From farm to fork

"Traceability in the supply chain of the Dutch potato sector"

A research to investigate the trade-offs for a traceable supply chain of the Dutch potato sector

- RESEARCH REPORT -

MASTER THESIS

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Acknowledgements

During my master programme our student association Mercurius Wageningen visited a Dutch potato factory. During the excursion we were shown the entire process from raw potatoes to processed potato products. As I have a keen interest in how the products we consume every day are made out of raw materials, I have visited several food processing companies (ranging from beer to chocolate or butter) in the past, and was impressed by all advanced techniques that are used to process the food we want to eat. The processing company (and an intermediate potato trader I visited as well) posed several interesting questions about the current situation in the Dutch potato sector and, especially about the influence of traceability and the impact on the Dutch potato supply chain. I decided that I wanted to find out how traceability is developed in the Dutch potato supply chain and I wanted to know the impact of a more traceable supply chain.

At the same moment the chocolate processor Mars started a procedure to recall their products from 55 countries all over the world. That message reminds me of a food problem some years ago where the EHEC bacteria killed several people and it took a long time before the source of the threat was known. These messages strengthened my interest to find out how well traceability is developed in the Dutch potato sector. You can read my findings in this research report.

I would like to take this opportunity to thank my supervisor Prof. Dr. J.H. Trienekens from Wageningen University for his valuable support. From the beginning till the end he was very helpful and it was a pleasure to change my thoughts with him about a traceable supply chain and all other interesting knowledge that came up during my research. In addition I want to thank my co-supervisor Dr. W.J.J. Bijman for his support, valuable feedback and guidance. Finally I want to show my gratitude to all respondents for their willingness to help me with sharing their knowledge and their view to a traceable supply chain with a special thanks to the two persons who inspired me with finding an interesting topic for my thesis.

Raymon Gores
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Executive summary

In the past, the world has been confronted with food safety issues and scandals such as food-and-mouth disease, mad cow disease, microbial contamination of fresh produce, dioxin in poultry and, more recently, the EHEC-bacteria and the horsemeat scandal. These scandals and food safety issues are one of the reasons that there is a growing interest in food traceability from consumers, the industry and the government.

Food traceability is understood as: *"a part of logistics management that captures, stores and transmits adequate information about a food, feed, food-producing animal or substance at all stages in the food supply chain so the product can be checked for safety and quality control, traced upward, and tracked downward at any time required"* (Bosona & Gebresenbet, 2013). Many concerns, drivers and opportunities have been described in literature: safety and quality concerns, regulatory, social and economic drivers and technological opportunities. Different strategies of traceability can be distinguished in food supply chains: a compliance-oriented strategy, a process improvement strategy and a market-oriented strategy (Vorst, van der, 2004). Each strategy has its own impact on operational processes and control, physical infrastructure, data capturing and information exchange and supply chain organisation. How these factors are set up is called the logistic and organisational structure and determines the level of traceability: the time needed for tracing products, the tracing unit that defines the level at which the traced object is uniquely identified and the reliability of the traceability analysis.

The growing interest in food traceability may also affect the potato sector. This study is concerned with the question how the logistic and organisational structure in the potato sector would change when a higher level of traceability is desired. In order to obtain a higher level of traceability organisations have to make choices. They have to decide whether they want to increase the level of traceability in exchange for a decreasing level of other desirable outcomes - also understood as a trade-off.

The first part of the study consists of a desk research, in order to find the logistic and organisational factors that have an influence on the level of food traceability in general. Subsequently, a case study was carried out, focusing on the traceability of the supply chain in the Dutch potato sector. In total 13 interviews were conducted with a farmer, a cooperative, an intermediate trader, processors and retailers. To check the results and to get information from a broader perspective, also experts from two different interest groups were interviewed.

The respondents together came up with 8 different factors that would change when choosing a higher level of traceability. The decision whether to change a factor or not depends on the trade-off. A trade-off is understood as: *"a technique of reducing or forgoing one or more desirable outcomes in exchange for increasing or obtaining other desirable outcomes in order to maximize the total return of effectiveness under given circumstances"* (BusinessDictionary, n.d.). For most of the changing factors also the trade-offs are described by respondents - the increasing outcome and the reducing outcome (Table 1). Except the increasing level of traceability also some positive side effects were mentioned by respondents which are also included in the overview of Table 1.

Table 1: Changing logistic and organisational factors including trade-offs

	Changing factor	Explanation	Increasing outcome	Reducing outcome
1	Physical infrastructure	Transport from field to potato storage is separated to (1) one farmer or even further to (2) a single potato field	Smaller tracing units	Less efficient transport, Higher costs, Being less sustainable
2	Physical infrastructure	Potato storage is separated to (1) one farmer or even further to (2) a single potato field	Smaller tracing units, Less quality variation in raw potato batches*	Lower air circulation , More time needed to move potatoes, Higher costs
3	Operational processes and control	Raw potato batches (from (1) one farmer or (2) a single potato field) are put into production separately	Smaller tracing units	Less consistent quality of output, Less optimal use of raw potato batches, More complex production process
4	Operational processes and control	Stop points between raw potato batches during a single production run	Smaller tracing units	Less consistent quality of output, Less efficient production process, Higher costs
5	Data capturing and information exchange	All farmers work with an online crop registration form	Shorter time to trace, Immediately detection of exceedance*	
6	Data capturing and information exchange	All freezing houses work with a HUM system	Shorter time to trace, More reliable traceability analysis	Being less flexible
7	Data capturing and information exchange	Knowing the customer/consumer who bought the product		
8	Data capturing and information exchange	The existence of one system where there is a direct traceability overview	Shorter time to trace	

** Positive side effect*

Based on the changing factors as stated above and the increasing outcome and decreasing outcome, 5 trade-off statements can be defined:

<u>Trade-off 1. **PHYSICAL INFRASTRUCTURE** | Transport from field to potato storage is separated to (1) one farmer or even further to (2) a single potato field</u>

Organisations have to choose whether they want to have *smaller tracing units*, in exchange for *less efficient transport*, *higher costs* and *being less sustainable*.

<u>Trade-off 2. **PHYSICAL INFRASTRUCTURE** | Potato storage is separated to (1) one farmer or even further to (2) a single potato field</u>

Organisations have to choose whether they want to have *smaller tracing units* in exchange for *lower air circulation capacity of stored potatoes*, *more time needed to move potatoes from storage to production* and *higher costs*.

