misshapen produce to retailers.

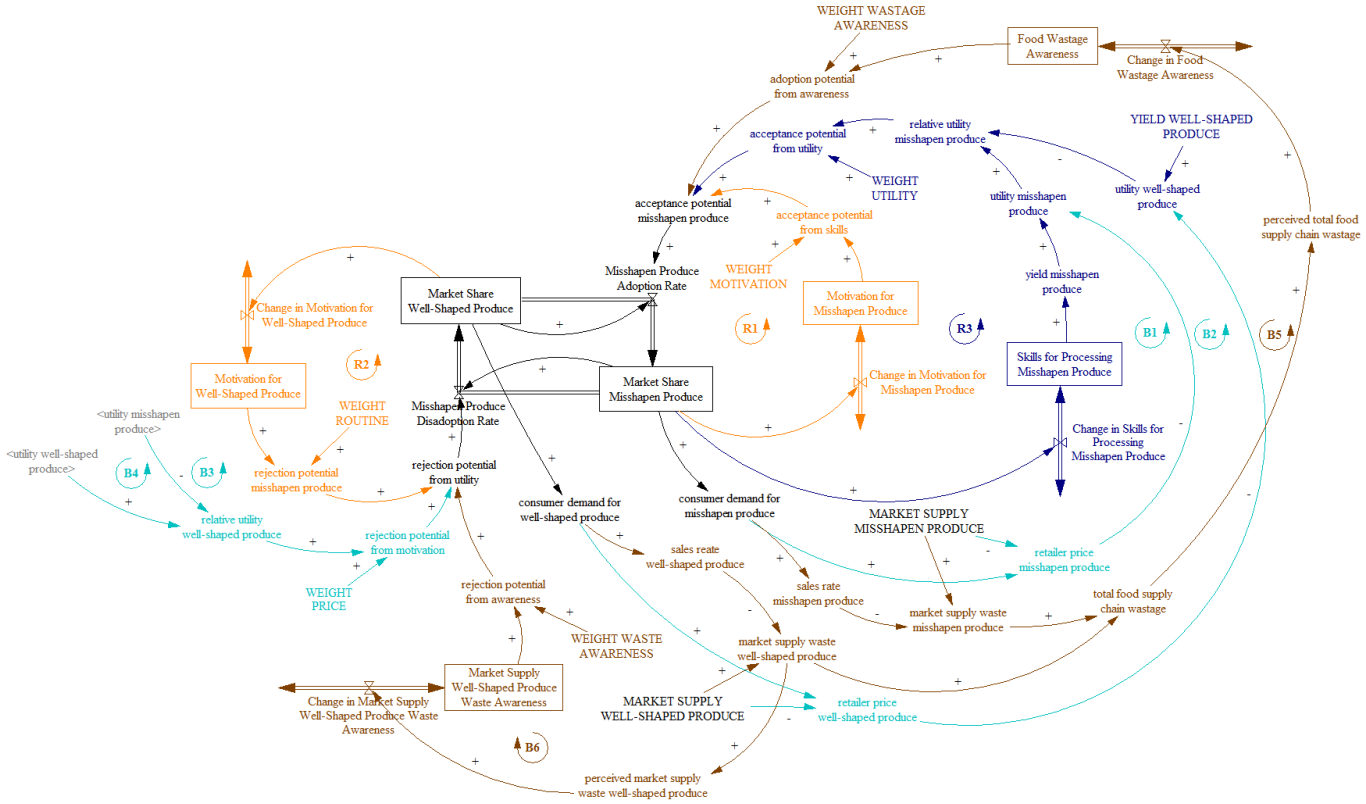


Figure 12: Food wastage awareness development

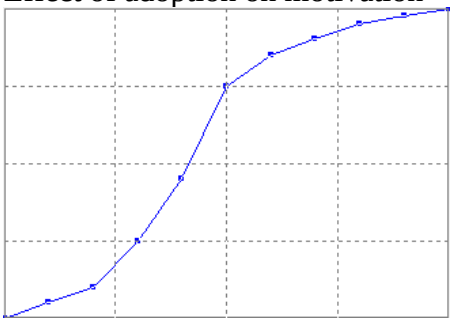
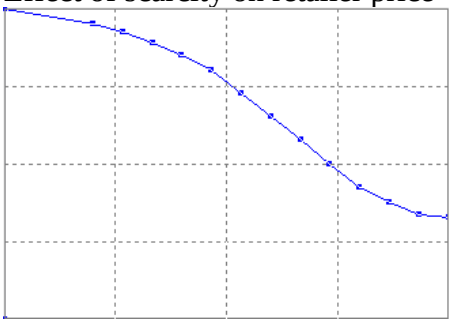
6.3 Model calibration

Quantitative findings from literature, interviews, and observations related to the conceptual framework introduced in the previous paragraph are given in Table 4. Most of these findings relate to production of vegetables in both greenhouses and in open ground, but in some cases the findings relate to both fruits and vegetables. Together with estimations of lacking quantitative data (also see Table 4), these findings are used for the calibration of the simulation model. The identified variables are categorized based on their position in the simulation model.

Exogenous input	Value	Unit	Data source
PRICES			
Farmer price well-shaped produce	0.95	Euro/ Kilogram	REO, 2016 (unspecified production; mushroom and cucumber)
Farmer price misshapen produce	0.57	Euro/Kilotonnes	Estimation (60 % of well-shaped produce) based on interviews and observations.
Standard retailer price well-shaped produce	2.67; 2.64 ; 2.32; 2.37; 2.49	Euro/Kilogram	Statistics Netherlands, 2017 (unspecified production; mushroom and cucumber; over 2012-2016)
Standard retailer price misshapen produce	2.41; 2.37; 2.09; 2.14; 2.24	Euro/Kilogram	Estimation (90 % of well-shaped produce) based on interviews and observations.

PRODUCTION			
Harvest	2,310; 2,348; 2,476; 2,476; 2,480	Kilotonnes /Year	Statistics Netherlands, 2017 (greenhouse; vegetables; over 2012-2016)
INITIAL VALUES			
INIT market share misshapen produce	0.93	Dmnl	Geelen Consultancy, 2017 (unspecified production and type; corrected)
INIT market share well-shaped produce	0.07	Dmnl	Geelen Consultancy, 2017 (unspecified production and type; corrected)
INIT motivation for well-shaped produce	0.9825	Dmnl	Calibration in equilibrium based on the initial market share of well-shaped produce. So it is assumed that the simulation starts from a stable point in the adoption process.
INIT market supply well-shaped produce waste awareness	0	Dmnl	Idem.
INIT motivation for misshapen produce	0.035	Dmnl	Calibration in equilibrium based on the initial market share of misshapen produce. So it is assumed that the simulation starts from a stable point in the adoption process.
INIT skills for processing misshapen produce	0.035	Dmnl	Idem.
INIT food wastage awareness	0.126	Dmnl	Idem.
FRACTIONS			
Fraction well-shaped produce	0.95 0.8	Dmnl	SH; GB (greenhouse; vegetables) Geelen Consultancy, 2017 (unspecified production and type; corrected)
Fraction side stream produce	0.04 0.19	Dmnl	SH; GB (greenhouse; vegetables) Geelen Consultancy, 2017 (unspecified production and type; corrected)
Fraction harvest loss	0.01 0.01	Dmnl	SH; GB (greenhouse; vegetables) Geelen Consultancy, 2017 (unspecified production and type; corrected)
Fraction storage and processing wastage well-shaped produce	0.02	Dmnl	DE (unspecified production; vegetables); FAO, 2016 (unspecified production and type)

Fraction market supply loss	0.05	Dmnl	Geelen Consultancy, 2017 (unspecified production and type; corrected)
Fraction market supply waste	0.05	Dmnl	Geelen Consultancy, 2017 (unspecified production and type; corrected)
Fraction storage and processing wastage misshapen produce	0.03	Dmnl	Estimation (150 % of well-shaped produce) based on interviews and observations.
CONSUMPTION			
Total demand for fresh produce	1,963; 1,996; 2,105; 2,105; 2,108	Kilotonnes/Year	Estimation (85 % of harvest) based on production and wastage data.
DELAYS			
Time to adjust motivation	2	Year	Change of motivation (i.e., routine; convenience; perceptions) is generally known as a relatively slowly developing process.
Time to adjust skills	1	Year	It is generally known that skills for processing misshapen produce can be acquired relatively fast.
Time to perceive wastage	1	Year	It is generally known that by reports from media, wastage can be perceived relatively fast.
Time to adjust awareness	2	Year	Becoming aware of an environmental issue is generally known as a relatively slowly developing process.
YIELDS			
Yield well-shaped produce	1,500	Kcal/Kilogram	Estimation based on various (online) sources
Potential yield misshapen produce	1,400	KCal/Kilogram	Idem. In addition, interviews revealed that the yield of misshapen produce is lower than the yield of well-shaped produce.
WEIGHTS			
Weight wastage awareness	0.1	Dmnl	It is generally known that awareness may increase to high extends, but hardly influences adoption and diffusion.
Weight waste awareness	0.1	Dmnl	Idem.

Weight utility	0.7	Dmnl	It is generally known that price- and utility-related factors are most dominant in adoption and diffusion.
Weight price	0.7	Dmnl	Idem.
Weight motivation	0.2	Dmnl	It is generally known that motivation- and routine-related factors are important in adoption and diffusion.
Weight routine	0.2	Dmnl	Idem.
EFFECTS AND ELASTICITIES			
Effect of adoption on motivation 	[(0,0)-(1,1)],(0,0),(0.1,0.05),(0.2,0.1),(0.3,0.25),(0.4,0.45),(0.5,0.75),(0.6,0.85),(0.7,0.9),(0.8,0.95),(0.9,0.975),(1,1)	Dmnl	Estimation based on adoption literature (e.g., Etzion, 2014; Kopainsky, Tröger, Derwisch & Ulli-Beer, 2012; Ulli-Beer et al., 2010; Ulli-Beer, 2004). An increase in adoption increasingly contributes to motivation until 75% of the people adopts the product. After this peak in (dis)adoption rate, the relative change in motivation increases decreasingly.
Effect of disadoption on motivation	Idem.	Dmnl	Same as 'Effect of adoption on motivation'
Effect of adoption on skills	[(0,0.5)-(1,1)],(0,0.5),(0.1,0.525),(0.2,0.55),(0.3,0.625),(0.4,0.725),(0.5,0.875),(0.6,0.925),(0.7,0.95),(0.8,0.975),(0.9,0.9875),(1,1)	Dmnl	Same as 'Effect of adoption on motivation', but on a 0.5 – 1 scale.
Effect of scarcity on retailer price 	[(0,0)-(30,2)],(0,2),(0.3,1.9),(0.4,1.85),(0.5,1.775),(0.6,1.7),(0.7,1.6),(0.8,1.45),(0.9,1.3),(1,1.15),(1.1,1),(1.2,0.85),(1.3,0.75),(1.4,0.675),(1.5,0.65),(30,0.65)	Dmnl	Estimation based on market mechanism literature (Smith & Cannan, 2003) and interviews. An increase in supply-demand ratio increasingly reduces retailer price until the supply-demand ratio decreased to 1.2. Hereafter, the relative change in retailer price decreases decreasingly and stabilizes at a supply-demand ratio of 1.5.

Elasticity of food wastage awareness	1.25	Dmnl	The elasticity indicates that food wastage awareness is 25 % higher than the food wastage fraction.
Elasticity of utility	2	Dmnl	In the model, the elasticity is activated when the utility of misshapen produce is higher than the utility of well-shaped produce. The elasticity indicates that from this point on, every increase in relative utility is a double increase in indicated utility.
Elasticity of valorization	4	Dmnl	In the model, the elasticity is activated when the farmer price of misshapen produce is at least half of the farmer price of well-shaped produce. The elasticity indicates that from this point on, every increase in relative price is a quadruple increase in valorization as misshapen produce.

Table 4: Parameter values from data sources and by estimation

PART III: Simulation model

The third part of this thesis presents the simulation model as product of the data collection and analysis in the second part of this thesis and refers back to the foundation that is established in the first part of this thesis. Figure 13 indicates the structure by which the simulation model is presented. Chapter 7 is concerned with the assessment of the internal and external validity of the model. It functions both as a check point of the model development and calibration so far and as preliminary analysis of the model. In chapter 8, the formal analysis the simulation model of is performed based on the results that are extracted from a 'business-as-usual' simulation and an 'ideal' simulation in the validated model. Based on this analysis, policies are developed and tested in chapter 9, including the assessment of these policies in the context of various scenarios.

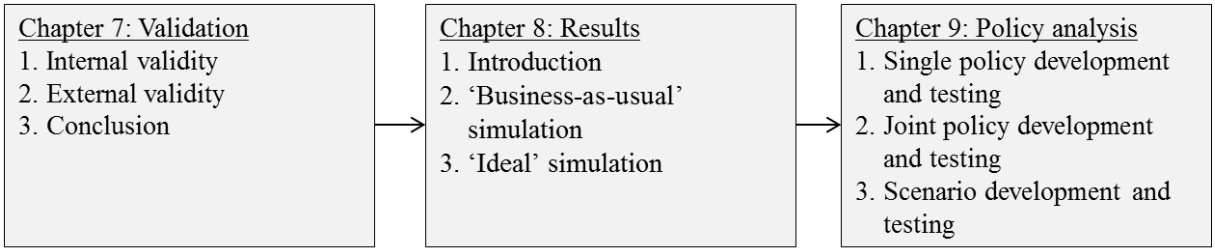


Figure 13: Simulation model

7. Validation

7.1 Internal validity

Validation in this thesis is perceived as a gradual process in which confidence in the model is built. The internal validation of the model is mostly addressed in the execution of this research by means of collecting and analyzing data that serves as the foundation of the model. Data originates from three sources, namely literature, interviews, and observations. This triangulation of data collection resulted in both overlapping and unique information, but never in contradicting information. In those cases in which information from various sources may seem contradicting, one should consider the contextual background (e.g., wastage fractions differ when comparing greenhouse horticulture with open ground horticulture).

During the interviews, respondents were very responsive to the questions that were addressed. This represents a very useful condition for validation since the model is largely developed based on insights from the reality lived by each of the interview respondents. Respondents were frequently asked to confirm or falsify statements about elements from the model and they were stimulated to elaborate on these statements on own initiative. This approach encouraged verification of the model and confirmation of the quality of the results provided by the model. The data from the various sources allowed the design of a high-scope framework that was translated into a low-scope simulation model based on the researcher's knowledge and past experience.

7.2 External validity

The external validity of the model is assessed by testing the robustness of the model. Barlas (1996) introduces three categories of tests that can be performed for assessing the robustness of a model: direct structure tests, structure-oriented behavior tests, and behavior pattern tests. It is only useful to perform tests from the second and third category if tests from respectively the first and second category proved validity of the model.

7.2.1 Direct structure tests

Direct structure tests assess the validity of the model structure by comparison of the model structure with the current knowledge about real structure of the system (Barlas, 1996). Direct structure tests include empirical tests (e.g., structure verification test; parameter verification test) and theoretical tests (e.g., direct extreme-condition test; boundary adequacy; dimensional consistency test).

The structure verification test is about verifying if model structure does not contradict knowledge about the structure of the 'real' system. For this test, an assessment of compliance of the model with existing theory is performed. Based on existing theory about adoption and diffusion (e.g., Etzion, 2014; Ulli-Beer et al., 2010) there is reason to believe that the model includes all relevant structures. Thus, the structure verification test is passed.

The parameter verification test is about verifying if each parameter matches the elements in the real system and if its value lies in plausible ranges. For this test, an assessment of coverage of data from literature and interviews in the model is performed. Based on Table 2 and Table 3, it can be said that there is a high coverage of data from literature, interviews, and observations. Excluded model elements from interviews are parts of the supply chain (e.g., strictness of quality standards) and parts of consumers' evaluation (e.g., convenience) that are found to merely influence dynamics. As compensation, these model elements are indirectly included in the model (e.g., wastage fractions representing strictness of quality standards; motivation representing convenience). Based on this, the parameter verification test is passed.

The direct extreme-condition test is about verifying the response of the model to extreme conditions of each model parameter. In case of a warning or error, an analysis is given. In Table 5, the predetermined conditions tested for each type of parameter dimension in the model is indicated. In those instances where the model parameter is used as denominator, the value zero is not tested as this inevitably results in a Floating Point Error. The extreme-condition test revealed that there is one element in the model that should be treated with caution. It appears that the lookup *'EFFECT OF SCARCITY ON RETAILER PRICE'* gets out of bounds for the value 1,000,000,000 of *'HARVEST'*. The reason is that after some small adjustments, this value is set-off to consumer demand, which is 2,055 at maximum, resulting in a ratio higher than 48,000 whereas the lookup allows a maximum input value of 30. An increase in consumer demand by the same proportion resolves the warning as expected. This warning is the only weakness in the structure of the model and, as described above, it can be defended well. The remaining structure of the model appears to be robust based on the extreme conditions (no other errors and/or warnings) and thereby this test is passed.

Unit	**Extreme conditions tested**
Dmnl (fractions; weights)	0; 1
Dmnl (other)	0.001; 1
Year	0.25;1,000
Euro/Kilogram	0; 0.1; 1,000
Euro/Kilotonnes	0; 1,000,000
Kilotonnes/Year	0; 1; 1,000,000,000
KCal/Kilogram	0; 0.1; 1,000,000

Table 5: Predetermined extreme conditions per type of parameter dimension

For the boundary adequacy test, the guiding question is: does the model include all relevant structures needed for fulfilling the purpose of the model? Therefore, the purpose of the model is reviewed. The purpose of the model is to answer the research question: *"Which processes drive adoption of misshapen produce in the Netherlands?"* Sub-questions indicate that the aim is to find out which product characteristics, consumer characteristics, and supply chain operations causally relate with adoption of misshapen produce. In addition, it needs to be possible to test policies. For every causality associated with adoption, one or multiple model elements have been introduced (i.e., shape; price; motivation; skills; waste; revenue), thereby satisfying the purpose of the model. In addition, an assessment of possible model extensions based on data collection is performed. It is certain that implementation of additional qualitative and quantitative data (e.g., supply chain; consumers' evaluation; alternative valorization; financial performance) would make the model fit better with reality and thus improve validity. However, the increase in understanding of the dynamics to which the system is subject in comparison with required additional data is expected to merely contribute. Based on these arguments, it can be concluded that the model boundary is adequate for the purpose of the model.

Key in the dimensional consistency test is consistent use of units from input values (exogenous parameters and stocks) when writing equations in the model. With help of the *'Units check'*-function in the software, the reported outcome is *"Units are OK."*.

7.2.2 Structure-oriented behavior tests

The structure-oriented behavior tests assess the validity of the structure indirectly by comparison of model-generated behavior patterns with the model structure (Barlas, 1996). This category includes the symptom generation test, multiple mode test, pattern/event prediction test, anomaly test, family member test, sensitivity test, policy sensitivity test, surprise behavior test, and characteristics test.

The symptom generation test is about assessing whether the behavior of variables in the model match the reference mode of these variables in the real system for the right reasons. For this test, the model is run with a 'business-as-usual' parameterization (see Table 2 and Table 3) up to the current date (2012 till 2016). Because of lacking data about the adoption of misshapen produce and related variables, there is no historical reference mode in terms of a behavior graph over time. Therefore, the 'business-as-usual' simulation is compared with the verbal historical reference mode as presented in the problem description paragraph of chapter 1. The most reliable reference mode for fraction of vegetables wasted in the supply chain is based on FAO's (2010) post-production and pre-consumption vegetables wastage in 2009 (207 Kilotonnes), Statistics Netherlands' (2017) vegetables harvest in 2009 (2385 Kilotonnes), and Geelen Consultancy's (2017) fraction of harvest loss (1 %). This results in 9,7 % of vegetables wasted in the supply chain in 2009 (pre-consumption).

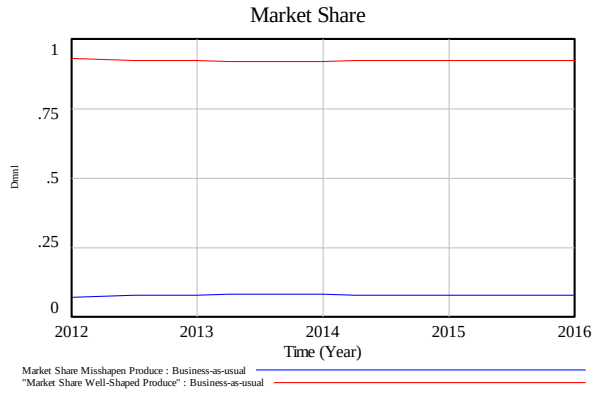
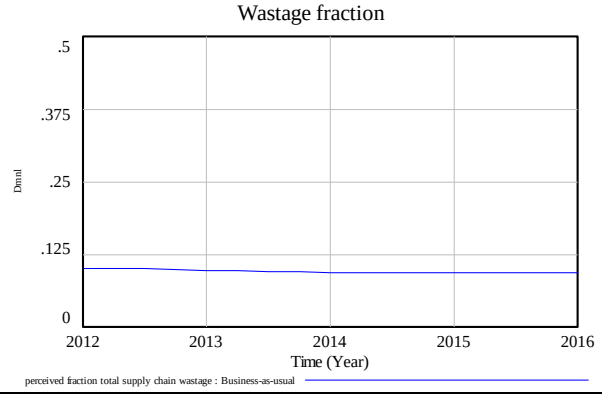
Historical reference mode	**'Business-as-usual' simulation**
"The assumption in this thesis is that the adoption of misshapen fruits and vegetables currently is in equilibrium."	
0.097	

Table 6: Symptom generation test

Table 6 shows that the 'business-as-usual' simulation of adoption and wastage fraction match the historical reference modes. Note that it requires some assumptions to perform this test. It is therefore hard to assess if the model is valid based on this test.

The multiple mode test is concerned with how many modes of behavior are produced that can be targeted by policies. The existence of modes of behavior indicates the presence of dissimilar structures for each element in the adoption and diffusion framework. The figures in Table 7 depict the behavior over time of different elements in the framework. Results suggest that there are indeed differences among the various adoption and diffusion elements. In the 'business-as-usual' simulation, the differences between market share, motivation, skills, and awareness are hardly observable as everything seems in equilibrium, but in the 'Financial-stimulus' simulation (indicating a reduction in price consumers pay for misshapen produce of 0.75 euro per kilogram) the differences become visible as all indicated variables respond with

a somewhat different pattern. Performing this multiple mode test indicates that policies can be targeted at these four modes of behavior.