<u>Trade-off 3. **OPERATIONAL PROCESSES AND CONTROL** | Raw potato batches (from (1) one farmer or (2) a single potato field) are put into production separately</u>

Organisations have to choose whether they want to have *smaller tracing units* in exchange for *less consistent quality of output*, *less optimal use of raw potato batches* and a *more complex production process.*

Trade-off 4. **OPERATIONAL PROCESSES AND CONTROL** | Stop points between raw potato batches during a single production run

Organisations have to choose whether they want to have *smaller tracing units* in exchange for a *less consistent quality of output*, a *less efficient production process* and *higher costs*.

Trade-off 5. **DATA CAPTURING AND INFORMATION EXCHANGE** | All freezing houses work with a HUM system

Organisations have to choose whether they want to have a *shorter time to trace* and a *more reliable traceability analysis* in exchange for *being less flexible*.

Five trade-offs are defined while at least 8 changing factors are mentioned earlier. Respondents who argued changing factors not always find trade-offs for these changing factors - in other words they formulated improvements for factors which will not always have negative consequences. The current logistic and organisational structure is a result of all developments in the past and the supply chain has already become more traceable. It is a step-by-step process in which the logistic and organisational structure will change further to increase the level of traceability even more, sometimes without negative consequences for other desirable outcomes. As a respondent of the processing industry explained, their current traceability system nowadays makes it able to have smaller tracing units, but it is a continuous process of improving their systems further - increasing their level of traceability step-by-step.

There could exist several scenarios of how the future can unfold regarding traceability in the Dutch potato supply chain. In this research two scenarios are set up: a scenario I in which raw potatoes are separated on farmer level; and a scenario II in which potatoes are separated on field level as can been seen from Table 2. The level of separation has consequences for transport, storage and production and cause a difference in the level of traceability between scenario I and scenario II - more separated raw potatoes batches contribute to a higher level of food traceability due to smaller tracing units. Changing factor 4, 5, 6, 7 and 8 are not subjected to a change in the level of separation - and do therefore not contribute to the increasing level of traceability from scenario I to scenario II.

Table 2: Traceability scenario I and II

	Changing factor	Traceability scenario I (separation on farmer level)	Traceability scenario II (separation on field level)
1	Physical infrastructure	Transport from field to potato storage is separated to *one farmer*	Transport from field to potato storage is separated to *a single potato field*
2	Physical infrastructure	Potato storage is separated to *one farmer*	Potato storage is separated to *a single potato field*
3	Operational processes and control	Raw potato batches from *one farmer* are put into production separately	Raw potato batches from *a single potato field* are put into production separately
4	Operational processes and control	Stop points between raw potato batches during a single production run	Stop points between raw potato batches during a single production run
5	Data capturing and information exchange	All farmers work with an online crop registration form	All farmers work with an online crop registration form

	Changing factor	Traceability scenario I (separation on farmer level)	Traceability scenario II (separation on field level)
6	Data capturing and information exchange	All freezing houses work with a HUM system	All freezing houses work with a HUM system
7	Data capturing and information exchange	Knowing the customer/consumer who bought the product	Knowing the customer/consumer who bought the product
8	Data capturing and information exchange	The existence of one system where there is a direct traceability overview	The existence of one system where there is a direct traceability overview
		+ Shorter time to trace + Smaller tracing units + More reliable traceability analysis	+ Shorter time to trace + + Smaller tracing units + More reliable traceability analysis

The table above doesn't mean that there do not exist other possible scenarios. Several more scenarios could exist in which more combinations of changing factors could be found. The literature review and the interviews showed that the level of separation of raw potatoes has an important impact on the tracing unit that defines the level at which the traced object is uniquely identified. Nowadays raw potato batches from different fields and from different farmers could be combined together - therefore two scenarios are formulated in which potatoes are separated on farmer level and on field level.

Many respondents explained that traceability has to do with risk analysis. Regarding food safety, a potato doesn't have a lot of risks - potatoes will always be cooked and almost never microbiological problems are found. Although potatoes are a low risk product the respondents from the processing industry and one expert explained that Quick Service Restaurants (QSRs) pay attention to traceability and that they ask for a faster traceability analysis than is required by current regulation. The future will show us how far the supply chain will be changed in order to obtain a higher level of food traceability and which choices actually have been made by supply chain parties.

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1. Introduction

In 2013 it became clear that there were some problems with the meat industry. In the United Kingdom it was discovered that horsemeat was used in ready-to-eat-products. On its own that is not a problem, but it is a problem when people assume it is beef (NRC, 2013). A lot of articles have been written about these horsemeat scandals in newspapers and even recently a Dutch newspaper (NRC, 2015) reported that a Dutch meat trader was convicted for trading horsemeat as beef and had to go to jail for 2.5 years. Several years before this horsemeat scandal, another issue came up in Europe about the EHEC-bacteria. As a result of this bacteria, 53 people died and more than 4,000 people from eight different countries became ill after they were infected (Volkskrant, 2012), and it took a long time before the source was found. But there are more examples of food scandals and food safety issues in the past, such as food-and-mouth disease, mad cow disease, microbial contamination of fresh produce and dioxin in poultry. These scandals and food safety issues are one of the reasons that there is a growing interest in food traceability (Opara, 2003). *"Food traceability is a part of logistics management that captures, stores and transmits adequate information about a food, feed, food-producing animal or substance at all stages in the food supply chain so that the product can be checked for safety and quality control, traced upward, and traced downward at any time required"* (Bosona & Gebresenbet, 2013). Traceability will become more important in the food sector and force food companies to pay more attention to it. This interest is also driven by the growth of consumers interested in the origin of their food and the higher demand for high quality food and feed production, non-GMO (genetically modified organisms) food and other specialised products such as organic food (Storoy, Thakur, & Olsen, 2013). Except for the increasing interest from the industry and consumers, the government is also paying more attention to food traceability. The government wants to protect the public health through the withdrawal of food products who will affect public health in case of food incidents. In addition they want to prevent food fraud (Food Standards Agency, 2002). An example is the proposed introduction by the Dutch State of Secretary of Economic Affairs of a special consumer app which allows to check the origin of (the ingredients) of products that are bought (NOS, 2015). This app will also be connected to a database where consumers can find all information about their food products and food components by using a code on the package. Looking at traceability in the food industry it looks like traceability is especially adopted in the meat and fish industry. The reason that most traceability initiatives are found in the meat and fish industry is mainly because of all past food incidents and scandals took place in these industries (Vorst, van der, 2004). Looking at literature there is not so much written about traceability in the sector of vegetables nor potatoes. Although there were no food incidents with potatoes these past years, it can be assumed that traceability is also becoming more popular in this sector. Michael Pollan for example, a renowned activist and author, explained in his presentation (2014) that for the cultivation of the potato variety Russet Burbank, used for French fries of McDonalds restaurants, a pesticide called Methamidophos is used. In his presentation he stated about Methamidophos that: *"this pesticide is so toxic that the farmers who grow these potatoes in Idaho won't venture outside and into their field for five days after they spray"*. Even when validity of this claim is taken out of the equation, statements like these could contribute to increasingly critical consumers who want to know where their potatoes come from.

According to two potato companies, a processing company (personal communication, January 7, 2016) and Wilhelm Weuthen (Juliën Jeurissen, personal communication, January 13, 2016), traceability will become more important in the potato sector. The processing company also explained that other disconcerting stories exist on social media. For example about the number of ingredients added to French fries from McDonalds. These concerns ask for a more transparent potato sector with more need for a traceable potato supply chain. If traceability of potatoes becomes more important, two questions will arise. The first being how should organisations (and the supply chain itself) change in order to reach a higher level of traceability? The second question that will arise, is what will be the trade-offs when going to a higher level of food traceability. A higher level of food traceability could have impact on (financial) costs and other desirable outcomes. For example if a certain level of traceability is desired, this could have consequences for the process and coordination in the supply chain or having a less flexible production process. What the trade-offs are when going to a higher level of food traceability will be investigated in this study. In order to give an answer to these questions, research will be conducted. This section will introduce the subject of food traceability and illustrates the objective of this research.

1.1 Background

This section will define food traceability. It will explain how different food definitions are described and how literature divides food traceability. This section will further explain the different concerns, drivers and opportunities why food traceability is becoming more important. And if food traceability is becoming more important, organisations can use food traceability in different ways. Food traceability strategies will explain which different strategies exist to adopt traceability. This section ends with an explanation how the level of food traceability can be expressed.

1.1.1 Defining food traceability

A multitude of food traceability definitions exist. In the introduction a definition of food traceability was given by Bosona and Gebresenbet (2013). But there exist a lot more definitions from literature to explain food traceability. The General Food Law from the European Commission, for example, defines food traceability as: "*the ability to trace and to follow food, feed, and ingredients through all stages of production, processing and distribution"* (EC, 2016). Many definitions use the term tracking and tracing. *"Tracking (forward) is the ability to follow the downstream path of a particular trade unit in the supply chain, while tracing (backward) is the ability to identify the origin of the products used in a particular trade unit"* (Foras, Thakur, Solem, & Svarva, 2015). Tielemans (2004), divides food traceability in real-time and historic traceability where the same approach holds for backward traceability and forward traceability. Real-time traceability is explained as the actual location and status of a unique object, where it is known for every moment. Historic traceability gives insight in the place and process of a typical object in the past. However, this distinction in forward and backward traceability is not made in every definition of food traceability. In some cases only the word tracing is used whether it is not clear if it indicates forward traceability or backward traceability. According to van de Vorst (2005) traceability is defined as: *"the ability to document and trace a product (lot) forward and backward and its history through the whole, or part, of a production chain from harvest through transport, storage, processing, distribution and sales".* Another definition about food traceability systems is more explained to the purpose of food traceability as: *'a food traceability system helps to increase food safety, through faster recalling products in case of food safety issues. Food traceability helps also to increase the perception of consumers about food safety'* (Tielemans, 2004).

Opara (2003) pays also attention to the consumer and other stakeholders in his definition of agricultural traceability: *"it simply refers to the collection, documentation, maintenance, and* *application of information related to all processes in the supply chain in a manner that provides guarantee to the consumer and other stakeholder on the origin, location and life history of a product as well as assisting in crises management in the event of a safety and quality breach".* Opara (2003) also divided traceability into six elements: product traceability ("*which determines the physical location of a product"*), process traceability ("*which ascertains the type and sequences of activities that have affected the product"*), genetic traceability ("*which determines the genetic constitution of the product"*), inputs traceability ("*which determines the type and origin of inputs"*), disease and pest traceability ("*which traces the epidemiology of pests and biotic hazards"*) and measurement traceability ("*which relates individual measurements results through an unbroken chain of calibrations to accepted reference standards"*). Karlsen et al. (2013) found also another way to divide traceability into horizontal traceability and vertical traceability. Horizontal traceability is explained as *"…to trace correspondent items between different models"* and vertical traceability is explained as the ability *"…to trace dependent items within a model".* Another way to classify traceability comes from Aung and Chang (2014). They distinguished traceability based on the activity in the food chain: back traceability or 'suppliers' traceability; internal traceability or process traceability; and forward traceability or client traceability. Donnelly and Olsen (2013) divided traceability from small to broad and divide food traceability within internal enterprise activities, along a supply chain and within a sector. The Food Standards Agency (2002) made a distinction in internal traceability and chain traceability where internal traceability works within one link of business within the chain and where chain traceability works between links in the chain.

As can be seen in this section there exist many different definitions of traceability which can make it confusing to understand traceability. In many definitions the words tracking and tracing are used which means the same as forward traceability and backward traceability. Not all definitions capture all the explanation of traceability. For example the definition given by the Food Standards Agency only focuses on historical information. *"In primary production, traceability has been defined as the ability to trace the history of the product through the supply chain to or from the place and time of production, including the identification of the inputs used and production undertaken"* (Food Standards Agency, 2002). The most extensive definition and clear explanation of traceability comes from Bosona and Gebresenbet (2013) which is already given and will be further used for this study.

1.1.2 Traceability concerns, drivers and opportunities

Many concerns, drivers and opportunities for food traceability have been described in literature. There are also different ways to categorise these concerns, drivers and opportunities. Karlsen et al. (2013) found ten drivers for food traceability: legislation, food safety, quality, sustainability, welfare, certification, competitive advantages, chain communication, bioterrorist threats and production optimisation. But when they tried to distinguish these formal drivers in empirical research, they found only five drivers: food safety, quality, competitive advantages, chain communication and production optimisation. Aung and Chang (2014) found eight different drivers for traceability in food supply chains: legislation, safety, quality, competitive advantages, trade globalisation, chain communication, process/supply chain efficiency and labour/cost reduction. Others defined concerns to explain why food traceability is becoming more important. Bosona and Gebresenbet (2013) formulated five concerns: regulatory concern, safety concern, social concern, economic concern and technological concern, in which the last one could better be defined as technological opportunities. This section explains why food traceability is becoming more important due to traceability concerns, drivers and opportunities.