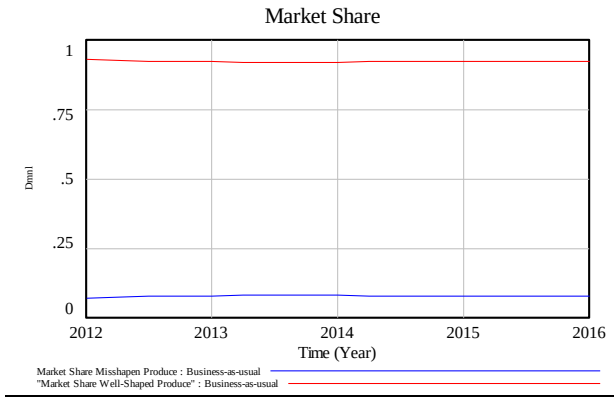
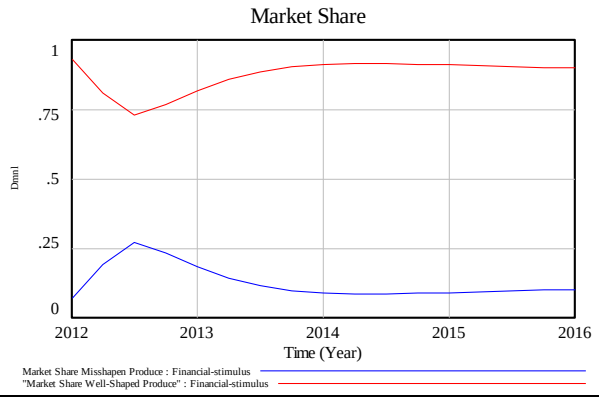
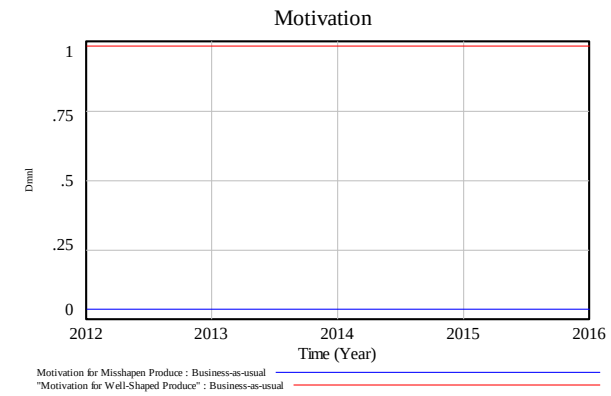
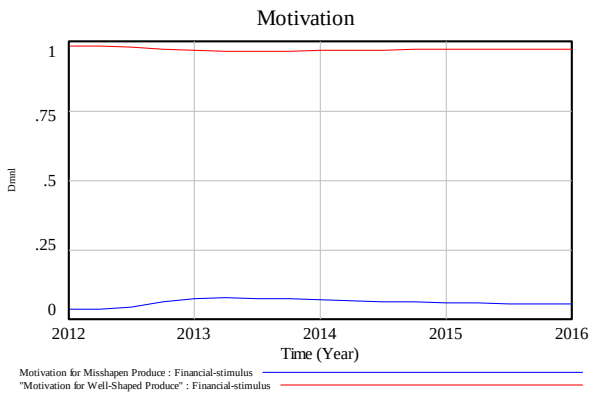
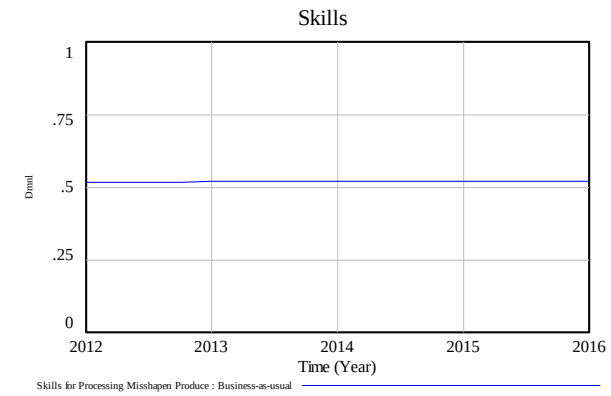
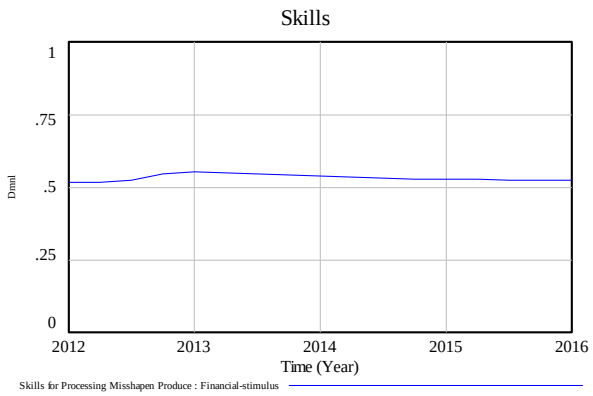
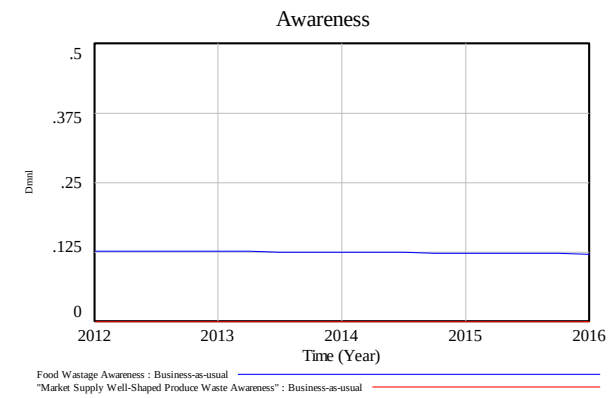
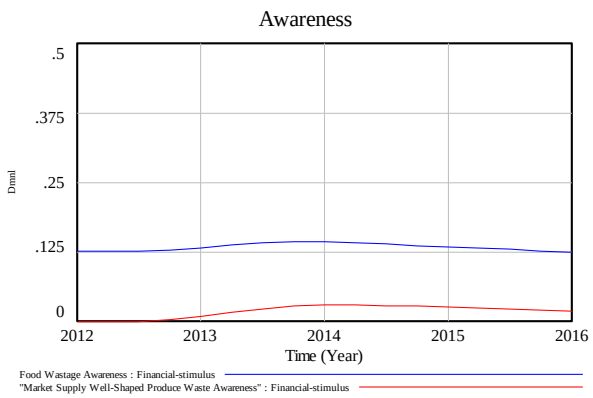
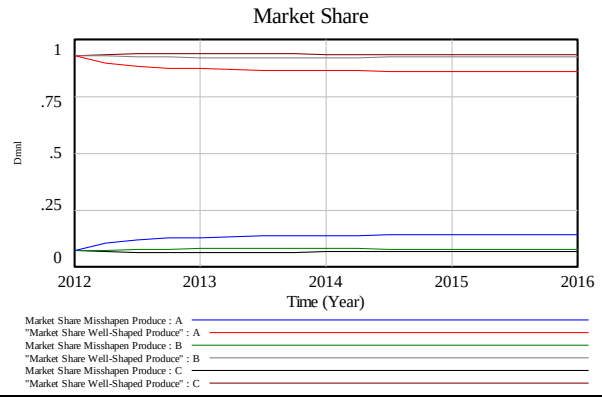
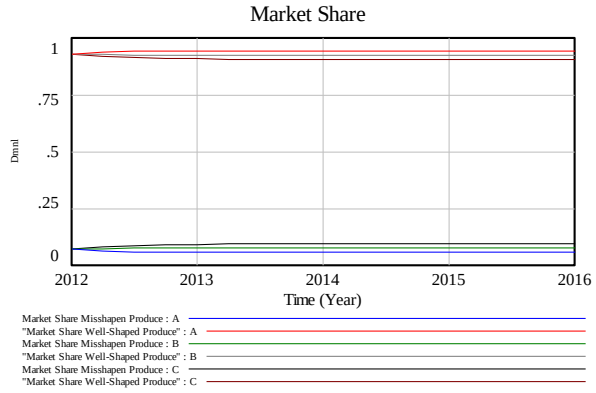
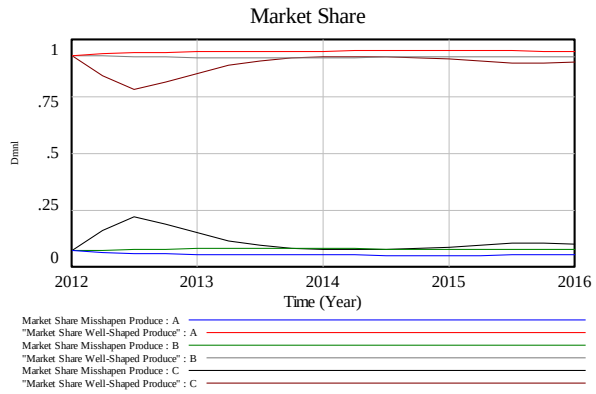
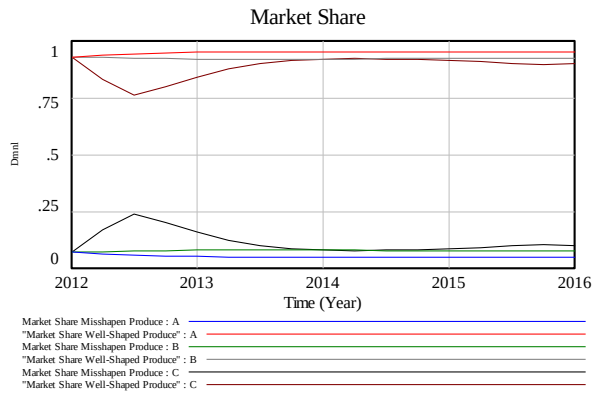
‘Business-as-usual’ simulation	‘Financial-stimulus’ simulation
	
	
	
	

Table 7: Multiple mode test

In the pattern/event prediction test the assessment is about whether the model behaves as expected under different conditions of parameter values. Table 8 shows five parameters with different combinations of parameter values with simulations of the behavioral output. The parameters were chosen without prior thought.

Parameter and conditions	**Simulation**
Total demand for fresh produce • A: 1000 • *B: 2055 ('Business-as-usual')* • C: 3000	
Harvest • A: 1400 • *B: 2418 ('Business-as-usual')* • C: 3400	
Potential yield misshapen produce • A: 900 • *B: 1400 ('Business-as-usual')* • C: 1900	
Standard retailer price well-shaped produce • A: 1.5 • *B: 2.5 ('Business-as-usual')* • C: 3.5	

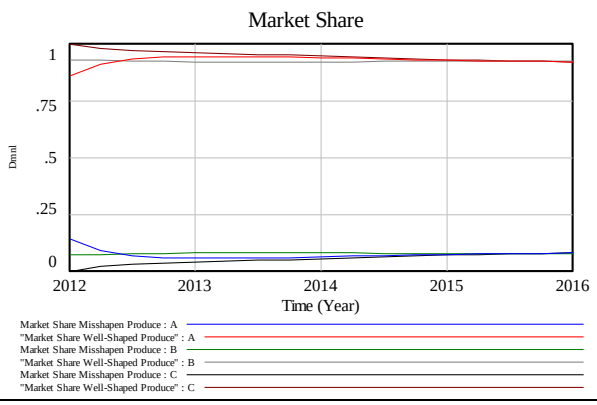
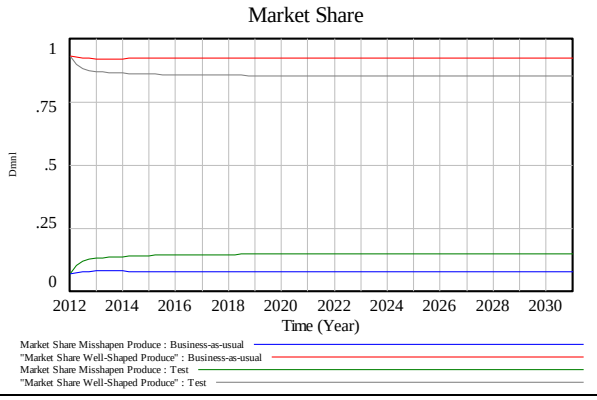
INIT market share well-shaped produce • A: 0.86 • *B: 0.93 ('Business-as-usual')* • C: 1	

Table 8: Pattern/event prediction test

All graphs in Table 8 show behavior that is to be expected based on the structure of the model. Different initial conditions in market share, for example, do not affect the development of adoption in the long run because of the strength of various factors that influence adoption. This is the case as the assumption in this thesis is that currently, these factors cause adoption to be in equilibrium. Other simulations do depict a permanent change in adoption. Different conditions for demand for fresh produce and harvest, for example, may result in a structurally higher or lower adoption of misshapen produce. This can be explained by the influence of supply and demand on price and on perceived food wastage, which both constitute a structural change in the system as they are elements that lock themselves in. Yield and price cause a permanent change in adoption as well, but its behavior seems unexpected due to the sensitive calibration of utility in the model. A change in adoption based on utility-evaluations alone does not seem to be lasting that long as the relative utility is easily affected. The assumption is that consumers still prefer to buy well-shaped produce if the associated utility is equal to misshapen produce. Based on the pattern/event prediction test it can be concluded that the parameter conditions in this model can be logically explained.

The anomaly test is of a different type. It assesses the consequences of taking out some of the assumptions in the model. It is tested whether the model predictions are different when some assumptions are taken out by simulating the model to the end of the time horizon (2012 till 2031). Table 9 shows the simulations of behavioral output from five assumptions about non-linearity that were taken out.

Assumption taken out	**Simulation**
Effect of scarcity on price • *'Business-as-usual': [(0,0)-(30,2)], (0,2), (0.3,1.9), (0.4,1.85), (0.5,1.775), (0.6,1.7), (0.7,1.6), (0.8,1.45), (0.9,1.3), (1,1.15), (1.1,1), (1.2,0.85), (1.3,0.75), (1.4,0.675), (1.5,0.65), (30,0.65)* • Test: [(0,0)-(30,2)], (0,1), (30,1)	

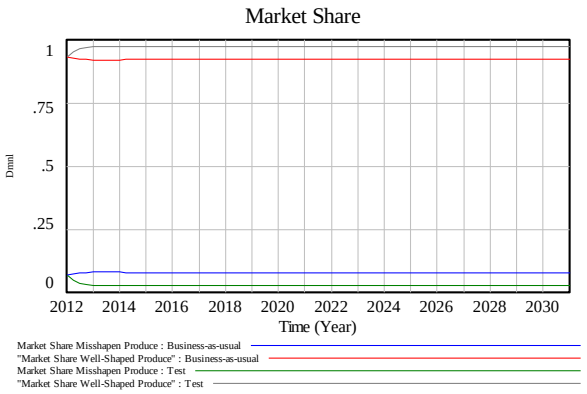
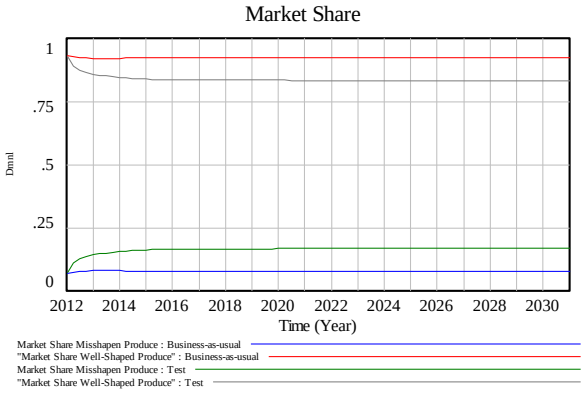
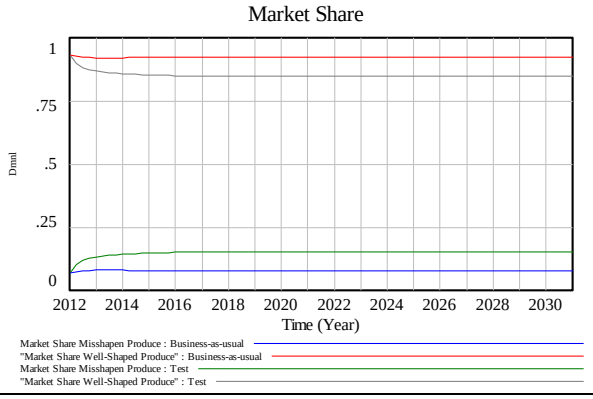
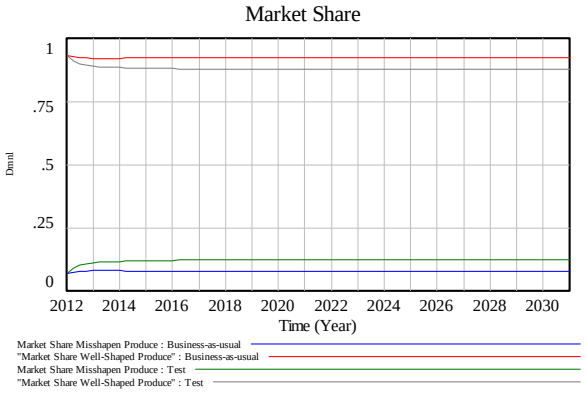
Elasticity of valorization • 'Business-as-usual': 4 • Test: 1	
Effect of adoption on motivation • *'Business-as-usual': [(0,0)-(1,1)], (0,0), (0.1,0.05), (0.2,0.1), (0.3,0.25), (0.4,0.45), (0.5,0.75), (0.6,0.85), (0.7,0.9), (0.8,0.95), (0.9,0.975), (1,1)* • Test: [(0,0)-(1,1)], (0,0), (1,1)	
Effect of adoption on skills • *'Business-as-usual': [(0,0.5)-(1,1)], (0,0.5), (0.1,0.525), (0.2,0.55), (0.3,0.625), (0.4,0.725), (0.5,0.875), (0.6,0.925), (0.7,0.95), (0.8,0.975), (0.9,0.9875), (1,1)* • Test: [(0,0.5)-(1,1)], (0,0.5), (1,1)	
Elasticity of food wastage awareness • 'Business-as-usual': 1.25 • Test: 1	

Table 9: Anomaly test

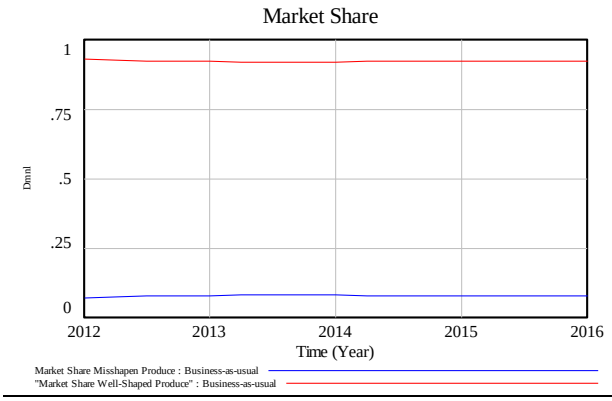
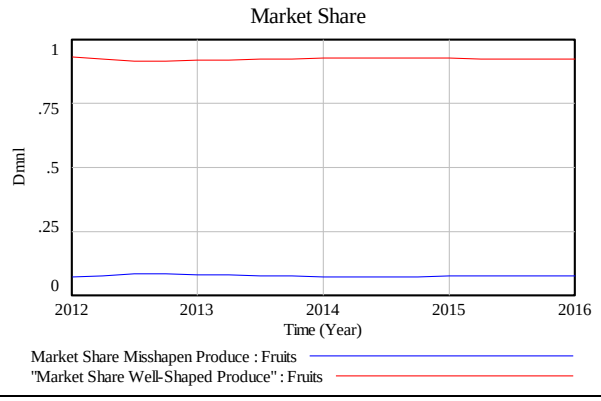
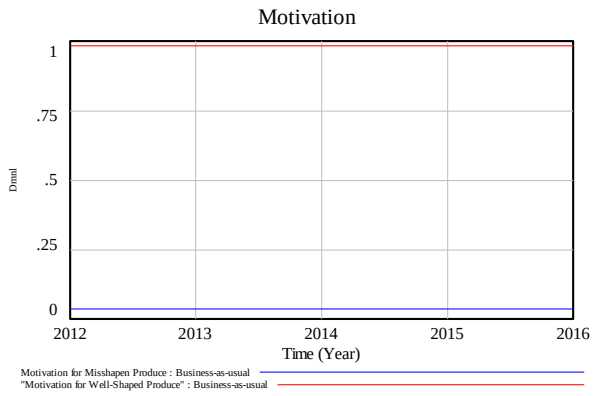
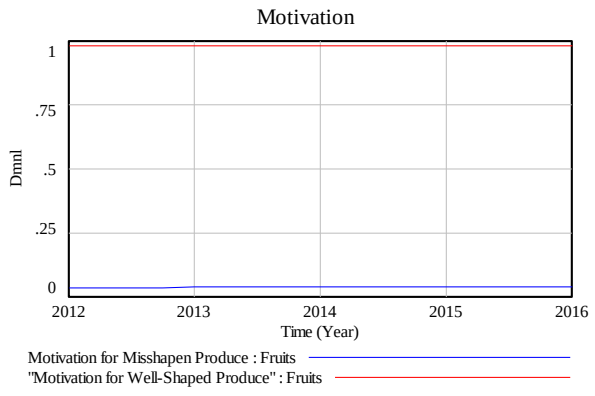
All graphs in Table 9 clearly show that taking out assumptions in the model changes the pattern of adoption and diffusion of misshapen produce, but to a limited extent. The straight lines from the 'test' simulations prove that the assumptions are not implemented to 'correct' for undesired model behavior. Based on this test, most assumptions do not seem to have an important contribution. This may be different under more dynamic conditions. Based on the

anomaly test it can be concluded that the assumptions in the model are necessary to reproduce the historical reference mode, since all simulations deviate from the reference mode when an assumption is taken out.

For the family member test, the model is run under a different set of parameter values to assess whether the model is a generic model of its class. There are various sets of parameter values that could be tested if data was available, but for this test the focus is on a set of parameter values for the adoption of misshapen fruit (see Table 10). These values are based on data from Statistics Netherlands (2016) and researcher's assumptions. All graphs of the 'Fruits' simulation in Table 11 show behavior that is highly comparable with the 'Business-as-usual' (vegetables) simulation. This indicates that the model is a generic model of its class. However, as indicated before, additional data for exact calibration of the model might indicate differently. Additional tests with parameter value sets for other types of production and produce (e.g., greenhouse horticulture; open ground horticulture; agriculture; aquaculture; livestock), would allow further assessment of the model as a generic model of its class.

Parameter	Value: vegetables	Value: fruits
Harvest	2,418	640
Total demand for fresh produce	2,055	608
Potential yield misshapen produce	1,400	700
Yield well-shaped produce	1,500	750
Standard retailer price well-shaped produce	2.5	1.2
Standard retailer price misshapen produce	2.25	1.1

Table 10: Family member test parameterization

'Business-as-usual' simulation	'Fruits' simulation
	
	

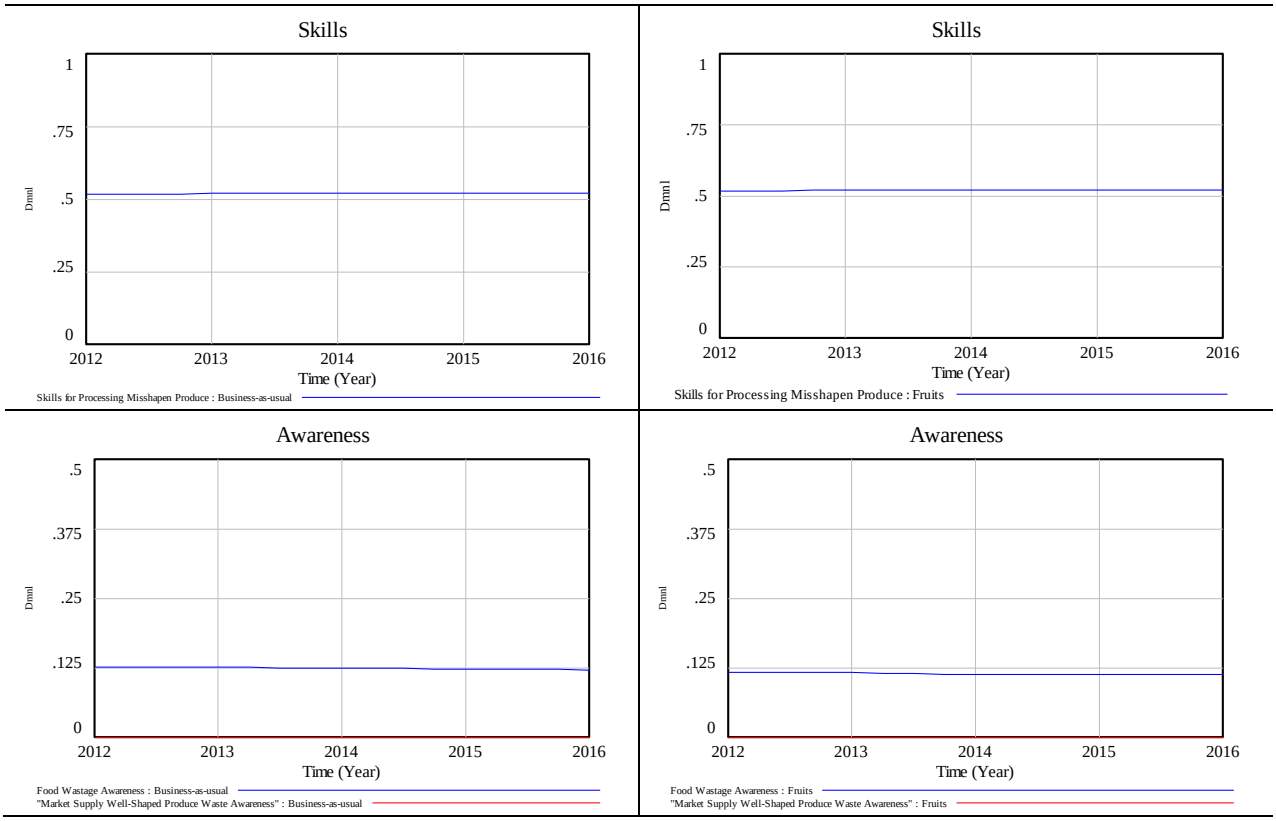
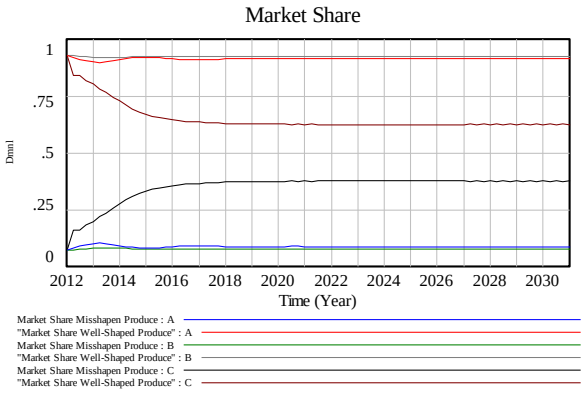


Table 11: Family member test simulation

In the sensitivity test the assessment is about whether the model behaves as expected under different combinations of parameter values. Table 12 shows simulations of the behavioral output from four different combinations of parameters values that relate to specific elements in the model.

Combination of parameter values	**Simulation**
Sensitivity towards motivation • Effect of (dis)adoption on motivation (A: weaker; *B: normal*; C: stronger) • Weight motivation/routine (A: 0.05; *B: 0.2*; C: 0.8) • Time to adjust motivation (A: 4; *B: 2*; C: 1)	

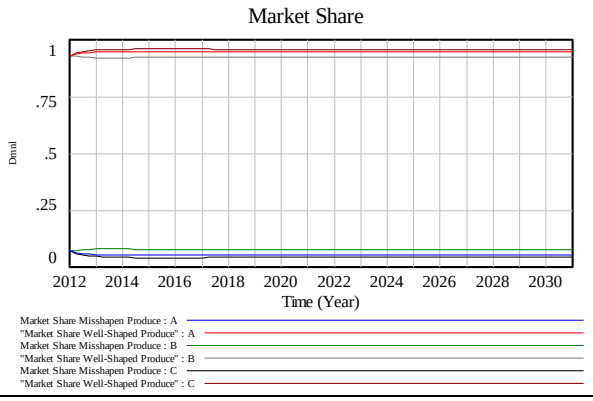
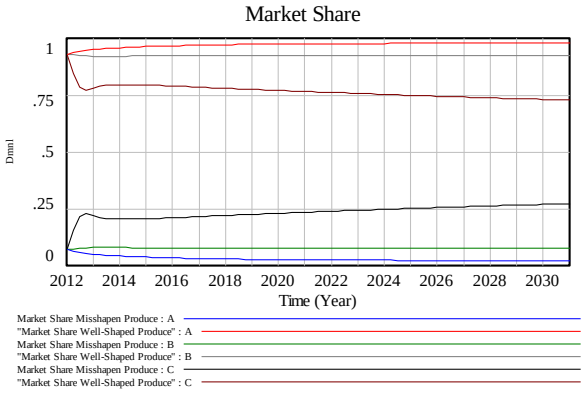
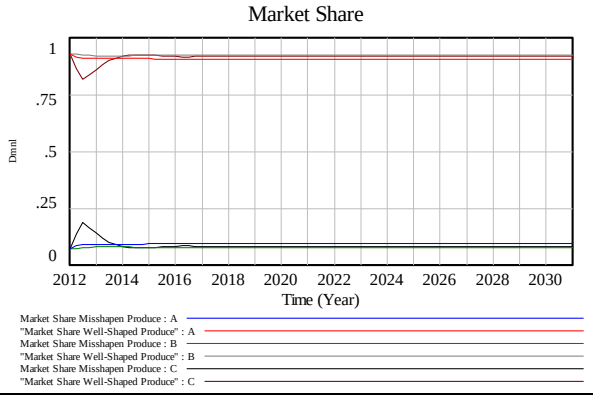
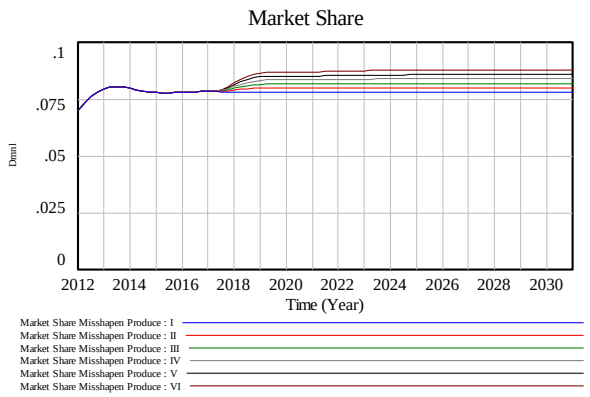
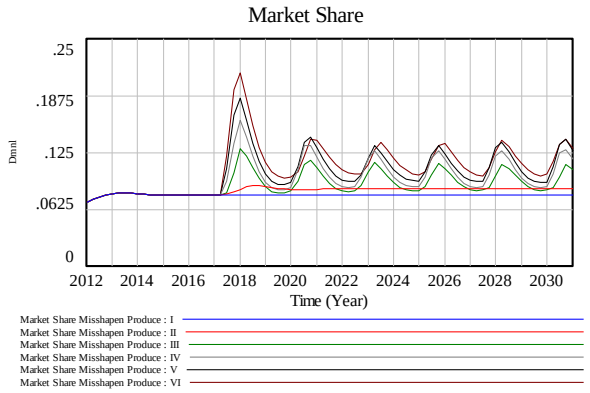
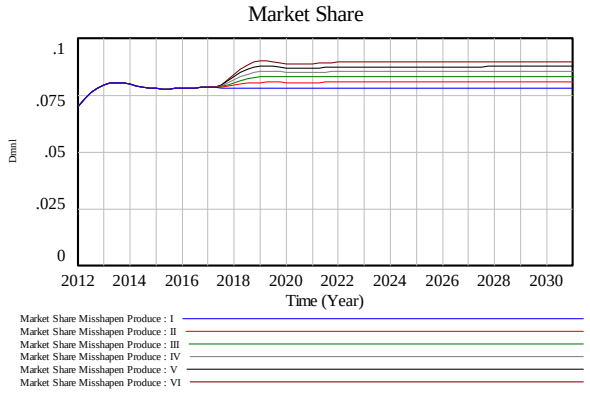
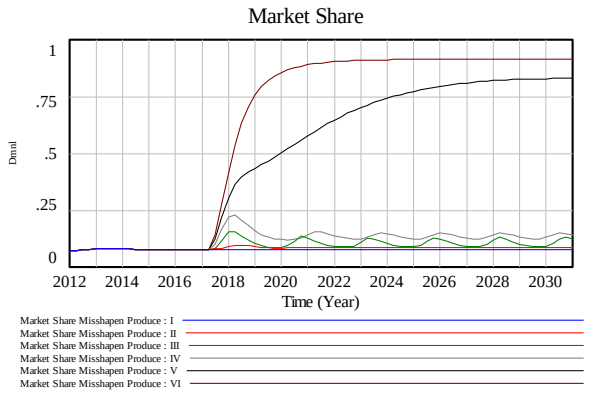
Sensitivity towards utility • Effect of adoption on skills (A: weaker; *B: normal*; C: stronger) • Weight utility/price (A: 0.5; *B: 0.7*; C: 0.9) • Effect of scarcity on retailer price (A: higher; *B: normal*; C: lower)	
Sensitivity towards awareness • Elasticity of food wastage awareness (A: 0. 675; *B: 1.25*; C: 2.5) • Weight (waste) awareness (A: 0.025; *B: 0.1*; C: 0.4) • Time to perceive wastage (A: 4; *B: 1*; C: 0.25)	
Sensitivity towards supply and demand • Total demand for fresh produce (A: 1,000; *B: 2,055*; C: 3,000) • Harvest (A: 3,400; *B: 2,418*; C: 1,400) • Farmer price misshapen produce (A: 0.25; *B: 0.57*; C: 0.95)	

Table 12: Sensitivity test

The graphs in Table 12 show that the influence of parameters on adoption is different per element. Parameters related to motivation cause a major change in the long run, but a relatively minor change in the short run. Parameters related to supply and demand have some influence, but much less when compared to parameters related to awareness, which changes drastically in the short run and continues developing in the long run. Parameters related to utility have to smallest influence on adoption because of the sensitivity of the price setting function. The model behavior is somewhat unexpected based on the prior finding that utility does have a major impact on adoption. However, this unexpected behavior can be explained as the three parameters tested per element vary in their nature (e.g., weight; effect; delay; elasticity) and in the sensitivity that is tested. The next test allows some further analysis of sensitivity in the model.

The policy sensitivity test is to assess the sensitivity of the model under different values of policy parameters. In Table 13, five policy parameters are described together with simulations of the behavioral output. The policy parameters were chosen based on potential policies that are extracted from interviews and observations and are activated from 2017 on.

Policy parameter and value	Simulation
Motivation creation (influencing *'indicated motivation'*) • I: 0 • II: 0.2 • III: 0.4 • IV: 0.6 • V: 0.8 • VI: 1	
Skills development (influencing *'indicated skills'*) • I: 0 • II: 0.2 • III: 0.4 • IV: 0.6 • V: 0.8 • VI: 1	
Awareness creation (influencing *'indicated food wastage awareness'*) • I: 0 • II: 0.2 • III: 0.4 • IV: 0.6 • V: 0.8 • VI: 1	
Price subsidies for consumer (influencing 'standard retailer price misshapen produce') • I: 0 • II: 0.2 • III: 0.4 • IV: 0.6 • V: 0.8 • VI: 1	

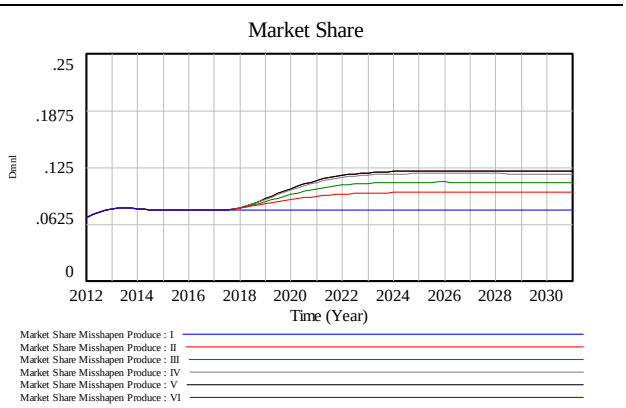
Price subsidies for farmer (influencing *'farmer price misshapen produce'*) • I: 0 • II: 0.2 • III: 0.4 • IV: 0.6 • V: 0.8 • VI: 1	

Table 13: Policy sensitivity test

The policy sensitivity test simulations in Table 13 show some interesting behavior patterns. The first remarkable finding is that price subsidies for consumers can be used to overcome a leverage point in the system of adoption. The second remarkable finding are the oscillations in the skills development policy. They indicate that the influence of skills development on utility is dominated by the influence of price on utility. This indicates that for a policy to be effective either skills need to develop much more to dominate price or development of skills should be combined with change in price as well. The other policies are clearly less sensitive for reaching such a leverage point and therefore demand the development of a strong joint policy, which is to be discovered in chapter 9. In general it can be concluded that the model is sensitive to implementation of policies.

Key in the surprise behavior test is a 'business-as-usual' simulation to the end of the time horizon (2012 till 2031). Given that no surprising behavior arose so far, there is no need to verify if this surprising behavior also occurs in the real system.

Finally, for the characteristics test, the pattern of behavior from the simulation should match the system in general. This means that the shape of curves, peaks, and possibly unusual events from various simulations needs to be assessed. The graphs in this paragraph show one particular development of which it is not clear if it matches the system in general (see 'Market Share' under 'Financial-stimulus simulation' in Table 7). The possibly unusual peak originates from the price-setting function in the model. Price changes due to scarcity and surplus of fresh produce. This change in price has a relatively strong effect on utility and thereby adoption and disadoption. This change in price influences consumer demand for produce, causing a rapid 'correction' of the scarcity or surplus. The rapid increase and decrease in price can be well explained. As empirical data of the influence of price on adoption from the real system is lacking, this fluctuation cannot be compared and therefore can only be validated based on the theoretical knowledge about supply and demand. As this is the only unusual behavior in the simulation, the characteristics test is passed.

7.2.3 Behavior pattern tests

The behavior pattern tests assess how accurate the model can reproduce the major behavior patterns in the real system (Barlas, 1996). These tests include plausibility tests, consistency tests, and prediction tests, which require detailed information about the past and present behavior of the real system of adoption and diffusion. This detailed information is lacking in the case of misshapen produce.

One of the behavior pattern tests is concerned with the stability of the simulation. For this purpose, the simulation time is extended from twenty years to a thousand years. Table 14 shows the simulations of behavioral output. These can be compared with the simulations resulting from the modes of behavior test in Table 7. The graphs in Table 14 indicate that

simulation of model behavior is stable for both the ‘business-as-usual’ simulation and the ‘financial-stimulus’ simulation.

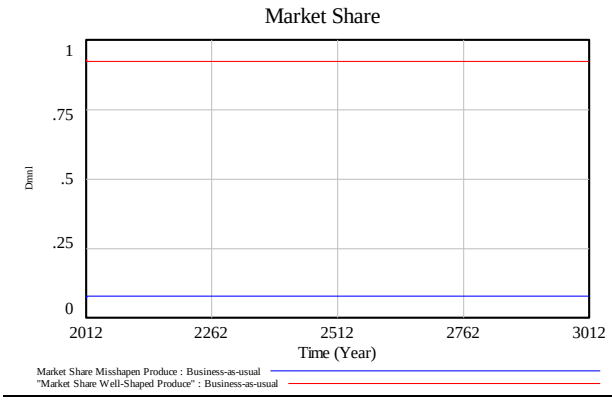
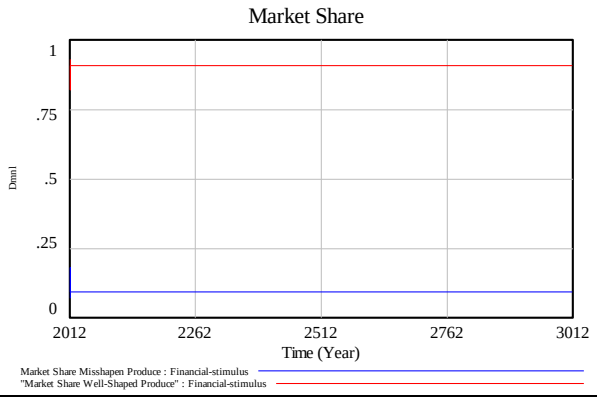
‘Business-as-usual’ simulation	‘Financial-stimulus’ simulation
	

Table 14: Stability test

7.3 Conclusion

Results of the model validation allow to affirm that the model developed in this thesis is a robust model. Internal validity in data collection and analysis highly improved the quality of the model so that the model is a reliable representation of reality. In addition, the assessment regarding direct structure tests indicates that the model behaves logically. The structure-oriented behavior tests allow to affirm validity of the model, but analyses would have been more interesting if it was possible to compare model behavior of several indicators with development of these indicators in the real system. As indicated before, this lack of data also resulted in the behavior pattern tests paragraph to be fairly limited in analysis. However, taken all external validity assessments together, it can be concluded that the model is a quite valid representation of reality. This conclusion allows the model to be used for testing scenarios and policies.

8. Results

8.1 Introduction

The simulation model provides output in the terms of simulations over time. These simulations indicate developments in the past and possible developments in the future based on the deterministic inclusion of effects and the dynamic consideration of time in the model. As a system dynamics model is simulated from a macro level perspective as a continuous progression of time, there is no representation of single events in the simulation. To understand the dynamics that are present in the simulations, a look back at the conceptual framework presented in chapter 6 is useful. In addition, a highly abstracted causal loop diagram summarizes the main dynamics in the model (see Figure 14). A sequenced approach is taken for describing the model and the results that originate from the model. The abstract dynamics are described first, followed by the dynamics that can be read from the 'business-as-usual' simulation, and concluded with the dynamics that can be read from the 'ideal' simulation.

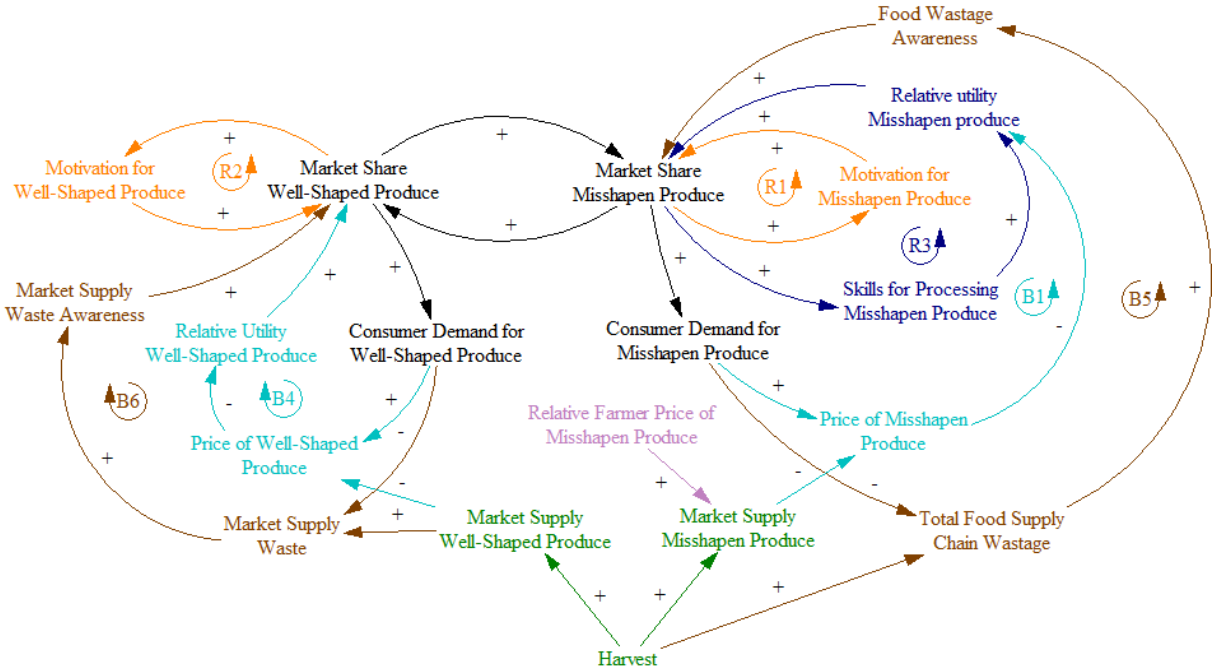


Figure 14: Causal loop diagram

In a situation in which adoption of misshapen produce is increasing – represented by an increase in market share of misshapen produce - the reinforcing loops of motivation (R1) and skills development (R3) cause adoption of misshapen produce to increase even further because consumers motivate each other and develop skills by the practice of adoption itself. In addition, adoption causes a higher consumer demand for misshapen produce. This causes price to increase, but wastage to decrease. The increase in price contributes to a balancing loop as it reduces the relative utility of misshapen produce so that adoption is negatively affected (B1). The decrease in wastage contributes to a balancing loop as well as it decreases food wastage awareness and negatively affects adoption (B5). Both price and wastage, however, are also dependent on the yearly harvest and on the financial trade-off farmers make to determine what share of misshapen produce they offer for sales. An increase in adoption of misshapen produce indicates an absolute decrease in market share of well-shaped produce. Similar patterns develop here: motivation reinforces (R2) the decreasing trend, while utility (B4) and market supply waste awareness (B6) balance potential abrupt developments in the system.

In the opposite situation, a situation in which adoption of misshapen produce is decreasing, the reinforcing loops of motivation (R1) and skills development (R3) cause adoption of misshapen produce to decrease even further because there is less motivation and skills development among consumers. Disadoption also causes a lower consumer demand for misshapen produce. This causes price to decrease and wastage to increase. The decrease in price (B1) and the increase in food wastage awareness (B5), however, make it more attractive to adopt misshapen produce, thereby positively influencing market share of misshapen produce. A decrease in adoption indicates an absolute increase in market share of well-shaped produce. Again, similar patterns develop: motivation reinforces (R2) the increasing trend and utility (B4) and market supply waste awareness (B6) balance potential abrupt developments in the system.

8.2 'Business-as-usual' simulation

The 'business-as-usual' simulation is founded in a parameterization based on actual data about the adoption of fresh produce and related factors. Details about this can be found in chapter 4, 5, and 6. The 'business-as-usual' simulation – in reproducing the assumed historical behavior – shows a stable simulation in which the market share of misshapen produce is around seven percent. Figure 8.2a shows that there is (almost) no development in adoption and diffusion of misshapen produce over the period 2012 till 2031.

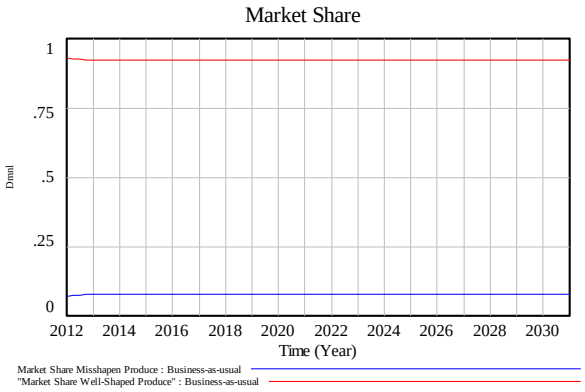


Figure 15: Market share ('business as usual')

When evaluating the causes and consequences of this stable simulation, it can be found in Figure 16 and Figure 17 that motivation (R1 and R2) and skills development (R3) are in stable simulation as well. This indicates that the respective reinforcing loops are not activated.

Figure 16: Motivation ('business as usual')

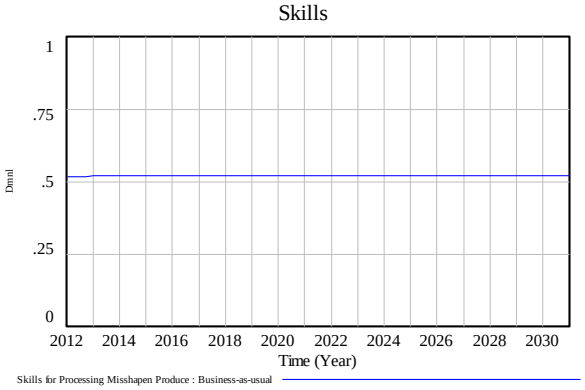


Figure 17: Skills ('business as usual')

Figure 18 and Figure 19 shows that also the balancing loops of respectively utility (B4) and food wastage awareness (B5 and B6) are not activated. This is interesting as these loops are partially influenced by external factors, like the annual harvest and farmers' financial

trade-off. Figure 20 indicates the stable levels of retailer price of well-shaped and misshapen produce (B1) and Figure 21 shows the stable selection rates of well-shaped and misshapen produce from the farmer.

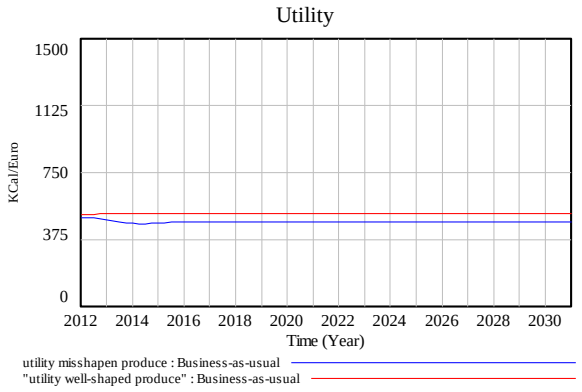


Figure 18: Utility ('business as usual')

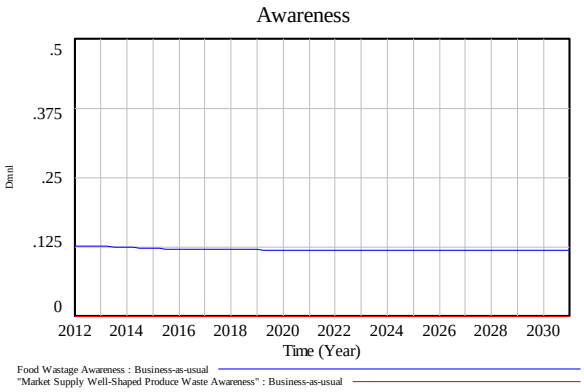


Figure 19: Awareness ('business as usual')

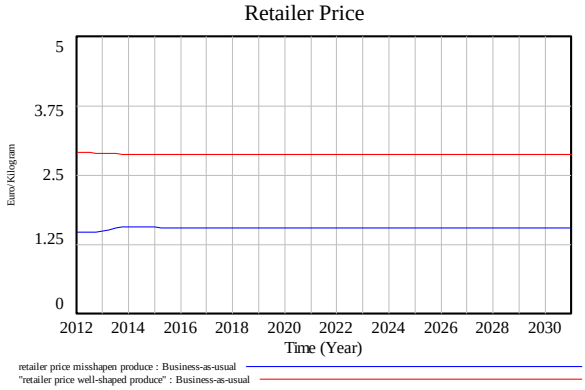


Figure 20: Retailer price ('business as usual')

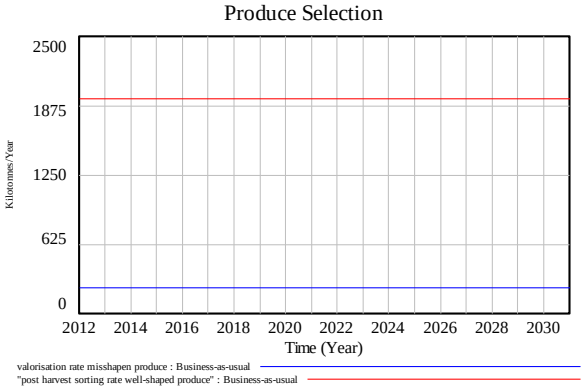


Figure 21: Selection ('business as usual')

8.3 'Ideal' simulation

The 'ideal' simulation is based on a parameterization in which the actual data about the adoption of fresh produce and related factors is adjusted for the benefit. The 'ideal' simulation shows an S-shaped development of adoption of misshapen produce that starts from a market share of misshapen produce of seven percent that grows on to almost twenty percent. In other words, from 2017 on, there is an increasing growth in adoption, followed by a decreasing growth so that market share stabilizes at a new, possibly maximum, level. Figure 22 shows the curve of development in adoption and diffusion of misshapen produce over the period 2012 till 2031.

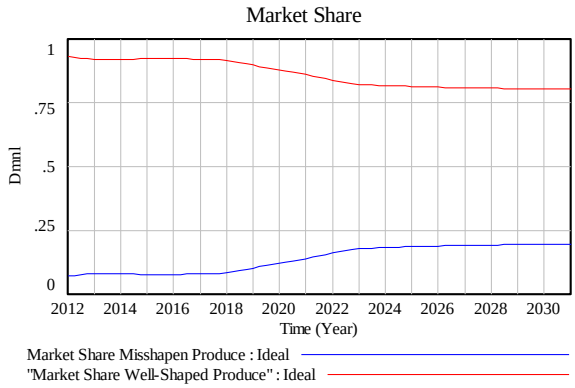


Figure 22: Market share ('ideal')

When evaluating the causes and consequences of this S-shaped development, it can be found in Figure 23 and Figure 24 that motivation (R1 and R2) and skills development (R3) experience an S-shaped development as well. This indicates that the respective reinforcing loops are activated. Motivation for misshapen produce increases almost tenfold and skills increase with about thirty percent. These developments are both caused by and causing an increase in market share of misshapen produce. Motivation for well-shaped produce remains relatively high at a level of approximately 95. This can be explained by the relatively high market share of well-shaped produce.