Safety and quality concerns

Consumers are much more informed through the media about food safety issues than ever before. The concern about food safety and quality is especially caused by food safety crisis from the meat and livestock sector (e.g. dioxin contamination of animal feed, bovine spongiform encephalopathy (BSE), Escherichia coli, etc.) (Hobbs, 2006; Tielemans, 2004; Bosona & Gebresenbet, 2013; Donnelly, Karlsen, & Dreyer, 2012; Karlsen, Dreyer, Olsen, & Elvevoll, 2013; Foras, Thakur, Solem, & Svarva, 2015). Government and NGOs impose pressure on retailers and processors to improve food safety procedures. The government (national and international) together with retailers are coming to action to work on food safety. Even insurance companies force the market to improve traceability systems in the industry to minimise the risk that they carry (Food Standards Agency, 2002).

Food traceability itself will not contribute to safer food products or higher quality products. But food traceability systems can provide information to determine where a batch is located and to trace the history of that batch when there are incidents within the food supply chain (Aung & Chang, 2014; Hobbs, 2006). Faster response and early detection make it possible to lower the impact of food incidents.

But also specialised products as hormone-free, organic, free-range, antibiotic-free and other non-observable product attributes (credence attributes) will cause demand for a more traceable food supply chain (Buhr, 2003).

Regulatory drivers

Because of concerns about food safety and quality the food industry itself and policymakers will use regulation to prevent food safety problems (Hobbs, 2006). The first initiatives from the EU forced the food supply chain to label beef products for traceability and started with a requirement for mandatory cattle identification. The European Commission also developed a 'White paper on food safety' (EC, 2000) which expressed their concerns and guidelines to handle food safety issues with food traceability. Two years later they formulated these concerns into actions by setting up an article (Appendix III) (EC, 2002). An overview of some regulations concerning food traceability can be found in Appendix II.

Van de Vorst (2004) stated that companies pay more attention to prevention instead of traceability. Legislation will not give any rules to the extent, or traceability level (e.g. time consuming to do a traceability analysis, reliability etc.) each organisation has to comply with. Because companies are more focused on prevention, they focus on GMP, HACCP, ISO, etc. But these systems only provide in-company traceability practices but won't do anything about traceability in the whole supply chain. Therefore companies set up supplier audits and monitoring programmes by themselves (Tielemans, 2004).

Social drivers

Social concerns from consumers motivate companies to implement traceability systems. Consumers want to know the origin of the product they bought and how it is produced (Hobbs, 2006; Food Standards Agency, 2002).

They want to have information of specific foods and food ingredients and they want to check food products because of allergenicity, food intolerance or lifestyle choice (Food Standards Agency, 2002).

Opara (2003) also mentioned genetically modified organisms (GMO) as one of the reasons of an increasing interest for traceability and he stated that there is a need to be able to identify GMO and non-GMO agricultural chains. All the concerns about the potential negative impacts on agriculture and the environment in relation to GMO will decline the confidence of consumers on food safety (Tielemans, 2004).
Another social driver has to do with long food supply chains as a result of globalisation (Aung & Chang, 2014). Food production, consumption and transportation have a huge impact on the use of energy, resources and the emission of Green House Gases (GHG). The distance that food travels is huge and will contribute to these negative impacts on the environment. Carbon labelling (i.e. carbon footprints of the products) and conception of food miles (the distance that food is transported as it travels from producer to consumer) are being part of food traceability due to environmental concerns of consumers.

Economic drivers
The economic driver has indirect also a relation with safety and quality concerns. The impact of safety hazards could be reduced by well-developed traceability systems and will have a positive effect on the overall cost-effective quality management system (Opara, 2003). Serious recalls have a negative effect on company profits according to numerous studies (Donnelly, Karlsen, & Dreyer, 2012). A good traceability system could reduce the economic impact of a recall. Navobi for example, a calf-milk replacer producer, who identified a salmonella problem in their production process recalled some of their products. When they discovered the problem, they used their traceability information system and were able to do a traceability analysis very quickly. Due to their traceability information system they were able to quickly pinpoint the origin of the problem with the consequence that the amount of recalled products was limited. The traceability information system saved them more than $100,000 of direct recall and recovery costs, as they calculated afterwards (Buhr, 2003). As another example, Coca Cola had a recall in 1998 and it costed Coca Cola $66 million to recall their products, without taking into account the indirect costs like reputation damage (Food Standards Agency, 2002). The biggest part of recall costs will not be the logistic costs to get a product returned, but the costs of decreasing revenue caused by reputation damage (Tielemans, 2004; Bosona & Gebresenbet, 2013). This reputation damage can affect the brand itself or even the whole industry (Food Standards Agency, 2002). Therefore, Tielemans (2004) argued the need for a fast recall procedure and explained that it can help when a product still has to be delivered to a supermarket in which there is still an opportunity to prevent reputation damage. In case products are already in the supermarket or if they are already bought by consumers, producers will give full attention when recalling their products and will show consumers that they work very secure in case of a food incident. But producers are also being aware of recalling too many products, which may indicate that producers have made huge mistakes (Tielemans, 2004). Therefore the number of recalling products is nowadays more based from a perspective of marketing than a recall size which is based on technical calculations (Tielemans, 2004; Vorst, van der, 2004).
But food traceability is much more than a mechanism to assure food safety. It can also be a source to achieve competitive advantages. HAK, a Dutch seller of preserved vegetables and fruits has already provided consumers with traceability information. Every vegetable or fruit jar had a unique code which could be checked on the company website. That website provided consumers with information about date of harvest, origin and date of canning (Tielemans, 2004). Bosona and Gebresenbet (2013) refer to better market access, better product prices and potential government funding due to traceability. In

the fish industry for example, consumers are poorly informed about the fish they eat (for example if it is wild or farmed). And particularly product and process information can be a tool for increasing market access and increasing market share (Donnelly & Olsen, 2012). Buhr (2003) stated that consumers in the U.S. are willing to pay for traceability and transparency of meat products according to a study from Dickinson and Bailey (2002).

Technological opportunities
Innovations in technology makes it easier to improve the speed and precision of recalling food products (Donnelly, Karlsen, & Dreyer, 2012). Increased processor speeds, increased data-storage capacity, electronic data capturing and measurement devices have contributed to these innovations. The improvements in information technology and information systems have made it economically feasible to develop logistics management and monitoring which enable traceability of food products through the food supply chain (Buhr, 2003). The need of improving technology can even be more specified (Opara, 2003). If a food traceability chain will work, then technology should be improved in six ways: product identification technology, quality and safety measurement technology, genetic analysis technology, environment monitoring technology, development in geospatial science and technology and software technology for traceability system integration.

The table below shows all different concerns, drivers and opportunities which are described above - based on the table of concerns from Bosona and Gebrensenbet (2013).

Table 3: Table of concerns, drivers and opportunities why food traceability is becoming more important

Major concern, driver or opportunity	Explanation	Sources
Safety and quality concerns	- Food safety crisis	(Hobbs, 2006), (Tielemans, 2004), (Bosona & Gebresenbet, 2013), (Donnelly, Karlsen, & Dreyer, 2012), (Karlsen, Dreyer, Olsen, & Elvevoll, 2013), (Foras, Thakur, Solem, & Svarva, 2015), (Food Standards Agency, 2002), (Aung & Chang, 2014), (Hobbs, 2006), (Vorst, van der, 2004)
	- Specialised quality products	(Buhr, 2003)
Regulatory drivers	- Regulations to prevent food safety issues	(Hobbs, 2006), (EC, 2000), (EC, 2002), (Vorst, van der, 2004), (Tielemans, 2004)
Social drivers	- The need to know the origin of the products and how it is produced	(Hobbs, 2006), (Food Standards Agency, 2002)
	- The need for typical information because of allergenicity, food intolerance or lifestyle choice	(Food Standards Agency, 2002)
	- The need to identify genetically modified organisms (GMO) and non-GMO agricultural chains (to address the concern of consumers)	(Opara, 2003), (Tielemans, 2004),
	- The need to identify carbon labelling and the conception of food miles in because of the impact on the environment	(Aung & Chang, 2014)

Major concern, driver or opportunity	Explanation	Sources
Economic drivers	- Effective recall management	(Opara, 2003), (Donnelly, Karlsen, & Dreyer, 2012), (Tielemans, 2004) (Buhr, 2003), (Bosona & Gebresenbet, 2013), (Food Standards Agency, 2002)
	- Achieving competitive advantages	(Bosona & Gebresenbet, 2013), (Donnelly & Olsen, 2012), (Buhr, 2003), (Tielemans, 2004)
Technological opportunities	- Advancement in technology (encouraging traceability)	(Donnelly, Karlsen, & Dreyer, 2012), (Buhr, 2003), (Opara, 2003)

As can be seen in all the explanations of different concerns, drivers and opportunities, they are also related to each other. For example, the use of a certification traceability scheme (regulatory driver) could also give access to the market (economic driver). Or in another example where animal health documentation (safety and quality concern) can help to achieve competitive advantages (economic driver) (Karlsen, Dreyer, Olsen, & Elvevoll, 2013).

1.1.3 Traceability strategies

How far traceability is adopted into an organisation or supply chain depends on the drivers and motivation of each organisation to work on a traceable supply chain. Van der Vorst (2004) did a benchmark study and found three different strategies in adopting food traceability:

Compliance-oriented strategy
If a company adopts traceability according to the compliance-oriented strategy they comply with the rules and regulations of food traceability. They will focus on the registration of incoming and outgoing materials. In this case each organisation operates individually since organisations should individually comply with the rules and legislation. Therefore the supply chain is in most cases fragmented (Vorst, van der, 2004). Specific general legal requirements for the establishment of a traceability system do not exist but there is some limited traceability required under a number of separate measures (Food Standards Agency, 2002).
It is the responsibility of the organisations itself to meet the minimal level of food traceability. This minimal level of food traceability depends on the rules and legislation developed by national and international government. It is the organisation’s decisions if this minimal level of food traceability in which they comply with the rules and legislation meets their strategy or that food traceability is also used for other purposes.

Process improvement-oriented strategy
With a process improvement-orientated strategy a company complies with the rules and legislation but also uses traceability to achieve a better return. Production integrated measures are used to control traceability of products within the own link. Local ICT-systems could be an example of an integrated measure to register all processed data (Vorst, van der, 2004; Tielemans, 2004; Food Standards Agency, 2002). Bosona and Gebresenbet (2013) appointed IT-supported food traceability systems in order to improve operational planning and increase efficiency of food logistic processes.

The optimisation of production planning and scheduling can help to minimise waste and ensures optimal use of raw materials (Karlsen, Dreyer, Olsen, & Elvevoll, 2013). Buhr (2003) described in his research about traceability and information technology in the meat supply chain, that participants observed better information capabilities of production and control, due to the implementation of a traceability system. The Food Standards Agency (2002) mentioned an increased efficiency in enterprise resource planning (ERP), a better integration of electronic data interchange and more efficient consumer response systems as a consequence of a traceability system.

Market-oriented (branding) strategy

Where the process improvement-oriented strategy focuses on the internal processes, this type of strategy aims to establish a full traceable supply chain where individual links will intensively work together to open new markets. Working following this strategy will change the production into more and better separated lots, it standardises the information carriers, it adjusts the planning and control of production processes, and so on. This strategy creates added value in the market to achieve competitive advantage (Vorst, van der, 2004; Karlsen, Dreyer, Olsen, & Elvevoll, 2013). Bosona and Gebresenbet (2013) explained why food traceability can achieve competitive advantages. Because it provides a good-faith legal defence in product liability cases, and it provides promotional advantages by connecting the manufacturer with consumers. In the previous section in which the economic drivers were explained, already some examples were given how organisations using traceability for marketing purposes, for instance like the aforementioned example of the Dutch seller of preserved vegetables and fruits HAK.

Organisations should at least comply with the rules and legislation regarding food traceability. Therefore a compliance-oriented strategy will be the minimal strategy an organisation can pick. Except the rules and legislation, traceability could also be used for other purposes. Traceability could be used to improve processes (process improvement-oriented strategy) or traceability could be used for marketing purposes (market-oriented branding strategy). It can be assumed that in practise organisations do not always pick only one strategy. In other words, combinations are possible in which several strategies are chosen - for example an organisation choose to pick the minimal strategy and wants to use traceability to improve processes as well as using traceability for branding purposes. But there is also a combination possible in which for example the minimal strategy is picked and an organisation only wants to use traceability for marketing purposes without the aim of improving processes.

1.1.4 Level of traceability

The strategy chosen by a company will determine 'the level of traceability' (Tielemans, 2004), 'traceability performance' (Vorst, van der, 2004) or the 'performance of a traceability system' (Bosona & Gebresenbet, 2013). All authors which are mentioned here use different definitions and all of them use different values to express the level of traceability as can be seen from Table 4.

These three comparable definitions do have some similarities. All three definitions have factors of time, precision and reliability in common: the time needed to do a traceability analysis, the precision or amount of a traceable resource unit and the reliability of the traceability analysis. The only difference that can be observed here is that Tielemans and Bosona and Gebrensebet also refer to the number of links upstream or downstream in a supply chain when doing a traceability analysis. They suggest a relation between the traceability performance and the length of a supply chain. Donnelly et al. (2012) investigated the relationship between supply chain length and effective recall performance. (They tested the relation between supply chain length and effective recall performance based on known origins). They found no evidence that a shorter supply chain leads to a more effective recall. The fish sector for example, which has the highest number of links (varying from 7-9), is characterised by a relatively high percentage of known origins (37%). Contrary, for unprocessed fruit and vegetable (3-4 links) they found a lower percentage (50%) of known origins.