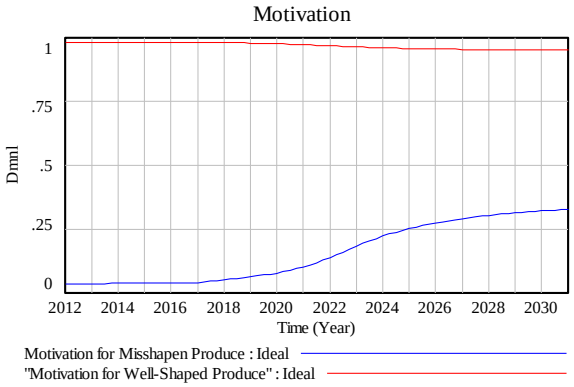


Figure 23: Motivation ('ideal')

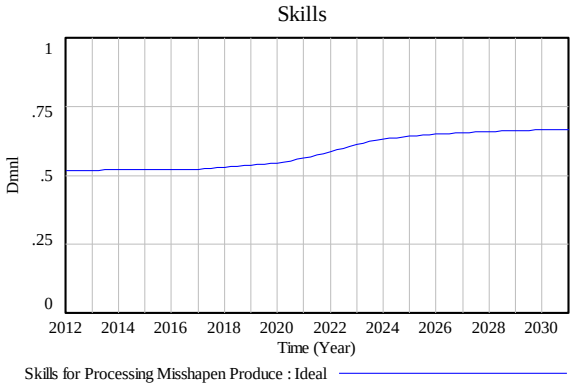


Figure 24: Skills ('ideal')

Figure 25 and Figure 26 show that the balancing loops of respectively utility (B4) and food wastage awareness (B5 and B6) are also activated in this 'ideal' simulation. It seems surprising that utility of misshapen produce decreases around the year 2022, but the development of retailer price (B1) in Figure 27 indicates that this is caused by a scarcity of misshapen produce combined with a surplus of well-shaped produce. This causes prices to change as a result from a change in market share. Figure 28 shows how a part of the scarcity of misshapen produce is covered because farmers start to select double the amount of misshapen produce for sales to consumers from 2017 on. Both the change in market share and the change in farmers' selection explain the increase in food wastage awareness. The change in market share causes a surplus in market supply of well-shaped produce and the change in farmers' selection causes an absolute increase in supply chain throughput, and thus an absolute increase in supply chain wastage.

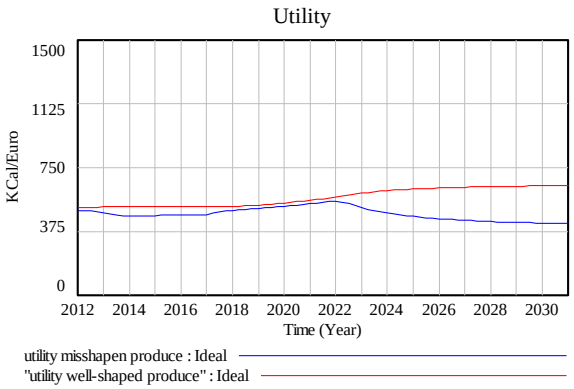


Figure 25: Utility ('ideal')

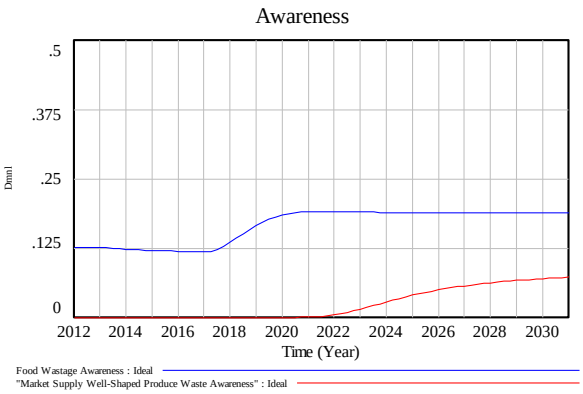


Figure 26: Awareness('ideal')

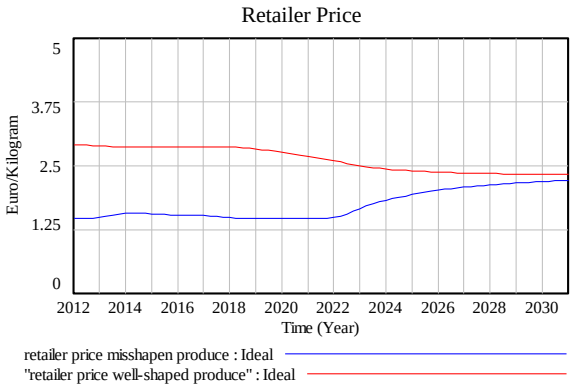


Figure 27: Retailer price ('ideal')

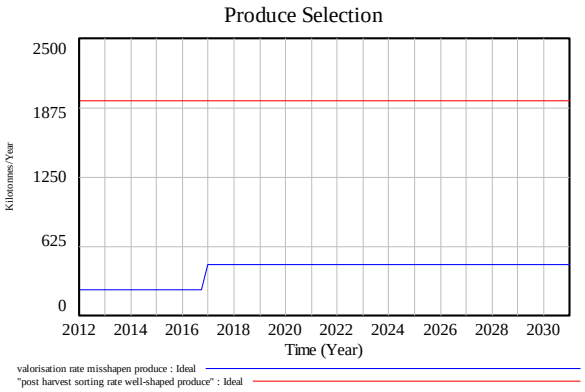


Figure 28: Selection ('ideal')

9. Policy analysis

9.1 Single policy development and testing

An endogenous simulation of adoption and diffusion in the context of the fresh food supply chain allows the evaluation of misshapen produce as a viable business model. Policies that foster the provision and adoption of misshapen produce need to be analyzed to evaluate the business model. In this thesis, there is no designated policy maker, so that it needs to be assumed that a policy maker is primarily concerned with two things: what needs to be done and for how long it needs to be done. Policy analyses can be evaluated at multiple levels. One level is the extent to which product characteristics and consumer characteristics influence the (dis)adoption of misshapen produce. Another level is the extent to which the food supply chain responds adequately to changes in demand for misshapen produce. The policies assessed in this chapter are implemented from 2017 for a varying number of years. The description and simulation graphs indicate the intensity and duration of each policy run.

9.1.1 Subsidizing retailer price

The policy sensitivity test in chapter 7 indicated that the influence of price on consumers' utility evaluation is dominant in the model. Therefore, the first single policy test is aimed at the price consumers pay for misshapen produce. This policy can be implemented as a subsidy plan in which the price consumers pay for misshapen produce is partially funded by an external institution, creating a financial incentive for consumers to adopt misshapen produce. A zero to hundred percent subsidy plan is assessed in this policy test.

Figure 29 and Figure 30 show interesting developments in adoption that are activated by this policy. Two patterns can be distinguished: oscillations for the zero to sixty percent subsidy plans and an exponential approach for the eighty and hundred percent subsidy plans. The oscillations in market share originate from the oscillations in retailer price and have a two-and-a-half year cycle. As can be found in Figure 31, these oscillations originate from a scarcity of misshapen produce. Scarcity is followed by surplus, which is followed by scarcity and so forth. Scarcity causes retailer price to increase and surplus causes retailer price to decrease. As market supply of misshapen produce remains equal (see Figure 32), the switch in the way the mechanism operates has a direct effect on the mechanism itself.

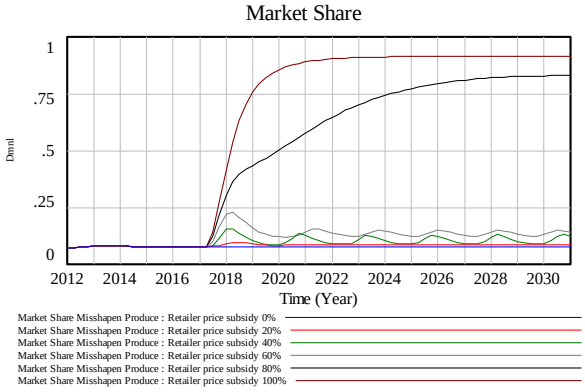


Figure 29: Market share ('sub. ret. price')

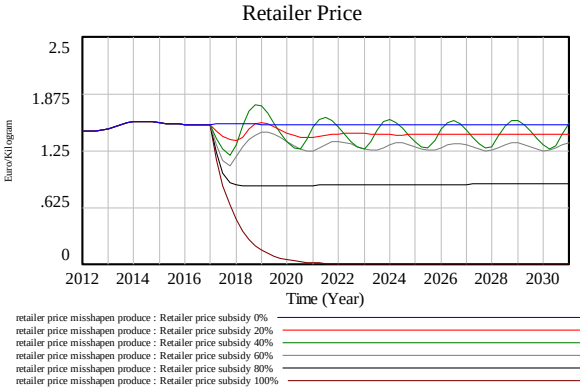


Figure 30: Retailer price ('sub. ret. price')

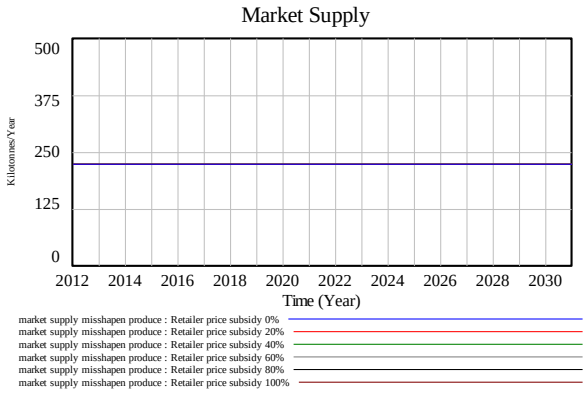


Figure 31: Market supply ('sub. ret. price')

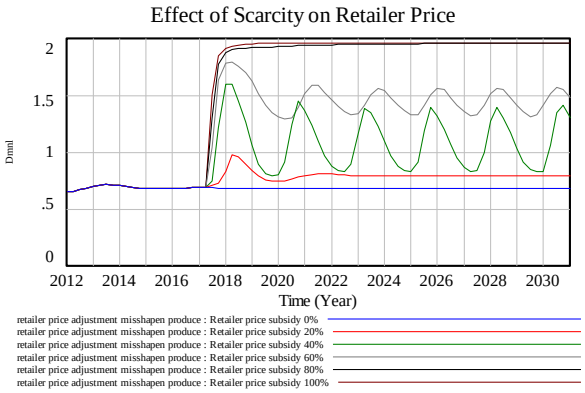


Figure 32: Scarcity effect ('sub. ret. price')

The switch from oscillations to an exponential approach indicates that a leverage point is overcome. This is the joint influence of retailer price, skills (see Figure 33), motivation (see Figure 34), and awareness (see Figure 35) on adoption. These values have become so dominant that the influence of scarcity on retailer price diminishes. The resulting increase in adoption to approximately ninety percent is abnormal, given that the provision of misshapen produce is twenty percent at maximum. It is interesting to find that the oscillations from the lower subsidy plans hardly influence skills, motivation, and awareness. The nonlinearity of these elements is most likely the reason that a relatively small change in adoption has a much smaller impact on these developments.

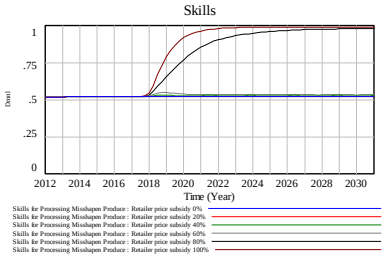


Figure 33: Skills ('sub. ret. price')

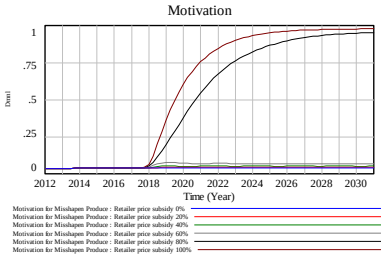


Figure 34: Motivation ('sub. ret. price')

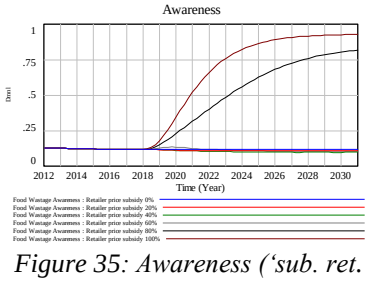


Figure 35: Awareness ('sub. ret. price')

Albeit a somewhat unrealistic adoption pattern, it is relevant to assess the required duration of implementation of the eighty and hundred percent subsidy plans. This provides an indication of whether the spent budget is a sustainable investment or not. Figure 36 and Figure 37 show the simulations of various durations (one to six years) of the most effective policy introduced, the hundred percent subsidy plan. It is found that the investment does not have a lasting influence on adoption of misshapen produce as levels in all elements of the system directly decrease in value. This is likely to be the result of the strong influence of scarcity, causing retailer price to increase to high values, thereby directly negatively influencing utility and thereby adoption.

Subsidizing retailer price appears to be effective for stimulating adoption when the subsidy level increases to eighty percent of retailer price and higher. However, the policy is far from efficient as the subsidy plan creates a scarcity of misshapen produce that causes retailer price to increase again. A subsidy plan may be a good option, but probably part of the budget needs to be allocated to generating an increase in supply of misshapen produce so that scarcity is counteracted.

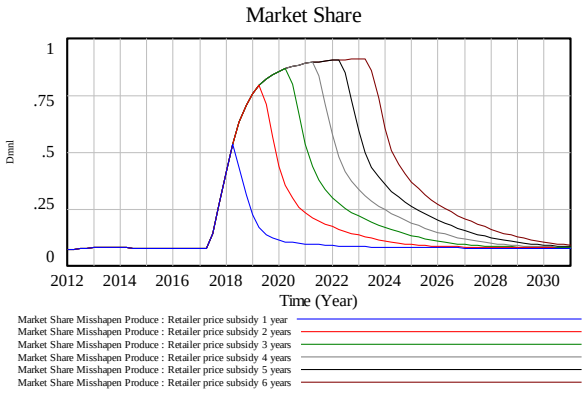


Figure 36: Market share ('sub. ret. price' duration)

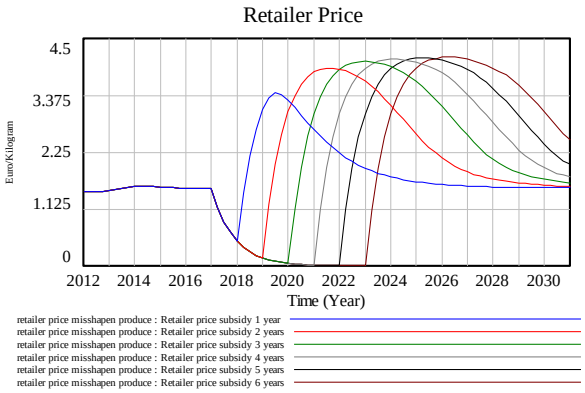


Figure 37: Retailer price ('sub. ret. price' duration)

9.1.2 Subsidizing farmer price

The previous paragraph elicited that an increase in supply of misshapen produce is a minimum requirement for a policy to be efficient since scarcity of misshapen produce counteracts adoption by an increase in retailer price. Therefore, the second single policy test is aimed at the price retailers pay for misshapen produce. This policy can be implemented as a subsidy plan in which the price farmers receive for misshapen produce is partially funded by an external institution, creating a financial incentive for farmers to provide misshapen produce to retailers and thus customers. A zero to hundred percent subsidy plan is assessed in this policy test.

Figure 38 shows a very modest increase in market share of misshapen produce in the first six years after policy implementation. This increase is the result of the direct and stable increase in market supply of misshapen produce (see Figure 39) because of the subsidy plan. Figure 40 shows that at first, the increase in supply causes a surplus of misshapen produce. This surplus causes retailer price to decrease, thereby stimulating the adoption of misshapen produce. As adoption increases because of the relatively low price and thus high utility, the surplus decreases and stabilizes after approximately six years. The surplus also causes a steep increase in market supply wastage of misshapen produce and thereby the total wastage fraction in the first two years after policy implementation (see Figure 41). The wastage fraction hardly decreases after this period because wastage rates in the whole supply chain have increased with the absolute increase in supply chain throughput. This is counterintuitive because from an economic point of view, food wastage has decreased because of the higher value of food that would have otherwise been used for lower ends, like animal fodder. However, the absolute increase in throughput in the food supply chain factually causes an increase in food wastage from the food supply chain.

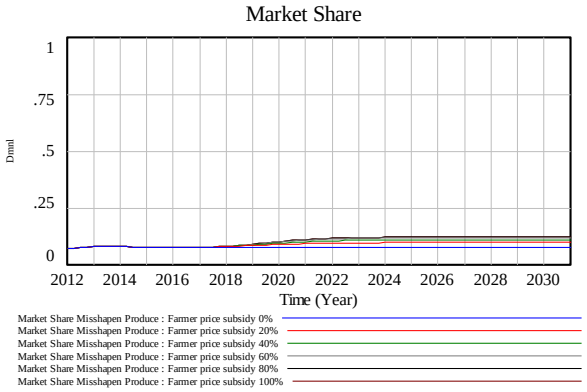


Figure 38: Market share ('sub. farm. price')

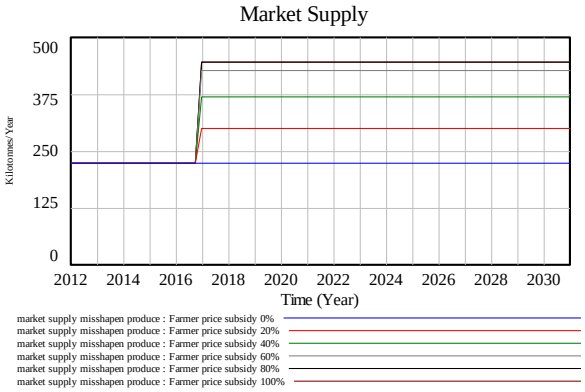


Figure 39: Market supply ('sub. farm. price')

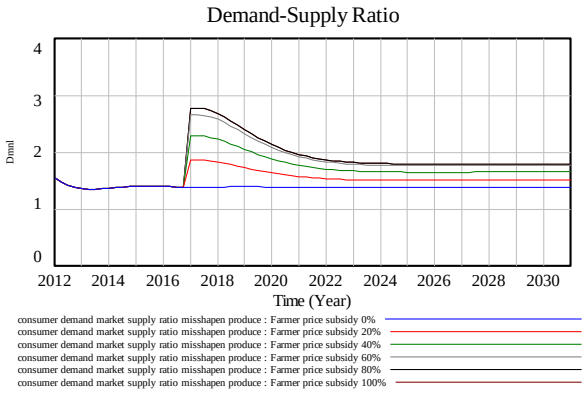


Figure 40: Demand-supply ratio ('sub. farm. price')

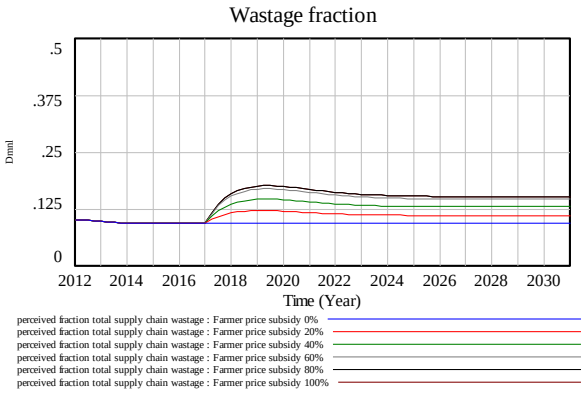


Figure 41: Wastage ('sub. farm. price')

Although the development in market share can be explained by the interaction between supply and demand and its influence on retailer price and wastage fraction, it is relevant to analyze the patterns of other elements in the system as well. The most striking development is that the increase in market share does not cause an increase in skills development (see Figure 42). Most likely the change in market share is too low to actually contribute to a structural change in the system. This is similar for motivation (see Figure 43), although it can be seen that there is some effect of the increase in market share of misshapen produce after policy implementation. As expected, the development of food wastage awareness in Figure 44 is in line with the development of the wastage fraction presented in Figure 41.

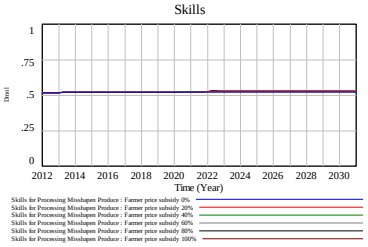


Figure 42: Skills ('sub. farm. price')

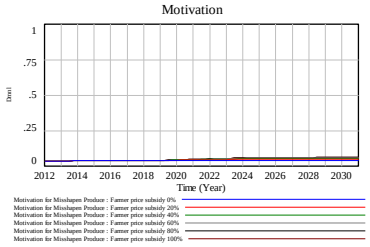


Figure 43: Motivation ('sub. farm. price')

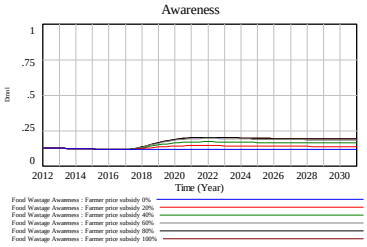


Figure 44: Awareness ('sub. farm. price')

Albeit somewhat predictable, it is relevant to assess the required duration of implementation of the subsidy plans. This provides an indication of whether the spent budget is a sustainable investment or not. Figure 45 and Figure 46 show the simulations of various durations (one to six years) of the most effective policy introduced, the hundred percent subsidy plan. Just like with the previous subsidy plan, the investment does not have a lasting influence on adoption of misshapen produce as levels in all elements of the system directly decrease in value. This is likely to be the result of underdeveloped skills, motivation, and awareness. At the same time, it underlines the need for a stable and long-lasting increase in market supply of misshapen produce.

Subsidizing farmer price does not appear to be effective for stimulating adoption, but it does contribute to the provision of misshapen produce. This is found to be a minimum requirement for any policy aimed at increasing the adoption of misshapen produce. It is an interesting finding that food wastage awareness increases because misshapen produce are provided to retailers. However, this can be explained as the total throughput in the food supply chain increases relative to the simulations in which part of misshapen produce is used for lower means of valorization, like producing animal fodder.

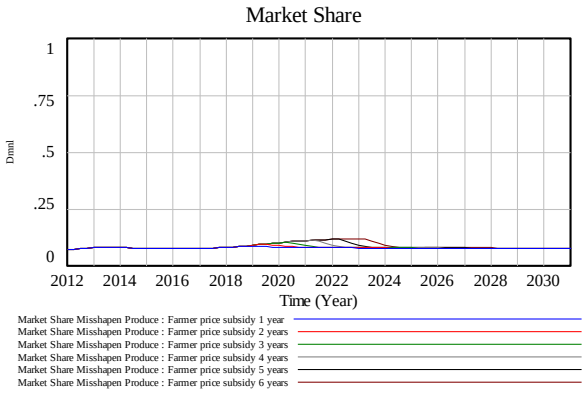


Figure 45: Market share ('sub. farm. price' duration)

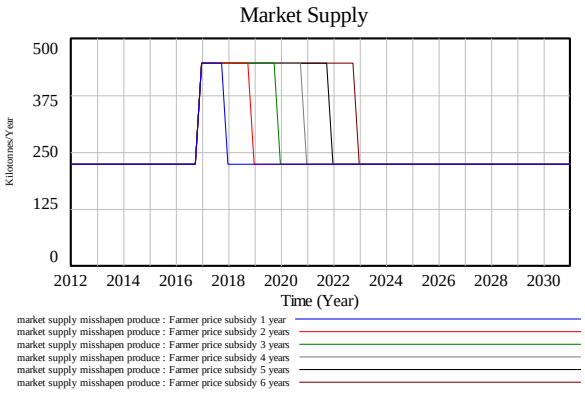


Figure 46: Market share ('sub. farm. price' duration)

9.1.3 Generating food wastage awareness

As it is not clear what the individual effect of this increase in food wastage awareness is on the adoption pattern, it is interesting to have a closer look at a policy that is developed to increase food wastage awareness. This policy can be implemented as a nationwide marketing campaign in which promotional material that can be used by consumers and media is developed and published. A one to six amplification of indicated food wastage awareness is assessed in this policy test.

Figure 47 shows a very modest increase in market share of misshapen produce in the first four years after policy implementation. This increase is the result of the amplified increase in food wastage awareness (see Figure 48). Figure 49 shows that the increase in market share causes a scarcity of misshapen produce. This scarcity causes retailer price to increase, thereby counteracting the adoption of misshapen produce. As the adoption development is stopped because of the relatively high price and thus low utility, the annual scarcity stabilizes after approximately two years. The scarcity also causes a minor decrease in market supply wastage of misshapen produce and thereby the total wastage fraction (see Figure 50). The wastage fraction hardly increases after this period because the adoption development is stopped. The decrease in wastage counteracts the effectivity of this policy in its aim to generate food wastage awareness.

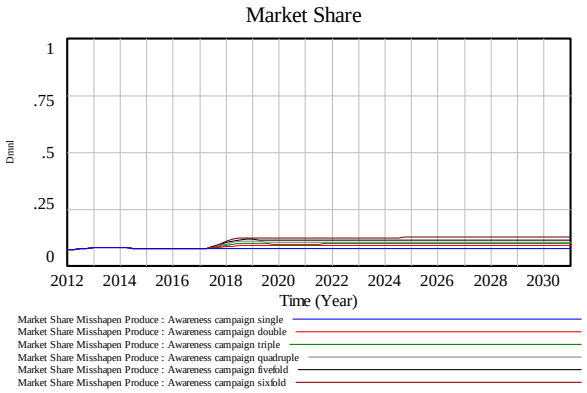


Figure 47: Market share ('gen. awareness')

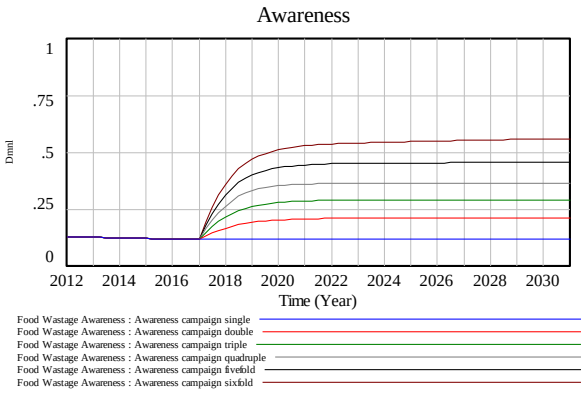


Figure 48: Awareness ('gen. awareness')

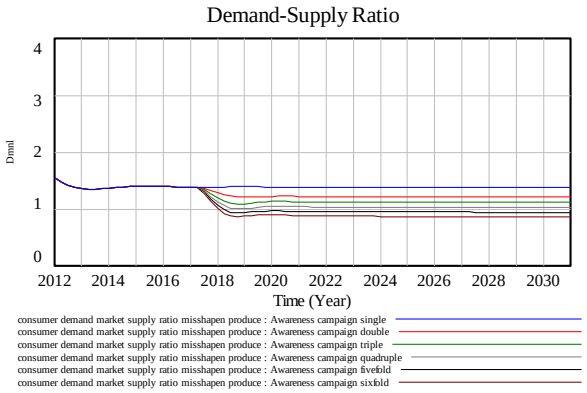


Figure 49: Demand-supply ratio ('gen. awareness')

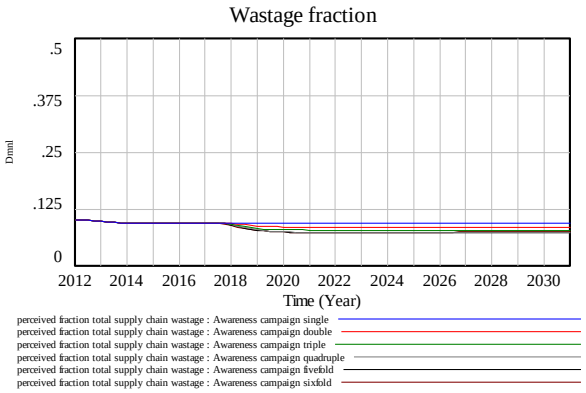


Figure 50: Wastage ('gen. awareness')

Again, the development in market share can be explained by the interaction between supply and demand and its influence on wastage fraction. Similar patterns to those described in the previous policy analysis are found for skills and motivation. The increase in market share does not cause an increase in skills development (see Figure 51) and has almost no influence on motivation (see Figure 52). As hypothesized, the interaction between supply and demand causes retailer price in Figure 53 to be in line with the development of the demand-supply ratio in Figure 49.

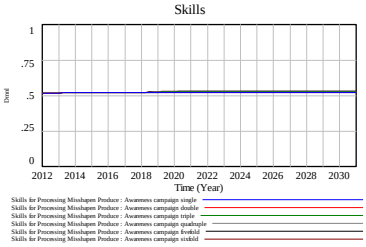


Figure 51: Skills ('gen. awareness')

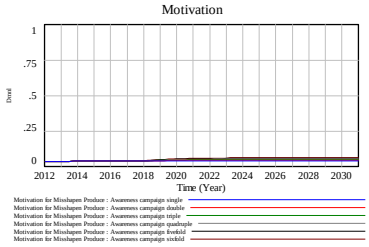


Figure 52: Motivation ('gen. awareness')

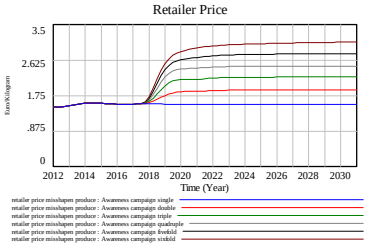


Figure 53: Retailer price ('gen. awareness')

Albeit somewhat predictable due to the low developments in skills and motivation, it is relevant to assess the required duration of implementation of the awareness creation campaign. Figure 54 and Figure 55 show the simulations of various durations (one to six years) of the most effective policy introduced, an amplification of indicated food wastage awareness by six. Just as with the other policies, the investment does not have a lasting influence on adoption of misshapen produce as awareness immediately decreases in value. This is the result of underdeveloped skills and motivation in combination with an increased retailer price of misshapen produce. It indicates that motivation or skills is likely to have a strong influence on the sustainability of a policy.

The tested policy is effective for the purpose of generating food wastage awareness, but it is not effective for stimulating adoption of misshapen produce. The simulations over time show that a policy aimed at generating food wastage awareness is inefficient. The reason is that the increase in awareness causes food wastage to decrease, thereby reducing awareness and thus reducing the efficiency of the effort put into increasing awareness. The minor increase in adoption causes scarcity of misshapen produce. Hereby, retailer price increases so that adoption of misshapen produce and the policy of generating food wastage awareness is counteracted. One of the insights is that skills and motivation are not stimulated by this policy. Further assessment of the effect of skills development and motivation creation on food wastage awareness is required to judge if these elements are completely independent from each other or if there is some relation between the two.

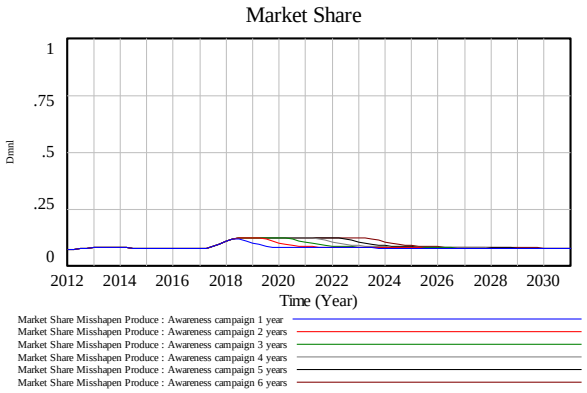


Figure 54: Market share ('gen. awareness' duration)

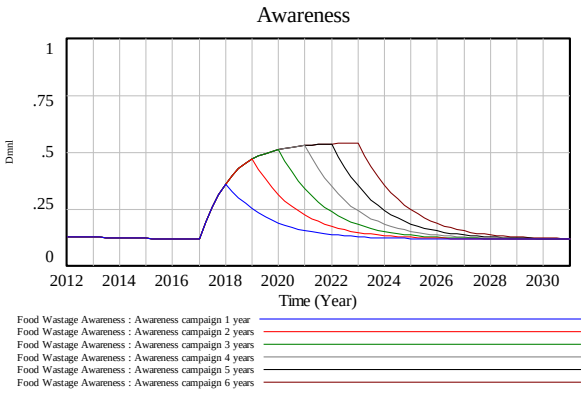


Figure 55: Awareness ('gen. awareness' duration)

9.1.4 Creating motivation for misshapen produce

As it is not clear to what extent motivation creation is independent from other social dynamics and utility evaluations, it is relevant to focus a policy on creating motivation for misshapen produce. The policy can be implemented as a nationwide marketing campaign that is aimed at explaining the factual characteristics of misshapen produce to consumers. One can think of explaining that misshapen produce is almost as convenient as well-shaped produce, that it is of good quality, that it is of no risk for your health, and that it can easily become part of a new routine. A one to six amplification of indicated motivation for processing misshapen produce is assessed in this policy test.

Figure 56 shows a modest but steady increase in market share of misshapen produce in the years after policy implementation. This increase is the result of the amplified increase in motivation creation (see Figure 57). Figure 58 shows that the increase in market share causes a scarcity of misshapen produce. This scarcity causes retailer price to increase, thereby counteracting the adoption of misshapen produce. The annual scarcity increases with the increase in market share. Whereas motivation for misshapen produce increases, Figure 59 shows that motivation for well-shaped produce hardly decreases. This makes practical sense as people are still comfortable with the produce they are already familiar with. Still, it presses the potential development of market share because the disadoption rate remains high.

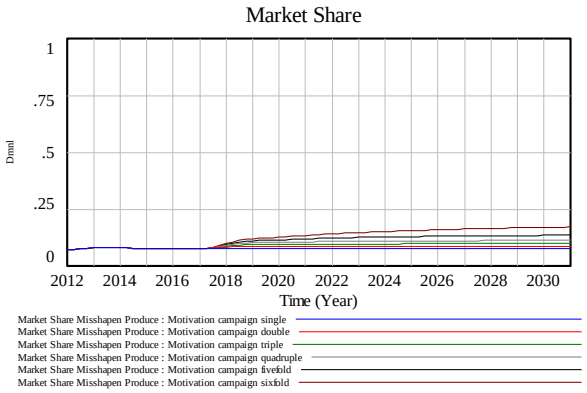


Figure 56: Market share ('cr. motivation')

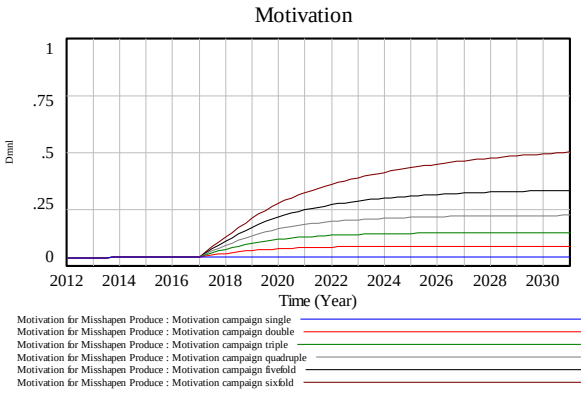


Figure 57: Motivation misshapen ('cr. motivation')

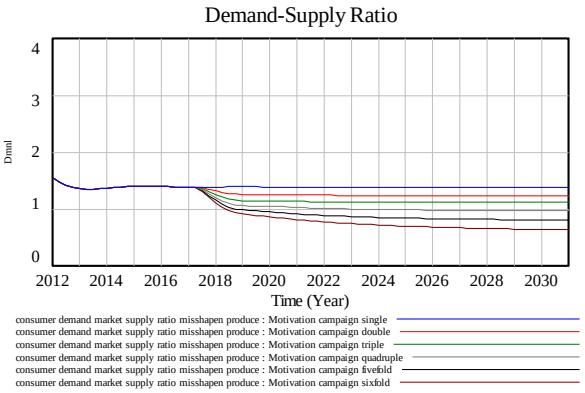


Figure 58: Demand-supply ratio ('cr. motivation')

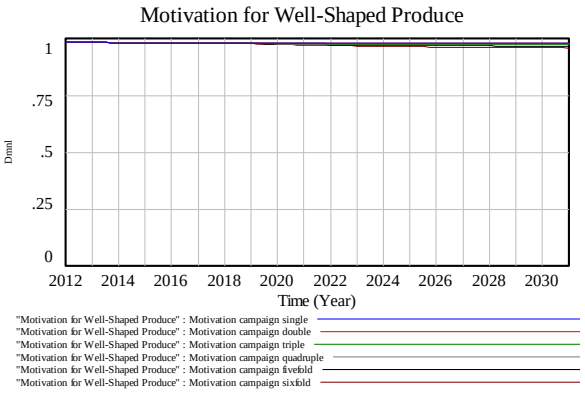


Figure 59: Motivation well-shaped ('cr. motivation')

Again, the development in market share can be explained by the interaction between supply and demand and its influence on retailer price (see Figure 61). Just like with the other policies, the scarcity causes a minor decrease in market supply wastage of misshapen produce and thereby food wastage awareness (see Figure 62). An interesting finding here is that the increase in market share again hardly influences skills development (see Figure 60).

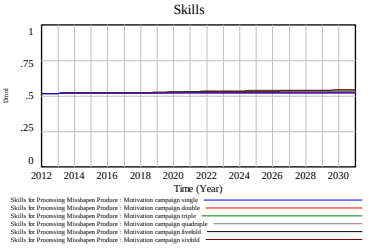


Figure 60: Skills ('cr. motivation')

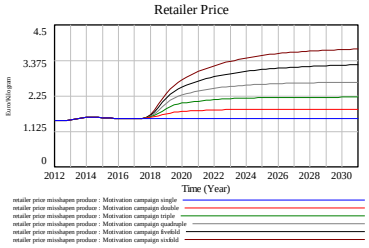


Figure 61: Retailer price ('cr. motivation')

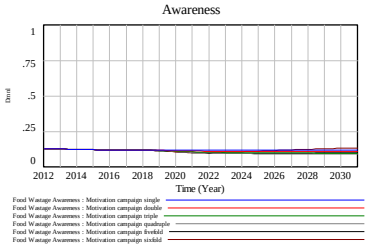


Figure 62: Awareness ('cr. motivation')

Figure 63 and Figure 64 show the simulations of various durations (one to six years) of the most effective policy introduced, an amplification of indicated motivation for processing misshapen produce by six. Underdeveloped skills and food wastage awareness in combination with an increased retailer price of misshapen produce is again expected to be the cause of the policy's ineffectiveness. Possibly, the relatively stable position of motivation for well-shaped produce is also part of the explanation why the policy for creating motivation is unsustainable.

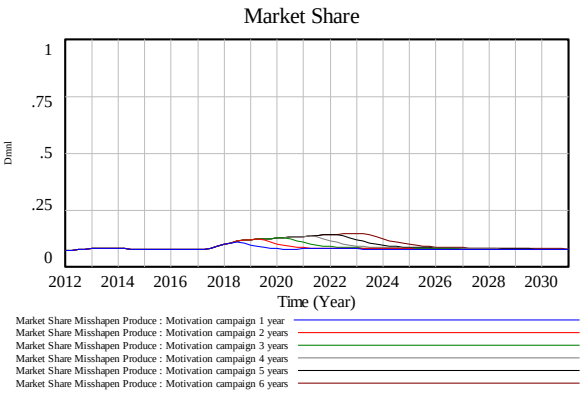


Figure 63: Market share ('cr. motivation' duration)

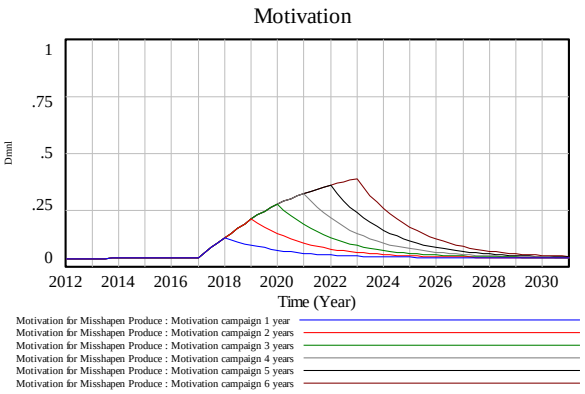


Figure 64: Motivation ('cr. motivation' duration)

Creating motivation for misshapen produce is only somewhat effective for stimulating adoption of misshapen produce. One of the constraints in this development is that the motivation for well-shaped produce remains high although motivation for misshapen produce is increased. Another constraint is similar to the cause of inefficiency of the food wastage awareness policy, namely the retailer price of misshapen produce that increases as a result

from the scarcity that originates from adoption. This causes consumers' utility evaluations of misshapen produce to decrease relative to consumers' utility evaluations of well-shaped produce.

9.1.5 Developing skills for processing misshapen produce

Since skills constitute consumers' utility evaluations together with retailer price, it will be interesting to assess the effectiveness of a policy aimed at skills development. The policy for developing skills can be implemented as a nationwide educational program that is aimed at educating consumers about the use of misshapen produce. Consumers can be taught how to get the most yield out of misshapen produce by, for example, learning about cutting techniques and processing techniques. A zero to hundred percent skills development education program is assessed in this policy test.

Figure 65 and Figure 66 show interesting developments in adoption that are activated by this policy. Two patterns can be distinguished: oscillations in the development of market share and exponential approach in the development of skills. The oscillations in market share originate from the oscillations in utility evaluations (see Figure 68) and have a two-and-a-half year cycle. As can be found in Figure 67, these oscillations originate from a scarcity of misshapen produce. Scarcity is followed by surplus, which is followed by scarcity and so forth. Scarcity causes retailer price to increase and utility evaluations to decrease and surplus causes retailer price to decrease and utility evaluations to increase. It is interesting to find that even though market share oscillates, skills increase and remain at a relatively stable level.

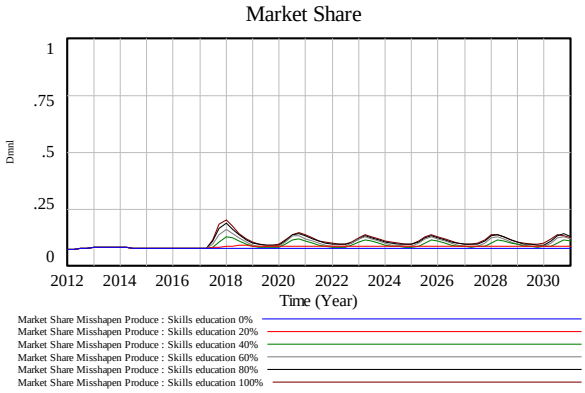


Figure 65: Market share ('dev. skills')

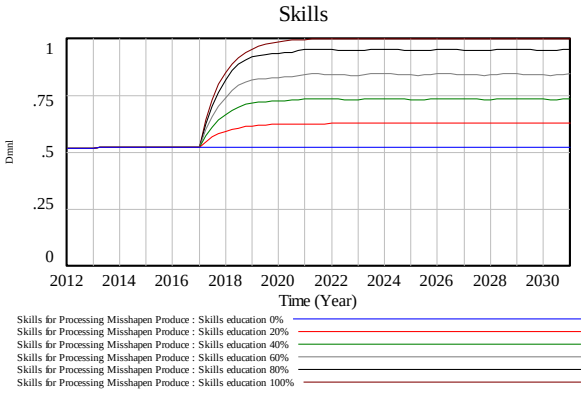


Figure 66: Skills ('dev. skills')

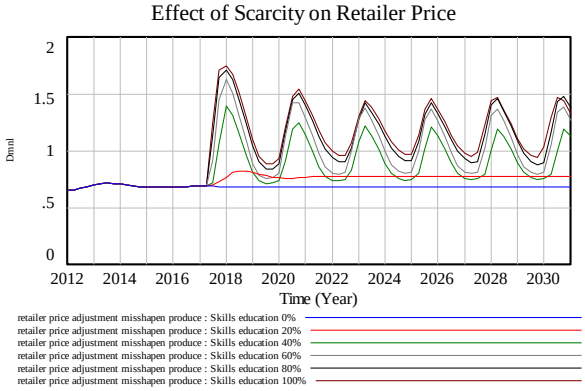


Figure 67: Scarcity ('dev. skills')

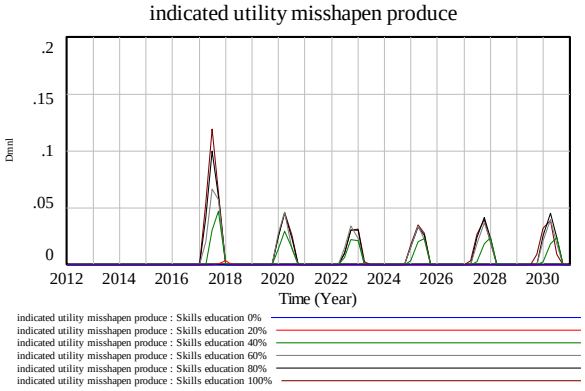


Figure 68: Utility ('dev. skills')

The interaction between supply and demand is again found to be a good indicator for the development of market share of misshapen produce. Retailer price develops as expected based on the previous line of thought (see Figure 69). Figure 70 and Figure 71 show that oscillations and the increase in skills development again have a very low influence on motivation and

food wastage awareness. This is again explained by the nonlinearity of these elements relative to market share.

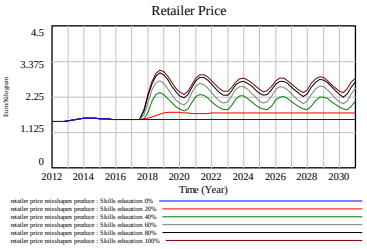


Figure 69: Retailer price ('dev. skills')

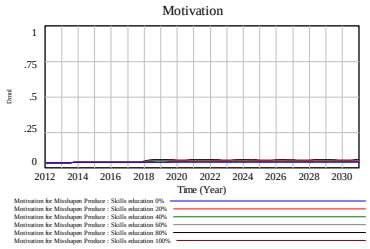


Figure 70: Motivation ('dev. skills')

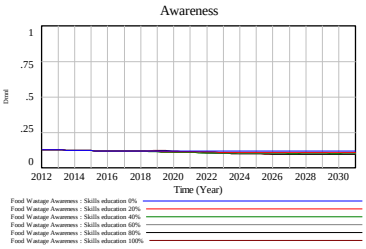


Figure 71: Awareness ('dev. skills')

Figure 72 and Figure 73 show the simulations of various durations (one to six years) of the most effective policy introduced, a hundred percent skills development education program. Underdeveloped motivation and food wastage awareness in combination with an oscillating retailer price of misshapen produce is again expected to be the cause of the policy's ineffectiveness.

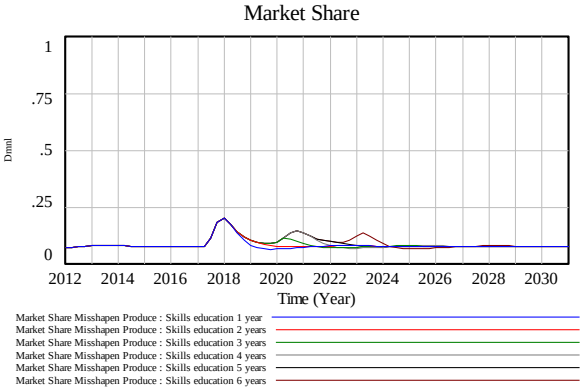


Figure 72: Market share ('dev. skills' duration)

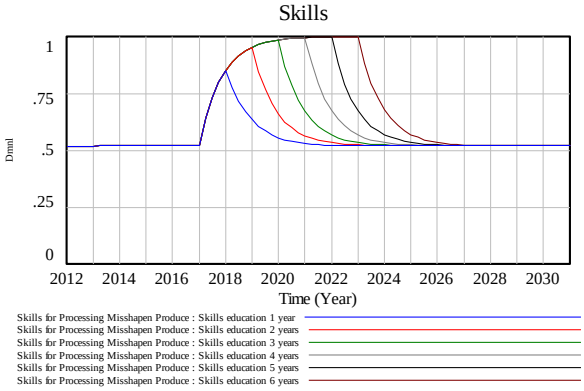


Figure 73: Skills ('dev. skills' duration)

An educational program for skills development in itself is effective for stimulating adoption of misshapen produce, but it is highly counteracted by the development of retailer price. Similar to the previous policy tests, the primary increase in adoption causes a scarcity in misshapen produce so that the retailer price increases. In this case, however, no balance is found in adoption as the development of skills directly influences the indicated utility of misshapen produce.

9.1.6 Summary

It appears that no single policy is significant enough to push the system over a leverage point so that it has a long-lasting contribution to the adoption of misshapen produce. This indicates that any implemented policy needs continuous (financial) efforts for it to be impactful. Multiple explanations are possible for analyzing this inability. First, it is possible that the weight of a single policy relative to the rest of the model is simply not strong enough. For example, the weight of motivation (0.2) might be too low to permanently activate social dynamics that cause a change in adoption. For this reason, joint implementation of policies is the next series of analyses to be performed in addition to single policy testing. Second, it is possible that the adoption potential of misshapen produce is structurally too low because of the low market supply of misshapen produce (nine percent of total production) relative to the production of well-shaped produce (eighty percent of total production). For this reason, various scenarios for the consumption market and for production type in the food supply chain are tested for synergizing joint policies. And finally, taking into considering that many

assumptions were made and that ‘all models are wrong’, which means that a model by definition is a simplification of reality, it is possible that further research needs to put effort into further development of the model.

9.2 Joint policy development and testing

The single policy analyses performed in the previous paragraph indicated that retailer price is a dominant element in the development in adoption of misshapen produce. Well-designed policies lose efficiency as a result from this dominance. For this reason, it is relevant to find out which combinations of policies are strong enough for a significant and long-lasting contribution to the adoption of misshapen produce. It is clear from the prior analyses that subsidizing farmer price always has a positive impact on adoption of misshapen produce. It is still relevant, however, to test and evaluate all combinations of policies and to find synergies between policies. In this way, robust strategies for stimulating adoption of misshapen produce can be formulated. The joint policy tests in this paragraph are based on a 50/50 division of policy intensity (e.g., subsidizing retailer price by 50% in combination with a motivation campaign amplification of 3)

9.2.1 Joint policies for subsidizing retailer price

From Figure 74 and Figure 75, it can be read that subsidizing retailer price in combination with subsidizing farmer price is synergetic in the sense that it further decreases retailer price and causes and increase in market share. A somewhat problematic issue, however, is that the oscillations are not counteracted by this policy so that the system is subject to possibly costly dynamics. Subsidizing retailer price in combination with an awareness campaign and in combination with a motivation campaign are similar to each other in outcome. The oscillations in retailer price are counteracted but in sum, retailer price has increased. Together with the increase in respectively food wastage awareness and motivation for misshapen produce, however, the joint policy is still synergetic as market share increases relative to the single policy of subsidizing retailer price. Subsidizing retailer price in combination with a skills education program is similar to the previously described synergy, but it is more effective as it constitutes a stable positive relative utility for misshapen produce.