Table 4: Different definitions to express the level of traceability.

Level of traceability (Tielemans, 2004)	Traceability performance (Vorst, van der, 2004)	Performance of traceability system (Bosona & Gebresenbet, 2013)
- Time consuming to do a traceability analysis; - How detailed a product can be found back; - Reliability of information found from a traceability analysis.	- The number of links in the supply chain that can be traced back- and forward; - The time needed for tracing the products; - The tracing unit that defines the level at which the traced object is uniquely identified (e.g. for meat it can be a specific farmer, delivery or an animal); - The reliability of the tracing.	- The amount of information the traceability system records; - How far upstream or downstream in supply chain the system traces and tracks; - The degree of assurance with which the system can pinpoint a particular product's movement or characteristics; - The speed with which tracking and tracing information can be communicated to supply chain members and the speed with which the requested information can be disseminated to public health officials during food-related emergencies.

Taking into account this last remark that no relation between the supply chain length and traceability performance exists, and combining all factors of the authors which are mentioned above, it is possible to come up with one definition. The definition 'level of traceability' will be used in this report and can be expressed in: the time needed for tracing products; the tracing unit that defines the level at which the traced object is uniquely identified and the reliability of the traceability analysis.

1.2 Conceptual model

Van de Vorst (2004) developed a conceptual model (Figure 1) to evaluate chain strategies. In his conceptual model he starts with chain traceability strategy which is derived from internal drivers and external drivers. Thereafter, chain traceability strategy determines how the chain is designed. In his model the chain design consists of chain infrastructure, chain control, chain information and chain organisation. Finally the way the chain is designed determines the level of food traceability (van de Vorst calls this 'traceability performance level').

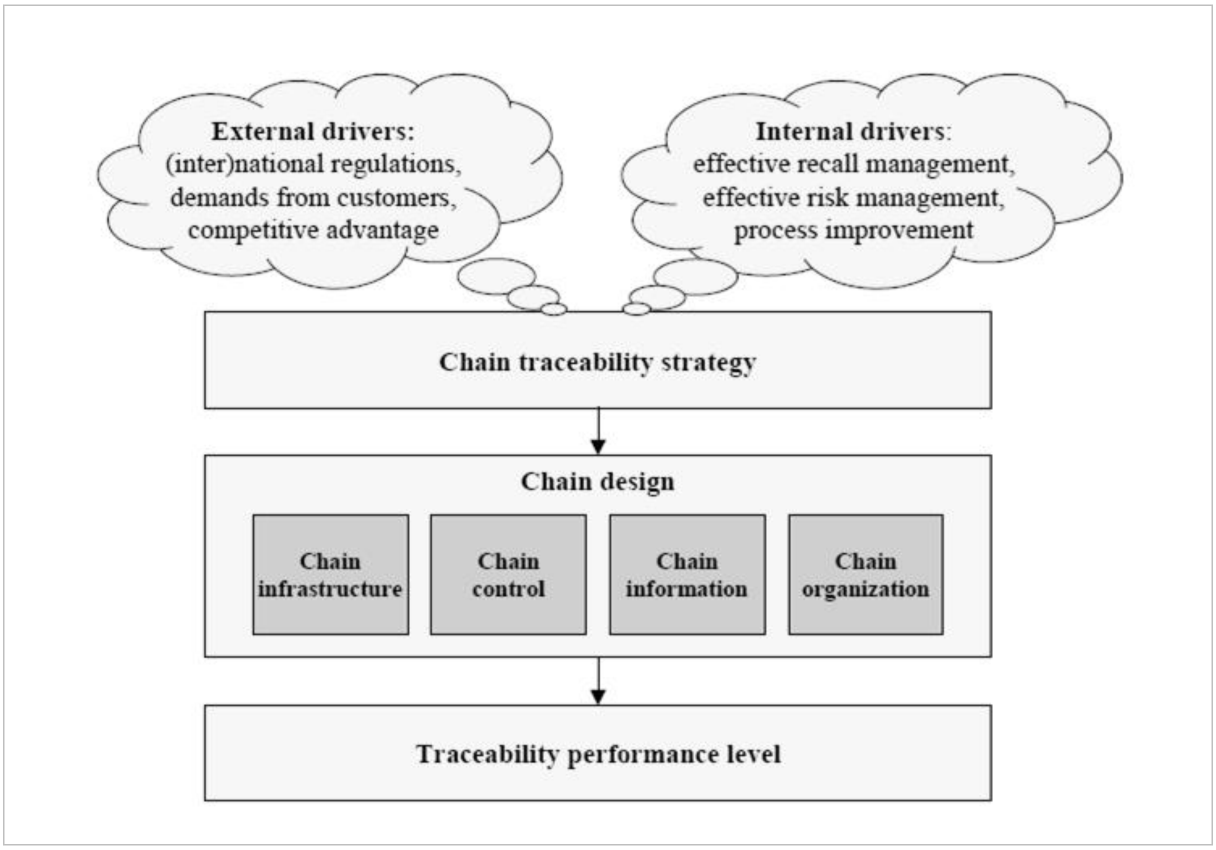

Figure 1: Conceptual model of van de Vorst (2004)

The conceptual model that is used for this research has some similarities with the conceptual model of van de Vorst (2004), but is build up from another approach (Figure 2). Also this model starts with different traceability strategies which in this model are derived from three drivers (regulatory drivers, social drivers, economic drivers). Van der Vorst assumed that traceability strategy affects the chain design. In this conceptual model it is assumed that traceability strategy first affects the 'level of food traceability'. When an organisation picked a certain traceability strategy they also have to define its level of food traceability. In other words they have to define the maximum time needed for tracing batches, the tracing unit that defines the level at which the traced object is uniquely identified and the reliability of the traceability analysis. Based on these decisions an organisation will develop its logistic and organisational structure. That logistic and organisational structure consists of four factors: physical infrastructure, organisational processes and control, data capturing and information exchange and supply chain organisation which will be explained more extensively in the theoretical background chapter.

Except the chosen strategy of traceability that is derived from three drivers, the way the logistic and organisational structure has been developed also depends on; the nature of a product itself, on farm practises or other agri-food chain operations, customer specifications, and requirements from law (Food Standards Agency, 2002).