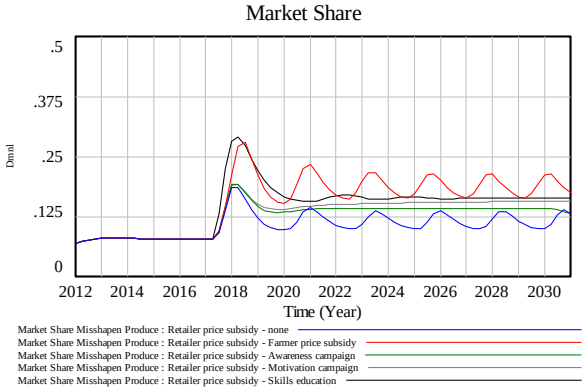


Figure 74: Market share (‘joint sub. ret. price')

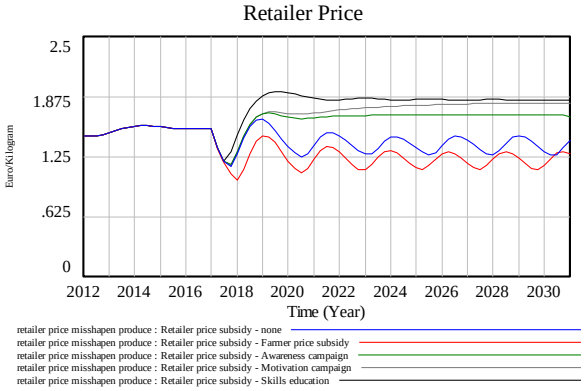


Figure 75: Retailer price (‘joint sub. ret. price')

9.2.2 Joint policies for subsidizing farmer price

From Figure 76 and Figure 77, it can be read that subsidizing farmer price in combination with subsidizing retailer price is most synergetic in the sense that it further increases the market share of misshapen produce. Subsidizing farmer price in combination with skills development causes a similar, but smaller behavior pattern. For both combinations a problematic issue remains, namely that it brings in oscillations that result from shifts in utility evaluations. Subsidizing farmer price in combination with an awareness campaign and in

combination with a motivation campaign are similar to each other in outcome. Both policies benefit from the increase in market supply so that market share increases more relative to the single policy of subsidizing farmer price.

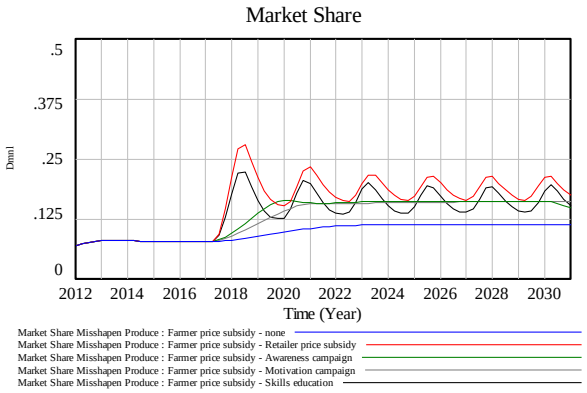


Figure 76: Market share ('joint sub. farm. price')

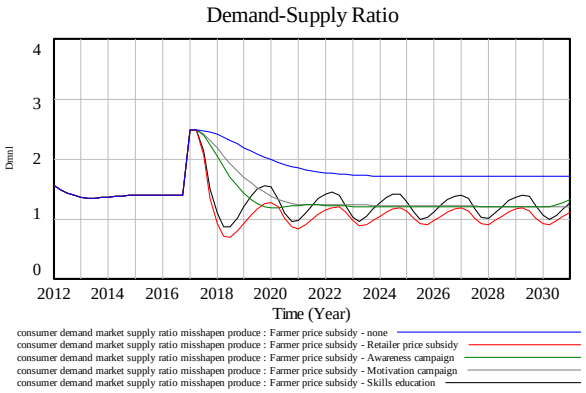


Figure 77: Demand-supply ratio ('joint sub. farm. price')

9.2.3 Joint policies for generating food wastage awareness

From Figure 78 and Figure 79, it can be read that generating food wastage awareness in combination with subsidizing farmer price is most synergetic in the sense that it highly increases food wastage awareness and causes the highest stable increase in market share of misshapen produce. Generating food wastage awareness in combination with subsidizing retailer price and in combination with skills education are similarly synergetic to each other in outcome in the sense that awareness and adoption increase, but they are counteracted in their development by utility evaluations. The policy of generating food wastage awareness in combination with the policy of creating motivation for misshapen produce slightly counteracts in the development of awareness and only has a small positive influence on the development of market share.

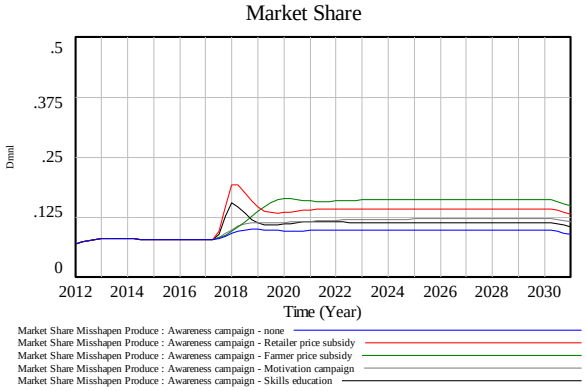


Figure 78: Market share ('joint gen. awareness')

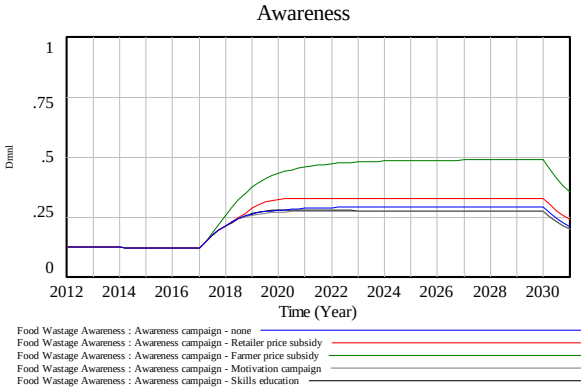


Figure 79: Awareness ('joint gen. awareness')

9.2.4 Joint policies for creating motivation for misshapen produce

From Figure 80 and Figure 81, it can be read that creating motivation for misshapen produce in combination with subsidizing farmer price and in combination with subsidizing retailer price are the most synergetic joint policies in the sense that it increases the motivation for misshapen produce and the market share of misshapen produce. Creating motivation for misshapen produce in combination with skills education is slightly less synergetic and it is counteracted in its development by utility evaluations. The policy of creating motivation for misshapen produce in combination with the policy of generating food wastage awareness is the least fruitful option as it only has a small positive influence on the development of market share and motivation.

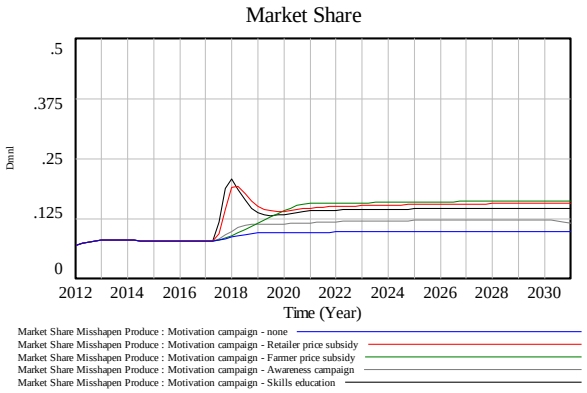


Figure 80: Market share ('joint cr. motivation')

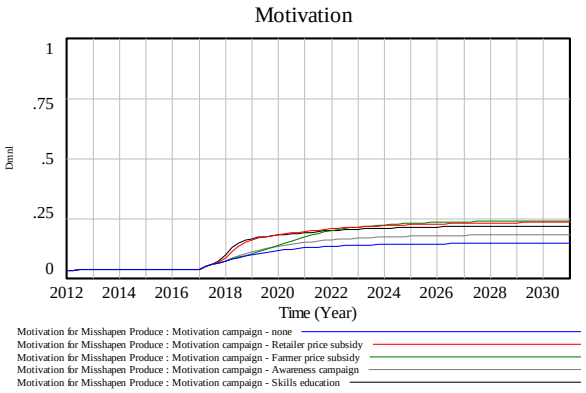


Figure 81: Motivation ('joint cr. motivation')

9.2.5 Joint policies for developing skills for processing misshapen produce

In general, skills are hardly influenced when combined with another policy, but together with other policies it does constitute to an amplified increase in market share. From Figure 82 and Figure 83, it can be read that skills development for processing misshapen produce in combination with subsidizing farmer price and in combination with subsidizing retailer price are the most synergetic joint policies in the sense that it increases the market share of misshapen produce. Skills development for processing misshapen produce in combination with generating awareness and in combination with creating motivation is hardly synergetic in that neither market share nor skills are significantly affected by joint implementation of these policies.

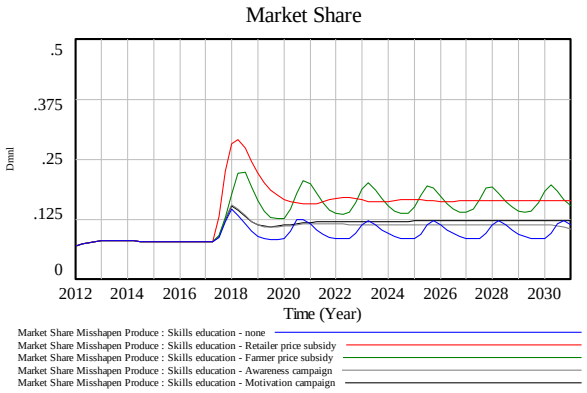


Figure 82: Market share ('joint dev. skills')

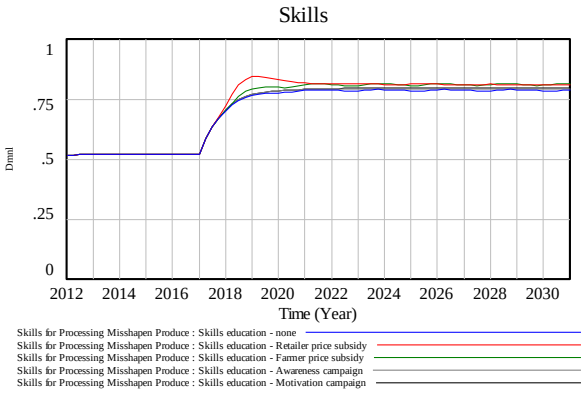


Figure 83: Skills ('joint dev. skills')

9.2.6 Summary

The findings described in this paragraph are summarized in Table 15. This table indicates if a synergy arises from implementing the policy in the left column with one of the policies in the upper row. A plus indicates a clear synergetic relationship between two policies and a zero indicates that no significant synergy is found to be present. A double plus indicates the most fruitful synergy among the joint policy tests. It can be concluded that subsidizing retailer price and subsidizing farmer price are key for stimulation adoption of misshapen produce. This can be explained as retailer price is most dominant in consumers' utility evaluation and farmer price is the means by which provision of misshapen produce is regulated.

Policy	Subsidizing retailer price	Subsidizing farmer price	Generating awareness	Creating motivation	Developing skills
Subsidizing retailer price		++	+	+	+
Subsidizing farmer price	++		+	+	+
Generating awareness	+	++		0	0
Creating motivation	++	++	+		+
Developing skills	++	++	0	0	

Table 15: Synergetic relationships between policies

9.3 Scenario development and testing

In the previous paragraph it was found that subsidizing retailer price and farmer price always needs to be part of a joint policy for it to be effective. This means that three joint policy tests remain: subsidizing retailer price and farmer price in combination with (1) generating awareness, (2) creating motivation, and (3) developing skills. The scenario tests in this paragraph are based on a 33/33/33 division of policy intensity (e.g., subsidizing retailer price by 33% and subsidizing farmer price by 33% in combination with motivation campaign amplification by 2).

Scenario testing in the policy analysis chapter of this thesis is included to assess the impact of various scenarios in the future of horticulture production on various joint policies. It allows to assess how adoption of misshapen produce develops under structurally different conditions. A wide range of scenarios exists, though in this thesis only four scenarios are tested and developed based on two axes: market supply of well-shaped produce for domestic (zero percent is exported) or foreign consumption (ten percent is exported) and open ground horticulture (80/19 division well-shaped/misshapen produce) or greenhouse horticulture (95/4 division well-shaped/misshapen produce). The scenarios are illustrated in Figure 84 with the associated line color.

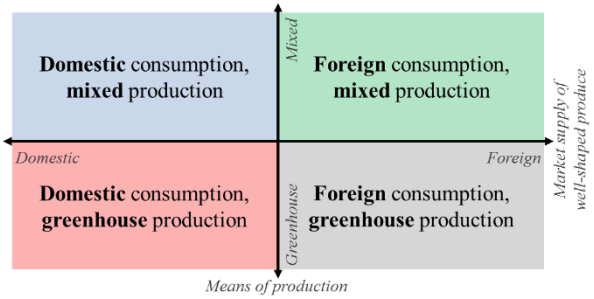


Figure 84: Scenario development

9.3.1 Joint policy of generating awareness and subsidizing prices

The joint policy of generating awareness and subsidizing prices captures the optimal potential of adoption of misshapen produce of about twenty percent in the 'mixed production' scenarios (see Figure 85). These scenarios are characterized by a relative large throughput of misshapen produce relative to the 'greenhouse production' scenarios. The overshoot in market share in the three years after implementation of the policy can be explained by the increase in retailer price in Figure 88 that results from a temporary scarcity of misshapen produce in Figure 87. An additional note is that also in the 'greenhouse production' scenarios, adoption is positively influenced by the joint policy of generating awareness and subsidizing prices.

An interesting finding is that the developments in food wastage awareness in Figure 86 highly differ. In the scenario of 'greenhouse production' for 'domestic consumption', food wastage awareness increases to over 0.6 because of the market supply wastage from well-shaped produce. This wastage originates from a sudden increase of supply relative to demand. This gap is much lower in the 'foreign consumption' scenario and for the 'mixed production' scenarios.

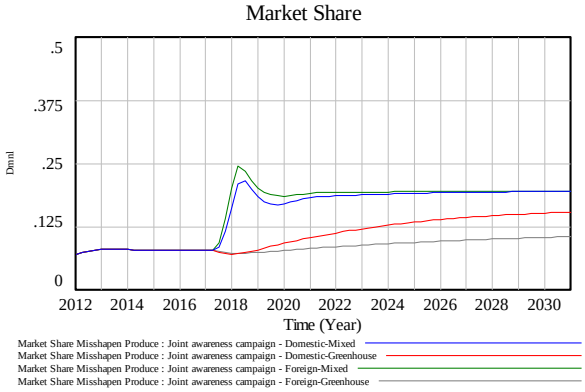


Figure 85: Market share ('joint awareness and subsidizing')

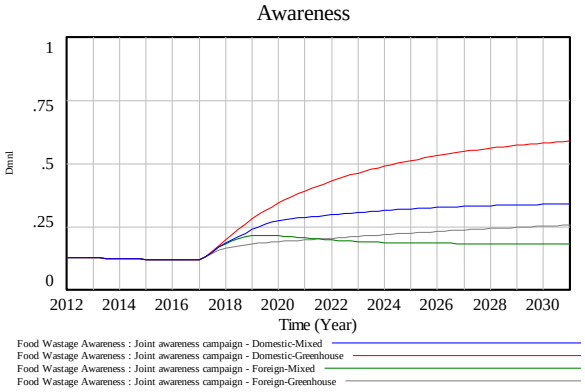


Figure 86: Awareness ('joint awareness and subsidizing')

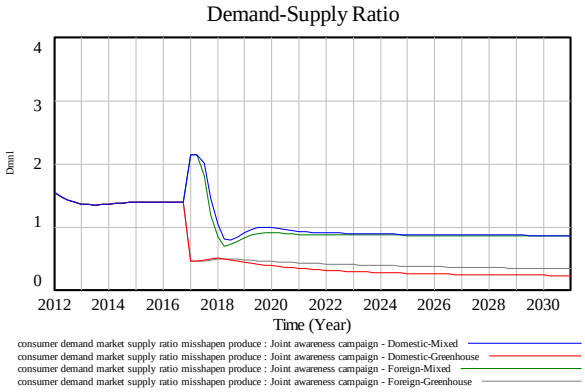


Figure 87: Demand-supply ratio ('joint awareness and subsidizing')

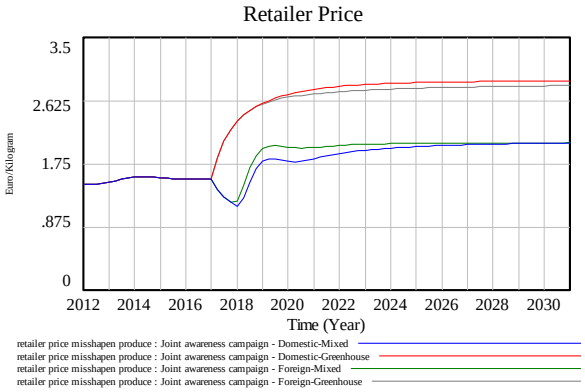


Figure 88: Retailer price ('joint awareness and subsidizing')

9.3.2 Joint policy of creating motivation and subsidizing prices

The joint policy of creating motivation and subsidizing prices captures an adoption potential of misshapen produce of about fifteen percent in the 'mixed production' scenarios (see Figure 89). The temporary oscillation in market share in the five years after implementation of the policy can be explained by the decrease-increase-decrease in retailer price in Figure 92 that results from a temporary scarcity-surplus-scarcity of misshapen produce in Figure 91. An additional note is that in the 'greenhouse production' scenarios, adoption is negatively influenced by the joint policy of generating awareness and subsidizing prices. This is likely to be the result of the increase in retailer price without the activation of any social dynamics.

A striking finding is that the developments of motivation in the 'greenhouse production' scenarios in Figure 90 are not influenced by the joint policy. In the scenario of 'mixed production', however, this is the case. It is likely that the switch from 'mixed production' to 'greenhouse production' and the resulting impact on market supply of misshapen produce have a dominant impact on the developments in the system.

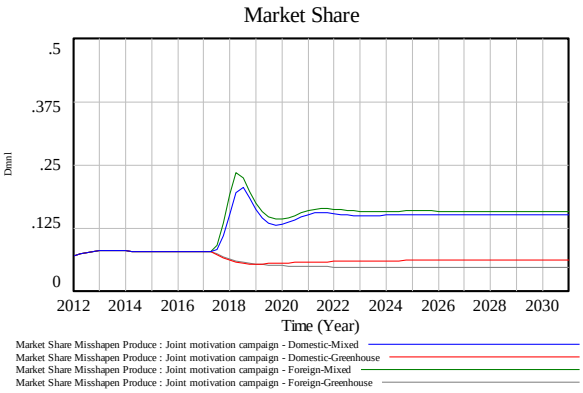


Figure 89: Market share ('joint motivation and subsidizing')

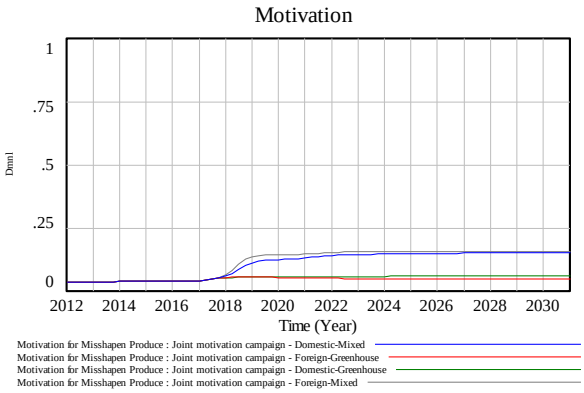


Figure 90: Motivation ('joint motivation and subsidizing')

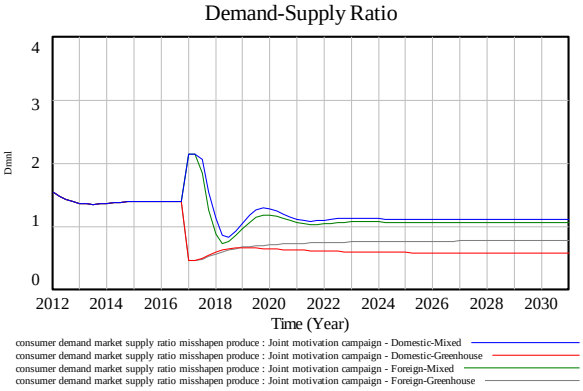


Figure 91: Demand-supply ratio ('joint motivation and subsidizing')

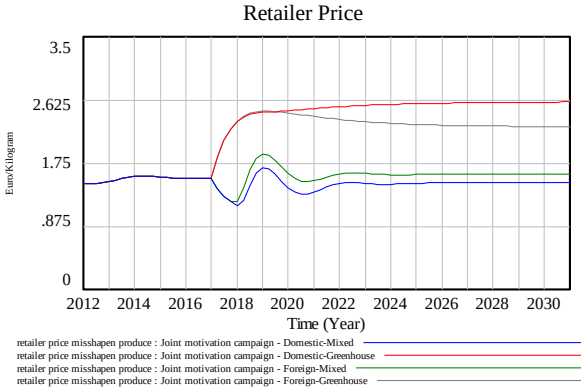


Figure 92: Retailer price ('joint motivation and subsidizing')

9.3.3 Joint policy of developing skills and subsidizing prices

The joint policy of skills development and subsidizing prices captures an adoption potential of misshapen produce of about seventeen percent in the 'mixed production' scenarios (see Figure 93). The oscillation in market share after implementation of the policy can be explained by the oscillations in retailer price in Figure 96 that results from oscillations in the demand-supply ratio of misshapen produce in Figure 95. An additional note is that in the 'greenhouse production' scenarios, adoption is again negatively influenced by the joint policy of generating awareness and subsidizing prices. Again it is expected that this is the result of the increase in retailer price.

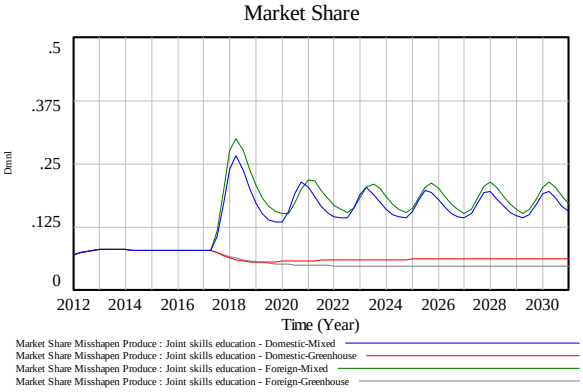


Figure 93: Market share ('joint skills and subsidizing')

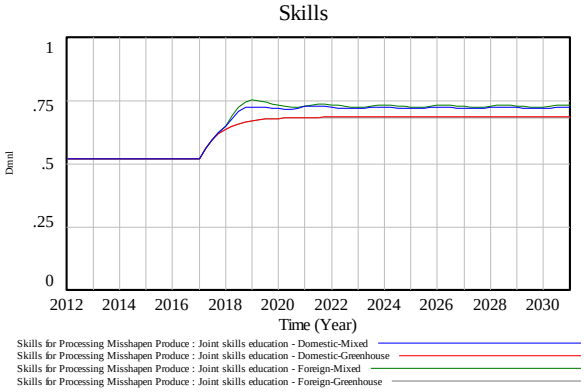


Figure 94: Skills ('joint skills and subsidizing')

It is interesting to find that skills development in Figure 94 is similarly activated by the joint policy for each of the scenarios, regardless of the development in market share of misshapen produce. It can be concluded that skills development is not very sensitive to changes in market share.

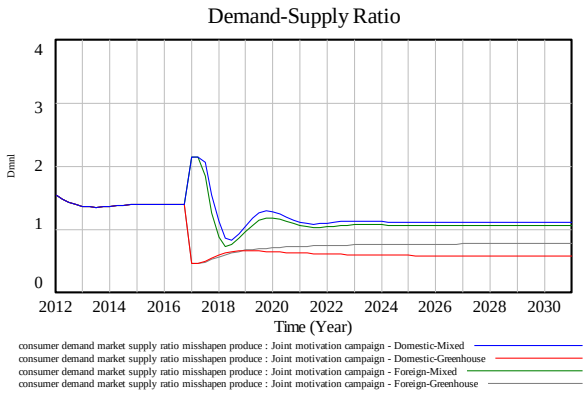


Figure 95: Demand-supply ratio ('joint skills and subsidizing')

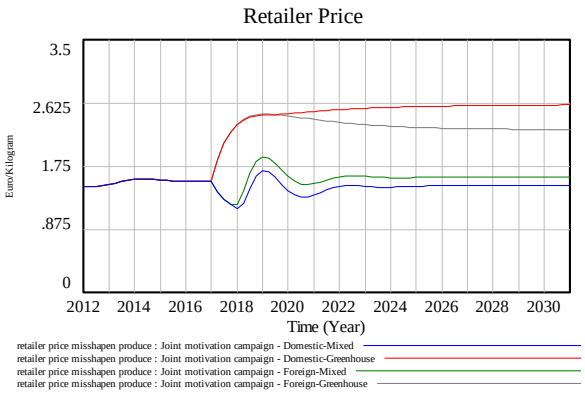


Figure 96: Retailer price ('joint skills and subsidizing')

9.3.4 Summary

It is clear that a joint policy of generating food wastage awareness, subsidizing retailer price, and subsidizing farmer price has the highest potential for an increase in market share of misshapen produce. In assessing the scenarios, entering the foreign consumption market for well-shaped produce seems to give more space for adoption of misshapen produce to take place for both farmers and consumers. This causes the adoption patterns to develop in a desirable way especially in the scenarios in which ten percent of well-shaped produce is exported for foreign consumption. The scenarios that simulate a sudden switch from mixed production to greenhouse production indicate an increase in food wastage from market supply of well-shaped produce. Such a sudden switch should therefore be avoided in reality. On the other hand, the surplus of well-shaped produce that originates from greenhouse production could theoretically be counteracted by exporting even more well-shaped produce for foreign consumption.

The three joint policies tested in this paragraph indicate promising and mostly desirable adoption patterns. The feasibility of each of the joint policies, however, is questionable. The policies that were found to be most effective demand a one-third subsidy of the price consumers pay for misshapen produce and a one-third subsidy of the price farmers receive for misshapen produce. The subsidies would cost millions of euros, let aside the additional policy aimed at one of the social processes like food wastage awareness. Part of these costs might be compensated by the increase in total supply chain throughput and the option to enter the foreign consumption market for well-shaped produce, but it is unlikely these weight up

PART IV: Reflection

The fourth and final part of this thesis covers the reflection on the approach in this research and the outcomes from this research. In chapter 10, some reflections on the research are discussed, followed by recommendations for further research. Chapter 11 closes this thesis with a conclusion that includes a brief summary of the research and answers the research questions as formulated in chapter 1. A visual description of the structure of part IV is given in Figure 97.