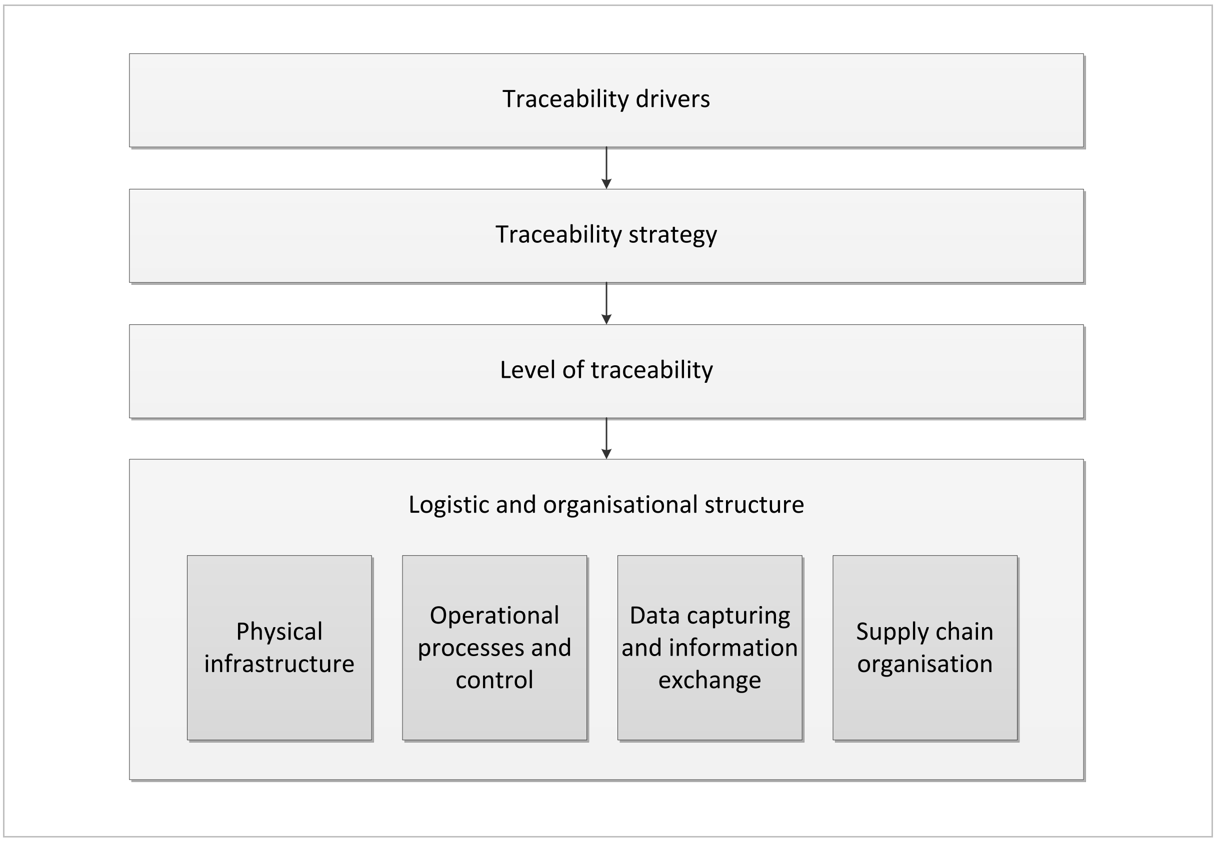

Figure 2: Conceptual model applied to this research

1.3 Research objective

As stated before, two potato companies, from the Netherlands and Germany, mentioned that traceability is becoming more important in the potato sector and it could be assumed that a scenario arises whereas the current Dutch potato supply chain will become more traceable. In that scenario organisations and the supply chain desire a higher level of traceability and therefore they may have to change their logistic and organisational structure.

It could be assumed that a higher level of traceability is at the expense of some other desirable outcomes. Organisations are confronted with trade-offs. A trade-off is understood as: *"a technique of reducing or forgoing one or more desirable outcomes in exchange for increasing or obtaining other desirable outcomes in order to maximize the total return of effectiveness under given circumstances"* (BusinessDictionary, n.d.). For example, an organisation wants to increase their level of traceability. Therefore the organisation may change their logistic and organisational structure. As a consequence, a production process may become less efficient or perhaps the quality of finished products may decrease. How the current logistic and organisational structure may change to obtain a higher level of traceability and what kind of trade-offs organisations are confronted with will be investigated in this research. Research will show the trade-offs when going from the current situation to a traceability scenario - a scenario in which a higher level of traceability is chosen and therefore the current logistic and organisational structure has changed as well. Scenarios are explained as: *"a coherent, internally consistent and plausible description of a possible future state of the world. It is not a forecast; each scenario is one alternative image of how the future can unfold"* (Mohmoud, Liu, & Hartmann, 2009).

1.3.1 Research objective statement

The research objective is to obtain insight in traceability scenarios in terms of logistic and organisational factors in which a higher level of traceability is desired, by using a combination of a literature review to obtain insight in these logistic and organisational factors, and empirical research (1) to see how the logistic and organisational factors change for the Dutch potato sector and (2) to formulate the trade-offs that organisations have to make, when going from the current situation to a traceability scenario in which a higher level of traceability is desired?

1.3.2 Research object

The research object is the supply chain of the Dutch potato sector. Looking at the potato sector, the Netherlands is part of the EU-5 zone, comprising also the UK, Belgium, Germany and Northern France (Commission of the European Communities, 2007). This EU-5 zone is being considered as the most efficient and integrated area in the EU's potato business. This study will concentrate on the EU-5 zone with a focus on the Netherlands. At national level potatoes play a very important role for the Netherlands, Belgium and the UK. The Netherlands even has the highest share (8.1%) of potato area within all usable agricultural area compared to the rest of Europe and is being considered as the biggest processor of potatoes within Europe as well (Commission of the European Communities, 2007). There will be a growing interest in food traceability from consumers, NGOs and other organisations (Storoy, Thakur, & Olsen, 2013). This changing market demand will be an interesting development for such an important sector in the Netherlands. It will even be more interesting because the Netherlands (and the UK) are being considered as general trendsetters regarding chain management and traceability. *"The Netherlands has some word-class examples that comprise complete supply chains from feed suppliers to farmers all the way to retailers"* (Vorst, van der, 2004). Appendix I describes which different parties are involved in the supply chain of the Dutch potato sector and how they interact with each other.

1.4 Research framework

The research framework shows all steps that have been taken during (a) literature review, (b) empirical research and (c) the analysis phase to achieve the research objective (Figure 3).