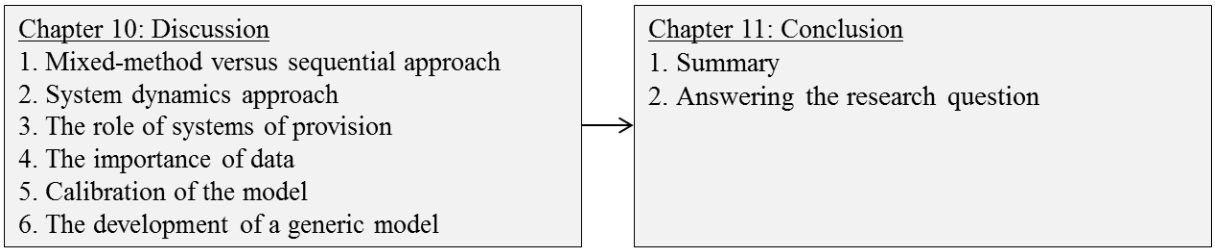


Figure 97: Reflection

10. Discussion

Conducting this research has been the source of many reflections on both the outcomes from this research and the means of arriving at those outcomes. Some of these reflections are described in this paragraph. Resulting from these reflections, some limitations of this research are reported and some recommendations for further research are provided.

10.1 Mixed-method approach versus sequenced approach

Triangulation of data collection in this thesis was performed as a mixed-method approach in which data collected from one source (e.g., an interview) provided direction for data collection from another source (e.g., a piece of literature). This approach fit the exploratory nature of this research in the way it allowed immediate cross-referencing of collected data. Therefore, a mixed-method approach is advised for similar exploratory researches that have a limited time horizon. Still, the warnings from many academics (e.g., Onwuegbuzie & Burke Johnson, 2006; Zohrabi, 2013) about the potential loss of validity when adhering a mixed-method approach should be taken into account.

The formal data analysis was performed as a sequenced approach in which the main focus at first was on literature, followed by respectively interviews and observations. This appeared to be useful for developing a conceptual model as each sequence introduced a more detailed understanding of the system. Data from literature provided the general elements for the simulation model, like Etzion's (2014) argument that awareness in general influences adoption and Loebnitz et al.'s (2015) finding that food wastage awareness influences consumers' purchase intention. Interviews provided more detail about the way in which these general elements operate in practice, like the comments from P1 and P2 that the fraction of misshapen produce supplied for human consumption is the result of a financial trade-off made by farmers. In addition, observations improved interpretation of both literature data and interview data so that elements could be connected in the proper way, like the observation at V1 that food loss is by definition unavoidable and that it takes place at every operation in the food supply chain.

For data collection in an exploratory research with a limited time horizon, a mixed-method approach can be advised when taking into account its limitations. For data analysis that serves the development of a conceptual framework, sequential data analysis fits best for establishing a thorough understanding of the structure of the system.

10.2 System dynamics approach

The analysis of adoption dynamics as split up into acceptance dynamics and supply chain dynamics is performed from a system dynamics perspective. This perspective allowed the exploration of influences that constitute adoption of misshapen produce as the interaction between a number of causal structures instead of the sum of individual impacts of a variety of factors. The structure-behavior perspective that is central in the system dynamics approach is found to be of value when compared to, for example, the autonomous-individual perspective in an agent-based approach or the rule/logic-based perspective in a knowledge-based approach (Kelly, Jakeman, Barreteau, Borsuk, ElSawah, Hamilton, Henriksen, Kuikka, Maier, Rizzoli, Van Delden & Voinov, 2013).

The habit in the system dynamics approach to explicitly and consistently represent findings and assumptions in a model (e.g., Sterman, 2000) feeds the discussion about the introduced concepts and thereby reinforces further development of theory. Furthermore, the maturity of the field of system dynamics allowed a structured validation of the findings and assumptions and the way these are represented in the simulation model (Barlas, 1996). Analysis of model

behavior and analysis of policies in different scenarios is enabled by combing qualitative and quantitative insights in the development and calibration of the model. Altogether, it can be concluded that the system dynamics approach in this research was of significant value for gaining insights from this research and possibly will remain of significant value in the way it contributes to the academic discussion on adoption dynamics. The system dynamics approach can therefore be recommended for research that is interested in uncovering the structures that underlie the dynamics that occur in complex systems.

10.3 The role of systems of provision

Development of the model on the basis of interviews revealed that adoption of misshapen produce in the upstream stages of the food supply chain in terms of provision to a large extent is a financial trade-off that hardly involves social dynamics. This trade-off is made by farmers based on the price they receive for misshapen produce relative to the price they receive for well-shaped produce. In contrast, social dynamics are much more prevalent in the downstream stages of the food supply chain.

Much theory is established about the role of lifestyles in a social practice like adoption of misshapen produce. Information about the role of the food supply chain in adoption, however, is limited to technical (e.g., Nakandala et al., 2017) and verbal (e.g., Lipinski et al., 2013) descriptions that lack details about cause-and-effect relationships. The practical implication is that this research is mainly focused on the social dynamics in the downstream part of the food supply chain and only limitedly on the processes that are present in the upstream part of the food supply chain as based on interviews and observations. This creates the notion that additional theory needs to be developed about cause-and-effect relationships in the interaction between the food supply chain and product acceptance. In particular it would be interesting to find out how operators in the food supply chain respond to changes in demand, changes in prices, and changes in perceptions of food wastage.

10.4 The importance of data

The stages in this research that were concentrated around the model (i.e., developing; calibrating; evaluating; analyzing; testing) revealed that there is a lack of data about misshapen produce. The most important data missing in this research are sales rates, wastage rates, and cost and revenue rates associated with misshapen produce. Data collection of the amount of misshapen produce that is sold, including a classification of shape abnormality (e.g., moderately abnormal shape; extremely abnormal shape) and information about where it is sold (e.g., supermarket; trendy supplier; international supplier), has the highest priority for better analysis of adoption of misshapen produce as viable business model.

In further research, this lack of data can be tackled by performing a case study at an organization or institution. Conducting the research at an actual case site may help to get access to more reliable data so that calibration of the model is improved. The data collected and analyzed for the simulation model in this research is obtained from a wide variety of sources in which the Netherlands is seen as case study. Although this approach fits the exploratory nature of this research, it is advised to conduct a similar case study together with an organization or institution to further develop the simulation model and enrich the findings for both theory and practice.

10.5 Calibration of the model

Based on literature and partially based on the interviews, it is clear that there are many factors that influence adoption. However, making these factors explicit in a conceptual framework and simulation model indicated that these factors boil down to a few causal

structures that explain the majority of the development in adoption of misshapen produce. Still, a critical finding in this research is the extent to which the simulations from the model are sensitive to the calibration of the model. Weights and effects dominate the impact of social dynamics and utility evaluations on adoption.

The previously described case study at an organization or institution allows improved calibration of effects with empirical data from a series of facilitated modeling sessions (e.g., Group Model Building; Vennix, 1996) with people at the organization or institution. This is expected to further improve the validity of the simulation model. However, note that the scope of such a research should be in line with the major benefits a facilitated modelling approach offers, like reaching consensus, creating commitment, and fostering implementation (Vennix, 1996).

Another way to improve calibration of the model is by performing a conjoint analysis for calibration of weights with empirical data. Calibration of weights is the exact reason why a conjoint analysis is performed in a comparable research by Kopainsky et al. (2011) about adoption and diffusion of maize varieties. In review of their research, Lane (2012) argues that a conjoint analysis is worth the effort if it contributes to a policy insight. It is expected that the improved calibration of weights contributes to policy insights, like the exact combination of policies required for the success policy implementation and a precise indication of leverage points in the adoption curve of misshapen produce.

10.6 The development of a generic model

This exploratory research is concerned with the adoption of misshapen fruits and vegetables. It is hypothesized that elements of the model structure outlined in this research are valid for other products as well. Future research could broaden the horizon by exploring the adoption other abnormal produce, like fruits and vegetables with other causes for low aesthetic value (e.g., miscoloured; bruised; forgotten), food produce with a limited “best-before” date (e.g., eggs; meat; milk), and second-hand produce (e.g., plants; clothes; cars). Merging the findings from these researches contributes to the development of a generic model of adoption and diffusion in the context of systems of provision. Leverage points that are to be discovered with the generic model can result in optimisation of supply chains and thereby may cause reductions in prices and wastage rates.

For organisations in any part of the food supply chain it is of interest to be aware of the development of adoption of their produce and they will want to develop ways in which they can bring their logistics in accordance with this development. In this way, a range of policies can be developed and implemented that are aimed at reducing (food) wastage and are thereby counteracting food insecurity.

11. Conclusion

11.1 Summary

In a context of increasing food insecurity, this thesis introduced a case study that evaluates adoption of misshapen produce by consumers as act to counteract food wastage. The potential of this type of valorization of side streams in the food supply chain is assessed by investigating the interplay between human agents and social structures in the social practice of adoption. A triangulation of data collection provided the building blocks for answering the research questions that address adoption dynamics as originating from acceptance dynamics and supply chain dynamics. The qualitative and quantitative data from literature, interviews, and observations were collected and analyzed for answering the sub-questions in this thesis. This allowed the researcher to arrive at causal relationships that serve as input for the conceptual framework as foundation of this research.

a. Which product characteristics causally relate with adoption of misshapen produce?

In literature, various product characteristics are found to relate with adoption of misshapen produce, like the size, color, and shape of a product and the label, price, and predetermined quantity of a product. All of these are confirmed by interview respondents, but according to both literature and interview respondents, price is the dominating product characteristic when it comes to consumers' evaluation of misshapen produce. In return, price is found to be influenced by adoption via demand for misshapen produce.

b. Which consumer characteristics causally relate with adoption of misshapen produce?

Literature lists a great deal of consumer characteristics that are found to relate with adoption of misshapen produce, of which the most tangible ones are consumers' skills for processing misshapen produce, consumers' food wastage awareness, and consumers' routine in buying fresh produce. These characteristics were confirmed by interview respondents who have expertise in consumer behavior, but they also listed many intangible characteristics like cognitive factors (e.g., knowledge) and personal determinants (e.g., identity). Also motivation was introduced as consumer characteristic, representing multiple intangible factors like trust, convenience, and evaluation of aesthetics. It is found that adoption of misshapen produce in turn causally relates to skills development, routine confirmation, food wastage awareness generation, and motivation creation in a variety of ways.

c. Which operations in the fresh food supply chain causally relate with adoption of misshapen produce?" and *d. Which components of adoption of misshapen produce causally relate with operations in the fresh food supply chain?*

Literature does not provide a preliminary answer to these questions, except for the economic theory about the market mechanism of supply and demand. This mechanism is confirmed by interview respondents: supply reduces price and thereby stimulates adoption, while adoption increases demand and thereby increases price. A second element in the fresh food supply chain that interacts with adoption of misshapen produce is partially supported by literature, but much more supported by interviews and observations, namely: the impact of food wastage. Food wastage occurs at every operation in the fresh food supply chain and influences consumers' food wastage awareness. As consumers perceive adoption of misshapen produce to reduce food wastage in the food supply chain, they adopt misshapen produce the more they become aware of food wastage. Finally, a finding from interviews and observations is that the fraction of misshapen produce supplied for human consumption is the result of a financial trade-off made by farmers.

In answering these sub-questions, motivation, skills, food wastage awareness, and price evaluations have become part of the adoption and diffusion structure, influenced by the amount of produce supplied by farmers. The conceptual framework has been developed, calibrated, and validated to establish a simulation model for replicating the assumed historical reference mode and for generating an 'ideal' simulation. The results from the simulation model showed that price indeed causally relates to adoption of misshapen produce and that adoption of misshapen produce causally relates to price in the way it influences demand relative to supply. The simulations also showed that skills, routine, and food wastage awareness indeed to some extent causally relate to adoption of misshapen produce. One of the critical issues this thesis addresses is whether adoption of misshapen produce actually reduces food wastage. From an economic point of view, food wastage decreases because of the higher value of food that would have otherwise been used for lower ends like animal fodder. However, the absolute increase in throughput in the food supply chain causes an increase in food wastage from the food supply chain. In addition to analysis of these results, the simulation model is used for testing a variety of policies in different scenarios, thereby formulating an answer to the final sub-question in this thesis.

e. Which robust policies stimulate adoption of misshapen produce?

One important finding was that it is difficult to formulate a robust policy in the case of adoption of misshapen produce. The reason is that the potential of this development is constrained by the supply of misshapen produce, which is a fraction of total fruits and vegetables production. This means that complete adoption of misshapen produce is not possible because of the everlasting existence of well-shaped produce. It appeared that single policies are inadequate for sustainably stimulating adoption of misshapen produce. Implementing joint policies offers an opportunity here as almost all of them have synergizing effects. It was concluded that, under the condition that budget is not a limitation, a policy that includes both a subsidy for retailer price for consumers and a subsidy for farmer price for farmers is most robust for stimulating adoption of misshapen produce. In addition, this combination is most fruitful when combined with an awareness campaign that is aimed at generating food wastage awareness among consumers, even though we nog know that adoption does not decrease food wastage.

Reflections on this research provided useful recommendations for further research. These recommendations include the experimentation with the mixed-method approach for data collection and with the sequential approach for data analysis for the development of a conceptual framework, the use of a system dynamics approach for unraveling complex systems, the development of theory about the operations in the food supply chain, data collection on a national level and at organizations and institutions, empirically-based calibration of the model by facilitated modelling sessions with experts and by a conjoint analysis, and the development of a generic adoption dynamics model.

11.2 Answering the research question

The primary objective in this research is to elicit the drivers of adoption of misshapen produce in the Netherlands. The research question that is addressed is:

Which processes drive adoption of misshapen produce in the Netherlands?

Based on literature and interviews, it can be concluded that a wide variety of factors constitute adoption of misshapen produce in the Netherlands. Making these factors explicit in a conceptual framework and simulation model indicated that these factors boil down to a few

causal structures that explain the majority of the development in adoption of misshapen produce. These interactions can be categorized as social dynamics (i.e., skills development; awareness creation; routine/motivation), utility evaluations (i.e.; price setting; skills development), and thresholds (i.e., production; farmers' trade-off). Dominant for the adoption potential of misshapen produce is the trade-off farmers make based on the relative price of misshapen produce. An increase in provision of misshapen produce often is a prerequisite for adoption to increase. In consumers' evaluation, the price consumers pay for misshapen produce relative to well-shaped produce is most important. Joint implementation of policies in social dynamics can counteract this dominance of price, but this is found to be far from efficient. Food wastage awareness may be good for many reasons, but it is weak in the way it contributes to adoption of misshapen produce. Part of the answer is that the impact of adoption of misshapen produce, like with many sustainability initiatives, is confusing: does it increase of decrease food wastage? Still, in combination with subsidy policies, a policy aimed at generating food wastage awareness has a more beneficial outcome than in combination with a policy aimed at creating motivation for misshapen produce or developing skills for processing misshapen produce. In sum, under the condition that budget is not a limitation, any policy aimed at increasing adoption of misshapen produce in the Netherlands needs to be aimed primarily at subsidizing farmer prices and retailer prices for misshapen produce. Social dynamics will follow, albeit restricted by the limited supply of misshapen produce. Only the joint effort from all actors in the food supply chain can drive adoption of misshapen produce by consumers in the Netherlands towards its full potential.

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Appendices

Appendix I: Simulation model (figure)

Figure 98 provides an image of the simulation model that includes the variables in pink by which the policy analysis is performed.

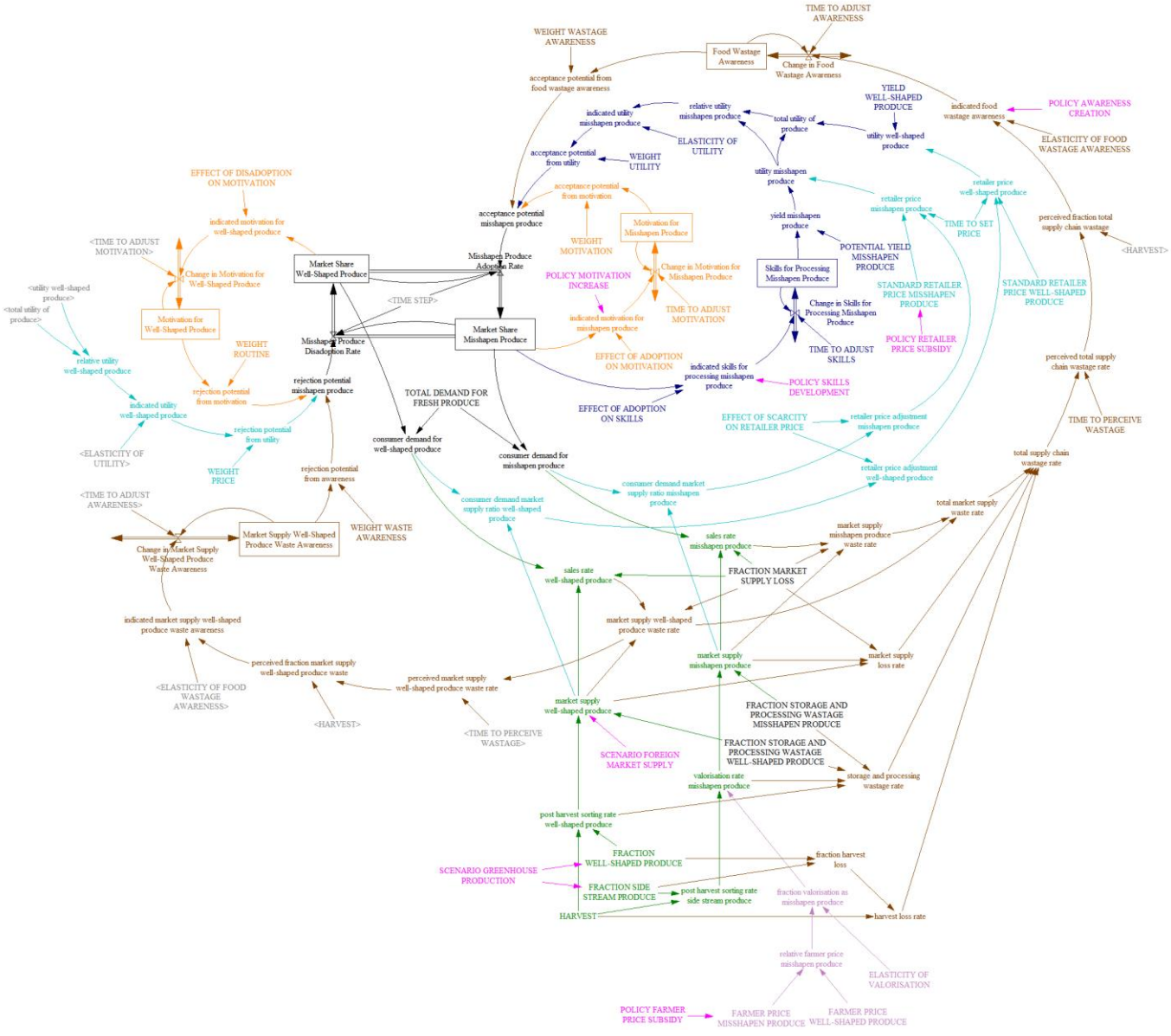

Figure 98: Simulation model

Appendix II: Documentation of simulation model

acceptance potential from food wastage awareness=Food Wastage Awareness*WEIGHT WASTAGE AWARENESS
Units: Dmnl

acceptance potential from motivation=Motivation for Misshapen Produce*WEIGHT MOTIVATION
Units: Dmnl

acceptance potential from utility=indicated utility misshapen produce*WEIGHT UTILITY
Units: Dmnl

acceptance potential misshapen produce=acceptance potential from motivation+acceptance potential from utility+acceptance potential from food wastage awareness
Units: Dmnl

Change in Food Wastage Awareness=(indicated food wastage awareness-Food Wastage Awareness)/TIME TO ADJUST AWARENESS
Units: Dmnl/Year

"Change in Market Supply Well-Shaped Produce Waste Awareness"=("indicated market supply well-shaped produce waste awareness"-"Market Supply Well-Shaped Produce Waste Awareness")/TIME TO ADJUST AWARENESS
Units: Dmnl/Year

Change in Motivation for Misshapen Produce=(indicated motivation for misshapen produce-Motivation for Misshapen Produce)/TIME TO ADJUST MOTIVATION
Units: Dmnl/Year

"Change in Motivation for Well-Shaped Produce"=("indicated motivation for well-shaped produce"-"Motivation for Well-Shaped Produce")/TIME TO ADJUST MOTIVATION
Units: Dmnl/Year

Change in Skills for Processing Misshapen Produce=(indicated skills for processing misshapen produce-Skills for Processing Misshapen Produce)/TIME TO ADJUST SKILLS
Units: Dmnl/Year

consumer demand for misshapen produce=Market Share Misshapen Produce*TOTAL DEMAND FOR FRESH PRODUCE
Units: Kilotonnes/Year

"consumer demand for well-shaped produce"="Market Share Well-Shaped Produce"*TOTAL DEMAND FOR FRESH PRODUCE
Units: Kilotonnes/Year

EFFECT OF ADOPTION ON MOTIVATION([(0,0)-(1,1)],(0,0),(0.1,0.05),(0.2,0.1),(0.3,0.25),(0.4,0.45),(0.5,0.75),(0.6,0.85),(0.7,0.9),(0.8,0.95),(0.9,0.975),(1,1))
Units: Dmnl

EFFECT OF DISADOPTION ON MOTIVATION([(0,0)-(1,1)],(0,0),(0.1,0.05),(0.2,0.1),(0.3,0.25),(0.4,0.45),(0.5,0.75),(0.6,0.85),(0.7,0.9),(0.8,0.95),(0.9,0.975),(1,1))
Units: Dmnl

EFFECT OF SCARCITY ON RETAILER PRICE([(0,0)-(30,2)], (0,2), (0.3,1.9), (0.4,1.85), (0.5,1.775), (0.6,1.7), (0.7,1.6), (0.8,1.45), (0.9,1.3), (1,1.15), (1.1,1), (1.2,0.85), (1.3,0.75), (1.4,0.675), (1.5,0.65), (30,0.65))
Units: Dmnl

ELASTICITY OF FOOD WASTAGE AWARENESS=1.25
Units: Dmnl

ELASTICITY OF UTILITY=2
Units: Dmnl

ELASTICITY OF VALORISATION=4
Units: Dmnl

"FARMER PRICE WELL-SHAPED PRODUCE"=0.95
Units: Euro/Kilogram

FINAL TIME = 2031
Units: Year
The final time for the simulation.

fraction harvest loss=MAX(1-"FRACTION WELL-SHAPED PRODUCE"-FRACTION SIDE STREAM PRODUCE,0)
Units: Dmnl

"FRACTION STORAGE AND PROCESSING WASTAGE WELL-SHAPED PRODUCE"=0.02
Units: Dmnl

"FRACTION WELL-SHAPED PRODUCE"=0.8+STEP(SCENARIO GREENHOUSE PRODUCTION,2017)
Units: Dmnl

EFFECT OF ADOPTION ON SKILLS([(0,0.5)-(1,1)],(0,0.5),(0.1,0.525),(0.2,0.55),(0.3,0.625),(0.4,0.725),(0.5,0.875),(0.6,0.925),(0.7,0.95),(0.8,0.975),(0.9,0.9875),(1,1))
Units: Dmnl

FARMER PRICE MISSHAPEN PRODUCE=0.57+0.57*POLICY FARMER PRICE SUBSIDY*PULSE(2017,15)
Units: Euro/Kilogram

Food Wastage Awareness= INTEG (Change in Food Wastage Awareness,INIT food wastage awareness)

Units: Dmnl

FRACTION MARKET SUPPLY LOSS=0.05
Units: Dmnl

FRACTION SIDE STREAM PRODUCE=0.19-STEP(SCENARIO GREENHOUSE PRODUCTION,2017)
Units: Dmnl

FRACTION STORAGE AND PROCESSING WASTAGE MISSHAPEN PRODUCE=0.03
Units: Dmnl

HARVEST=2418
Units: Kilotonnes/Year

harvest loss rate=HARVEST*fraction harvest loss
Units: Kilotonnes/Year

indicated food wastage awareness=MIN(perceived fraction total supply chain wastage*ELASTICITY OF FOOD WASTAGE AWARENESS+perceived fraction total supply chain wastage*ELASTICITY OF FOOD WASTAGE AWARENESS*POLICY AWARENESS CREATION*PULSE(2017,15),1)
Units: Dmnl

"indicated market supply well-shaped produce waste awareness"= MIN("perceived fraction market supply well-shaped produce waste"*ELASTICITY OF FOOD WASTAGE AWARENESS,1)
Units: Dmnl

indicated motivation for misshapen produce=MIN(EFFECT OF ADOPTION ON MOTIVATION(Market Share Misshapen Produce)+EFFECT OF ADOPTION ON MOTIVATION(Market Share Misshapen Produce)*POLICY MOTIVATION INCREASE*PULSE(2017,15),1)
Units: Dmnl

indicated skills for processing misshapen produce= MIN(EFFECT OF ADOPTION ON SKILLS(Market Share Misshapen Produce)+EFFECT OF ADOPTION ON SKILLS(Market Share Misshapen Produce)*POLICY SKILLS DEVELOPMENT*PULSE(2017,15),1)
Units: Dmnl

INIT consumer demand misshapen produce=INIT market share misshapen produce*TOTAL DEMAND FOR FRESH PRODUCE
Units: Kilotonnes/Year

"INIT consumer demand well-shaped produce"="INIT MARKET SHARE WELL-SHAPED PRODUCE"*TOTAL DEMAND FOR FRESH PRODUCE
Units: Kilotonnes/Year

INIT food wastage awareness= INITIAL((INIT total supply chain wastage rate/HARVEST)*ELASTICITY OF FOOD WASTAGE AWARENESS)

Units: Dmnl

INIT fraction valorisation as misshapen produce=MIN(1,MAX(0,((FARMER PRICE MISSHAPEN PRODUCE/(FARMER PRICE MISSHAPEN PRODUCE+"FARMER PRICE WELL-SHAPED PRODUCE"))-0.25)*ELASTICITY OF VALORISATION))
Units: Dmnl

INIT market share misshapen produce= INITIAL(TOTAL MARKET SHARE-"INIT MARKET SHARE WELL-SHAPED PRODUCE")
Units: Dmnl

"INIT MARKET SHARE WELL-SHAPED PRODUCE"= INITIAL(0.93)
Units: Dmnl

INIT market supply misshapen produce=HARVEST*FRACTION SIDE STREAM PRODUCE*INIT fraction valorisation as misshapen produce*(1-FRACTION STORAGE AND PROCESSING WASTAGE MISSHAPEN PRODUCE)*(1-FRACTION MARKET SUPPLY LOSS)
Units: Kilotonnes/Year

INIT market supply misshapen produce waste rate=MAX(0,INIT market supply misshapen produce-INIT consumer demand misshapen produce)
Units: Kilotonnes/Year

"INIT market supply well-shaped produce waste awareness"= INITIAL(ELASTICITY OF FOOD WASTAGE AWARENESS*("INIT market supply well-shaped produce waste rate" /HARVEST))
Units: Dmnl

"INIT market supply well-shaped produce waste rate"=MAX(0,"INIT market supply well-shaped produce"-"INIT consumer demand well-shaped produce")
Units: Kilotonnes/Year

"INIT market supply well-shaped produce"=HARVEST*"FRACTION WELL-SHAPED PRODUCE"*(1-"FRACTION STORAGE AND PROCESSING WASTAGE WELL-SHAPED PRODUCE")*(1-FRACTION MARKET SUPPLY LOSS)
Units: Kilotonnes/Year

INIT motivation for misshapen produce= INITIAL(EFFECT OF ADOPTION ON MOTIVATION(INIT market share misshapen produce))
Units: Dmnl

"INIT motivation for well-shaped produce"= INITIAL(EFFECT OF DISADOPTION ON MOTIVATION("INIT MARKET SHARE WELL-SHAPED PRODUCE"))
Units: Dmnl

INIT skills for processing misshapen produce= INITIAL(EFFECT OF ADOPTION ON SKILLS(INIT market share misshapen produce))
Units: Dmnl

INIT total supply chain wastage rate=HARVEST*(1-FRACTION SIDE STREAM PRODUCE-"FRACTION WELL-SHAPED PRODUCE")+(HARVEST*"FRACTION WELL-SHAPED PRODUCE"*"FRACTION STORAGE AND PROCESSING WASTAGE WELL-SHAPED PRODUCE")+(HARVEST*"FRACTION WELL-SHAPED PRODUCE"*(1-"FRACTION STORAGE AND PROCESSING WASTAGE WELL-SHAPED PRODUCE")*FRACTION MARKET SUPPLY LOSS)+(HARVEST*FRACTION SIDE STREAM PRODUCE*INIT fraction valorisation as misshapen produce*FRACTION STORAGE AND PROCESSING WASTAGE MISSHAPEN PRODUCE)+(HARVEST*FRACTION SIDE STREAM PRODUCE*INIT fraction valorisation as misshapen produce*(1-FRACTION STORAGE AND PROCESSING WASTAGE MISSHAPEN PRODUCE)*FRACTION MARKET SUPPLY LOSS)+INIT market supply misshapen produce waste rate+"INIT market supply well-shaped produce waste rate"
Units: Kilotonnes/Year

INITIAL TIME = 2012
Units: Year
The initial time for the simulation.

Market Share Misshapen Produce= INTEG (Misshapen Produce Adoption Rate-Misshapen Produce Disadoption Rate,INIT market share misshapen produce)
Units: Dmnl

"Market Share Well-Shaped Produce"= INTEG (Misshapen Produce Disadoption Rate-Misshapen Produce Adoption Rate, "INIT MARKET SHARE WELL-SHAPED PRODUCE")
Units: Dmnl

market supply loss rate=(market supply misshapen produce+"market supply well-shaped produce")*FRACTION MARKET SUPPLY LOSS
Units: Kilotonnes/Year

market supply misshapen produce=valorisation rate misshapen produce*(1-FRACTION STORAGE AND PROCESSING WASTAGE MISSHAPEN PRODUCE)
Units: Kilotonnes/Year

market supply misshapen produce waste rate=market supply misshapen produce*(1-FRACTION MARKET SUPPLY LOSS)-sales rate misshapen produce
Units: Kilotonnes/Year

"Market Supply Well-Shaped Produce Waste Awareness"= INTEG ("Change in Market Supply Well-Shaped Produce Waste Awareness", "INIT market supply well-shaped produce waste awareness")
Units: Dmnl

"market supply well-shaped produce"="post harvest sorting rate well-shaped produce"*(1-"FRACTION STORAGE AND PROCESSING WASTAGE WELL-SHAPED PRODUCE")-STEP("post harvest sorting rate well-shaped produce"*SCENARIO FOREIGN MARKET SUPPLY,2017)
Units: Kilotonnes/Year

consumer demand market supply ratio misshapen produce=IF THEN ELSE(consumer demand for misshapen produce=0, 0, market supply misshapen produce/consumer demand for misshapen produce)
Units: Dmnl

"consumer demand market supply ratio well-shaped produce"=IF THEN ELSE("consumer demand for well-shaped produce"=0, 0, "market supply well-shaped produce"/"consumer demand for well-shaped produce")
Units: Dmnl

fraction valorisation as misshapen produce=MIN(1,MAX(0,(relative farmer price misshapen produce-0.25)*ELASTICITY OF VALORISATION))
Units: Dmnl

"indicated motivation for well-shaped produce"=EFFECT OF DISADOPTION ON MOTIVATION("Market Share Well-Shaped Produce")
Units: Dmnl

indicated utility misshapen produce=MIN(1,MAX(0,(relative utility misshapen produce-0.5)*ELASTICITY OF UTILITY))
Units: Dmnl

"indicated utility well-shaped produce"=MIN(1,MAX(0,("relative utility well-shaped produce"-0.5)*ELASTICITY OF UTILITY))
Units: Dmnl

Misshapen Produce Adoption Rate= ("Market Share Well-Shaped Produce"*acceptance potential misshapen produce)/TIME STEP
Units: Dmnl/Year

Misshapen Produce Disadoption Rate=(Market Share Misshapen Produce*rejection potential misshapen produce)/TIME STEP
Units: Dmnl/Year

Motivation for Misshapen Produce= INTEG (Change in Motivation for Misshapen Produce, INIT motivation for misshapen produce)
Units: Dmnl

"Motivation for Well-Shaped Produce"= INTEG ("Change in Motivation for Well-Shaped Produce", "INIT motivation for well-shaped produce")
Units: Dmnl

"perceived fraction market supply well-shaped produce waste"="perceived market supply well-shaped produce waste rate"/HARVEST
Units: Dmnl

perceived fraction total supply chain wastage=perceived total supply chain wastage rate/HARVEST
Units: Dmnl

"perceived market supply well-shaped produce waste rate"=SMOOTH("market supply well-shaped produce waste rate",TIME TO PERCEIVE WASTAGE)
Units: Kilotonnes/Year

perceived total supply chain wastage rate=SMOOTH(total supply chain wastage rate,TIME TO PERCEIVE WASTAGE)
Units: Kilotonnes/Year

POLICY AWARENESS CREATION=0
Units: Dmnl

POLICY MOTIVATION INCREASE=0
Units: Dmnl

POLICY RETAILER PRICE SUBSIDY=0
Units: Euro/Kilogram

POLICY SKILLS DEVELOPMENT=0
Units: Dmnl

post harvest sorting rate side stream produce=HARVEST*FRACTION SIDE STREAM PRODUCE
Units: Kilotonnes/Year

"post harvest sorting rate well-shaped produce"=HARVEST*"FRACTION WELL-SHAPED PRODUCE"
Units: Kilotonnes/Year

"market supply well-shaped produce waste rate"="market supply well-shaped produce"*(1-FRACTION MARKET SUPPLY LOSS)-"sales rate well-shaped produce"
Units: Kilotonnes/Year

POLICY FARMER PRICE SUBSIDY=0
Units: Euro/Kilogram

POTENTIAL YIELD MISSHAPEN PRODUCE=1400
Units: KCal/Kilogram

rejection potential from awareness="Market Supply Well-Shaped Produce Waste Awareness"*WEIGHT WASTE AWARENESS
Units: Dmnl

rejection potential from motivation="Motivation for Well-Shaped Produce"*WEIGHT ROUTINE
Units: Dmnl

rejection potential from utility="indicated utility well-shaped produce"*WEIGHT PRICE
Units: Dmnl

rejection potential misshapen produce=rejection potential from motivation+rejection potential from utility+rejection potential from awareness
Units: Dmnl

relative farmer price misshapen produce=FARMER PRICE MISSHAPEN PRODUCE/(FARMER PRICE MISSHAPEN PRODUCE+"FARMER PRICE WELL-SHAPED PRODUCE")
Units: Dmnl

relative utility misshapen produce=utility misshapen produce/total utility of produce
Units: Dmnl

"relative utility well-shaped produce"="utility well-shaped produce"/total utility of produce
Units: Dmnl

retailer price adjustment misshapen produce=EFFECT OF SCARCITY ON RETAILER PRICE(consumer demand market supply ratio misshapen produce)
Units: Dmnl

"retailer price adjustment well-shaped produce"=EFFECT OF SCARCITY ON RETAILER PRICE("consumer demand market supply ratio well-shaped produce")
Units: Dmnl

retailer price misshapen produce=SMOOTH(retailer price adjustment misshapen produce*STANDARD RETAILER PRICE MISSHAPEN PRODUCE,TIME TO SET PRICE)
Units: Euro/Kilogram

"retailer price well-shaped produce"=SMOOTH("retailer price adjustment well-shaped produce"*"STANDARD RETAILER PRICE WELL-SHAPED PRODUCE",TIME TO SET PRICE)
Units: Euro/Kilogram

sales rate misshapen produce=MIN(consumer demand for misshapen produce,market supply misshapen produce*(1-FRACTION MARKET SUPPLY LOSS))
Units: Kilotonnes/Year

"sales rate well-shaped produce"=MIN("consumer demand for well-shaped produce","market supply well-shaped produce"*(1-FRACTION MARKET SUPPLY LOSS))
Units: Kilotonnes/Year

SAVEPER = TIME STEP
Units: Year [0,?]
The frequency with which output is stored.

SCENARIO FOREIGN MARKET SUPPLY=0
Units: Dmnl

SCENARIO GREENHOUSE PRODUCTION=0
Units: Dmnl

Skills for Processing Misshapen Produce= INTEG (Change in Skills for Processing Misshapen Produce, INIT skills for processing misshapen produce)
Units: Dmnl

STANDARD RETAILER PRICE MISSHAPEN PRODUCE=2.25-2.25*POLICY RETAILER PRICE SUBSIDY*PULSE(2017,15)
Units: Euro/Kilogram

"STANDARD RETAILER PRICE WELL-SHAPED PRODUCE"=2.5
Units: Euro/Kilogram

storage and processing wastage rate="post harvest sorting rate well-shaped produce"*"FRACTION STORAGE AND PROCESSING WASTAGE WELL-SHAPED PRODUCE"+valorisation rate misshapen produce*FRACTION STORAGE AND PROCESSING WASTAGE MISSHAPEN PRODUCE
Units: Kilotonnes/Year

TIME STEP = 0.25
Units: Year [0,?]
The time step for the simulation.

TIME TO ADJUST AWARENESS=2
Units: Year

TIME TO ADJUST MOTIVATION=2
Units: Year

TIME TO ADJUST SKILLS=1
Units: Year

TIME TO PERCEIVE WASTAGE=1
Units: Year

TIME TO SET PRICE=1
Units: Year

TOTAL DEMAND FOR FRESH PRODUCE=2055
Units: Kilotonnes/Year

TOTAL MARKET SHARE=1
Units: Dmnl

total market supply waste rate=market supply misshapen produce waste rate+"market supply well-shaped produce waste rate"
Units: Kilotonnes/Year

total supply chain wastage rate=harvest loss rate+storage and processing wastage rate+market supply loss rate+total market supply waste rate
Units: Kilotonnes/Year

total utility of produce=utility misshapen produce+"utility well-shaped produce"
Units: KCal/Euro

utility misshapen produce=yield misshapen produce/retailer price misshapen produce
Units: KCal/Euro

"utility well-shaped produce"="YIELD WELL-SHAPED PRODUCE"/"retailer price well-shaped produce"
Units: KCal/Euro

valorisation rate misshapen produce=post harvest sorting rate side stream produce*fraction valorisation as misshapen produce
Units: Kilotonnes/Year

WEIGHT MOTIVATION=0.2
Units: Dmnl

WEIGHT PRICE=0.7
Units: Dmnl

WEIGHT ROUTINE=0.2
Units: Dmnl

WEIGHT UTILITY=0.7
Units: Dmnl

WEIGHT WASTAGE AWARENESS=0.1
Units: Dmnl

WEIGHT WASTE AWARENESS=0.1
Units: Dmnl

yield misshapen produce=Skills for Processing Misshapen Produce*POTENTIAL YIELD MISSHAPEN PRODUCE
Units: KCal/Kilogram

"YIELD WELL-SHAPED PRODUCE"=1500
Units: KCal/Kilogram

Appendix III: Interview respondents

Figure 99 provides an chronological overview of conducted interviews with experts at various positions in the food supply chain. An indication is given of their contribution (large, small, or not) to one of the four major operations in the food supply chain described in chapter 5, namely production, processing, retailing, and consumption. The abbreviations stand for their primary expertise in the food supply chain: production (P), processing (V), retailing (S), consumption (C), and general (A).

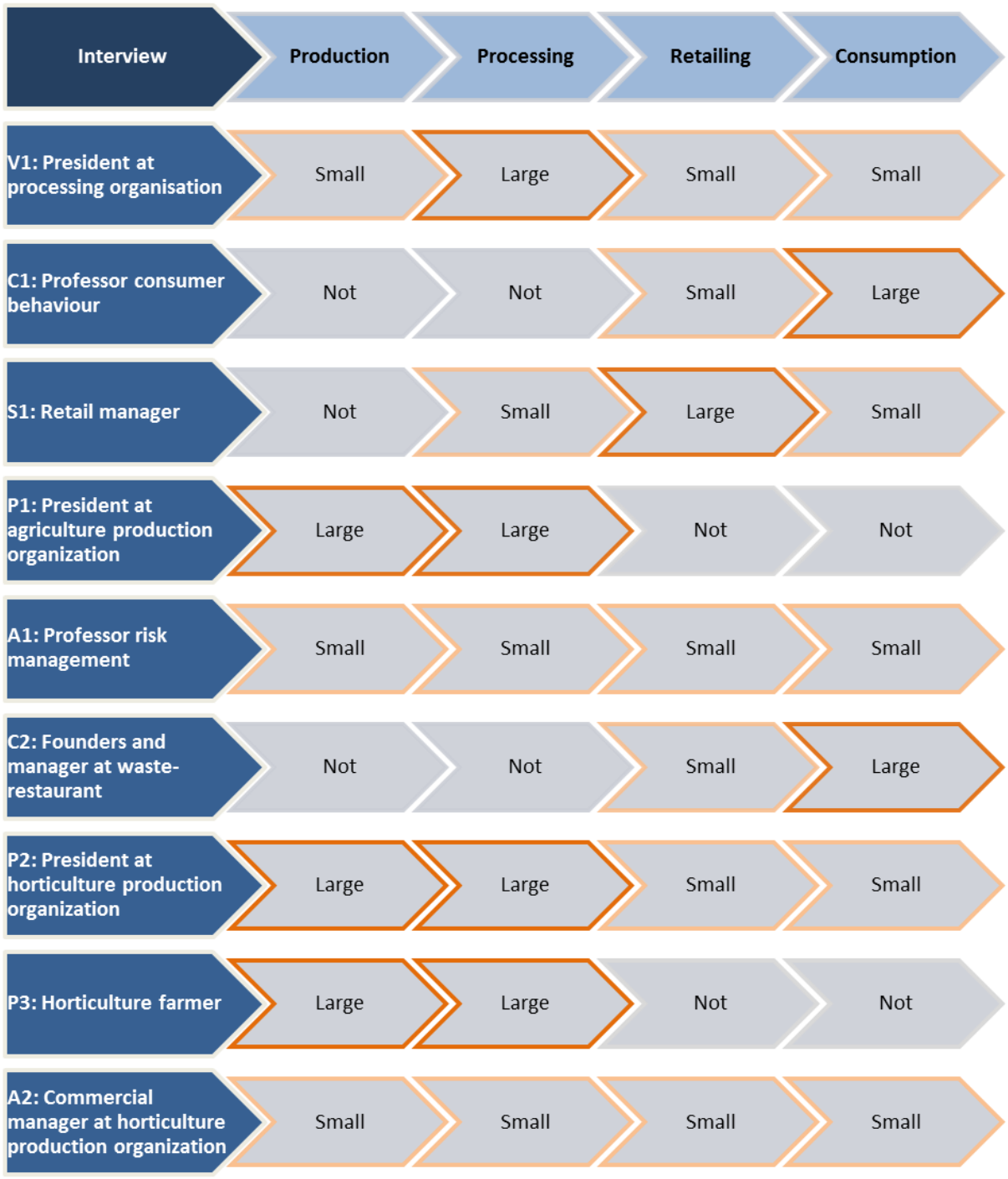

Figure 99: Interview respondents

Appendix IV: Interview guide

The interview guide below provides an indication of the items addressed during most of the interviews. The exact order and formulation of questions differs as the interviews have been tailored to the professional background of the interview respondent.

Introduction
[Greeting], thank you for making it to our appointment. Please make yourself comfortable. My name is Jo Deckers and - as I already informed you by email - I am a master student at Radboud University. I approached you in the context of my master thesis, which is about the adoption of misshapen fruits and vegetables in the context of food waste. Thank you for your time and energy. I approached you for this interview because I think you can guide me through the exploration of the adoption of misshapen fruits and vegetables and its effects on and from the food chain.

As I wrote you, this interview will be used confidentially and only serves the research for my thesis. It would help me if I could record this interview. Would that be okay with you? I will use this interview as data source for investigating the product characteristics of fruits and vegetables and the effects on and from the food chain. It will help me to design this research in a meaningful way and to find out to what extent misshapen fruits and vegetables are a viable business model. After this interview, I will briefly go over the topics we have talked about to make sure that we have addressed everything. After having done the analysis I will report to you the preliminary outcomes. Quotations will not be taken, unless communicated on forehand. I expect that this interview will take approximately 30 minutes.

I suggest to introduce ourselves before we start. Could you briefly describe your background?

Questions
1. To prevent misinterpretation, I would like to verify my definition of food waste and of misshapen fruits and vegetables with yours:
   Food waste: food, like fruits and vegetables, that is removed from the food supply chain while being appropriate for human consumption.
   Misshapen fruits and vegetables: fruits and vegetables that do not meet aesthetic standards.
   Do you agree with these definitions?

Interactions between product characteristics and consumer characteristics
My research is concerned with the adoption of misshapen fruits and vegetables. I first have some questions about characteristics of fruits and vegetables.
1. What factors drive you to adopt misshapen fruits and vegetables?
   i. What may be related to the factor you mention?
   ii. What may influence the factor you mention?

Interactions with the food supply chain
Part of my research is concerned with the influence of adoption of misshapen fruits and vegetables on the food supply chain and the influence of the food supply chain on the adoption of misshapen fruits and vegetables. This is why I will now ask you some questions related to this.
2. What effects does the adoption of misshapen fruits and vegetables have on the food chain in general?

3. What effects does the adoption of misshapen fruits and vegetables have on the supply of misshapen fruits and vegetables?
4. What effects does the adoption of misshapen fruits and vegetables have on the demand for misshapen fruits and vegetables?
5. Where is demand for misshapen produce originating from?
    i. How did demand for misshapen produce develop over de past years?
    ii. To what extent is it important for you to be aware of the (potential) demand for misshapen produce?

Adoption of misshapen fruits and vegetables

6. What makes it attractive to valorize misshapen fruits and vegetables?
7. What makes it unattractive to valorize misshapen fruits and vegetables?
8. What problems arise due to the adoption of misshapen fruits and vegetables?
9. What solutions result from the adoption of misshapen fruits and vegetables?

Snowball-sampling

Thank you for your contribution so far. I have one final question for this interview:

10. What persons would you advise me to have an interview with as well in relation to this research?

Conclusion

Thank you very much for all the input you provided. I have the impression that I gained quite some insights about the way in which adoption of misshapen fruits and vegetables is influenced. I noted down that we talked about *[wrap-up of answers to the questions]*.

Would you like to add or rephrase anything in this regard?

Thank you again. As I told you before I will report the preliminary outcomes to you once the analysis is finished. I expect that I can inform you about this within two weeks.

Are you okay with it if I contact you if additional questions pop up when analyzing this interview?

Please let me know if there is anything you would like to inform me about in the meanwhile and do not hesitate to discuss the analysis and outcomes that I will share with you.

Would you like to receive the final version of the thesis after submission?

I am sure that your time and energy have been well spend and I hope you will feel the same about this.

Appendix V: Coding nodes

Figure 100 provides an image of the nodes used for coding. The nodes are compared in size by number of coding references to all interviews. The larger the square, the higher the number of coding references in a node, and vice versa. In addition, the nodes are compared in color by number of interviews to which they refer. The greener the square, the higher the number of interviews to which a node refers, and vice versa.

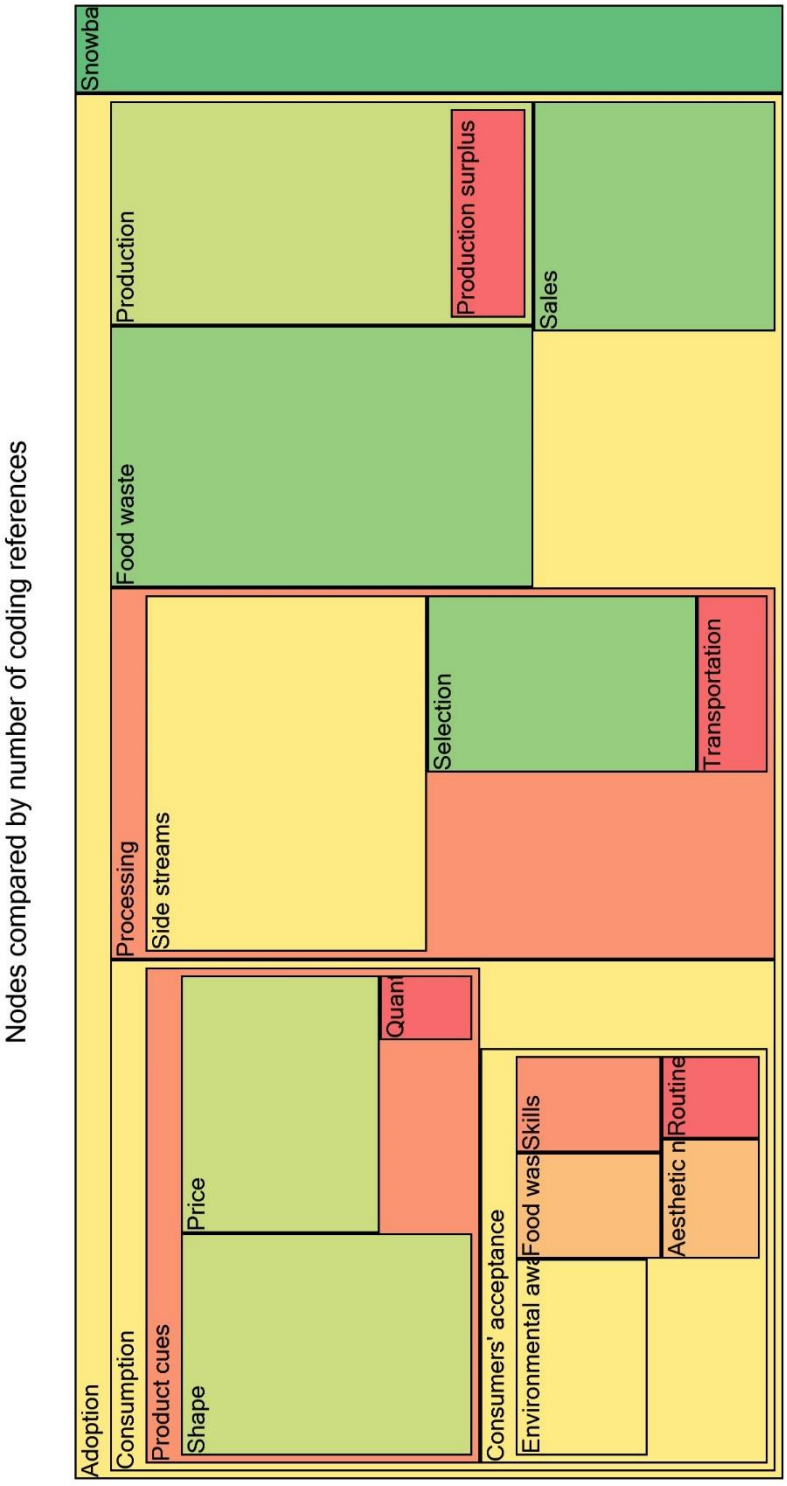

Figure 100: Coding nodes