As a result of (a) literature review a theoretical framework was set up which describes the four main factors affecting the level of food traceability - also understood as the logistic and organisational structure. As been stated in the research objective statement this study will make understand how the logistic and organisational structure may change for the supply chain of the Dutch potato sector in order to obtain a higher level of traceability. Therefore (b) empirical research has been conducted in order to test which factors do change for organisations in the supply chain of the Dutch potato sector. Interviews were held with a farmer, a cooperative, an intermediate trader, processors and retailers. In addition empirical research also investigated the trade-offs to obtain a higher level of food traceability. Experts who do have a broad overview of the whole Dutch potato supply chain can also indicate these changing factors and the trade-offs when going form the current situation to a traceability scenario in which a higher level of traceability is desired. In the next step the data has been (c) analysed to formulate different traceability scenarios in terms of changed logistic and organisational factors including the trade-offs that belong to these changing factors. The research framework can be found in Figure 3 on the next page.

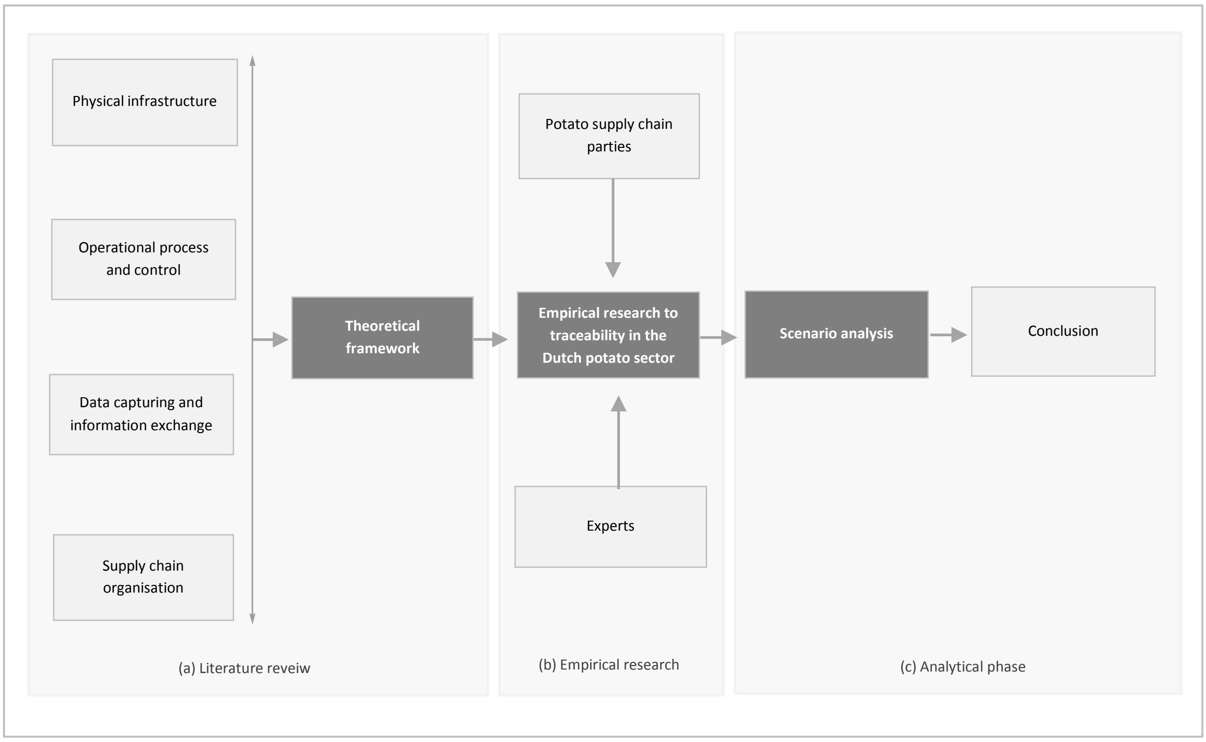

Figure 3: Research framework for the research about 'Traceability in the supply chain of the Dutch potato sector'

1.5 Research strategy

This section covers the central research question, the related sub-questions and the research strategy to achieve the research objective.

The central research question is:
What scenarios with regard to traceability may be adopted in the supply chain of the Dutch potato sector and what will be the trade-offs when going from the current situation to a traceability scenario in which a higher level of traceability is desired?

Where Verschuren and Doorewaard (2010) distinguished different research strategies, two strategies are applied for this study, namely desk research and a case study.

Desk research
This study started with desk research. For this part a lot of existing material has been studied and the desk research strategy can be typified as a literature review (Verschuren & Doorewaard, 2010). Research question 1 and 2 are answered by doing desk research. These questions help to understand food traceability in general:

1. *What are drivers for a traceable food supply chain?*
2. *What logistic and organisational factors affect food traceability?*

Case study
After desk research about food traceability with a broad orientation, the case study focused on food traceability in the supply chain of the Dutch potato sector. Through qualitative research, by conducting

interviews, a profound insight was gained to formulate the changing logistic and organisational factors and the trade-offs. The case study is used to answer research question 3 and 4:

3. *How will logistic and organisational factors change in the supply chain of the Dutch potato sector when going from the current situation to a traceability scenario with a higher level of traceability?*
4. *What are the trade-offs that organisations in the supply chain of the Dutch potato sector have to make when going from the current situation to a traceability scenario with a higher level of traceability?*

1.6 Definitions of concepts

In order to gain understanding of how terms and concepts are used during this research project, this section provides definitions of the fundamental terms and concepts.

Food sector = includes a broad range of actors, from farmers to retailers and consumers (Zukauskaite & Moodysson, 2015).

Food traceability = part of logistics management that captures, stores and transmits adequate information about a food, feed, food-producing animal or substance at all stages in the food supply chain so the product can be checked for safety and quality control, traced upward, and tracked downward at any time required (Bosona & Gebresenbet, 2013).

Food (supply) chain = the total supply process from agricultural production, harvest/slaughter, through primary production and/or manufacturing, to storage and distribution to retail sale or use in catering and consumer practise (Stringer & Hall, 2007)

Potato sector = is investigated in this paper and the focus will be on the Dutch potato sector. It is assumed that the same definition holds for food sector, but applied to potato products. Four categories for potatoes are defined: early potatoes, main crop potatoes, seed potatoes and starch potatoes (Commission of the European Communities, 2007). For this research starch potatoes are excluded because this product is sold on the starch market and is not suitable for direct consumption.

Scenario = a coherent, internally consistent and plausible description of a possible future state of the world. It is not a forecast; rather, each scenario is one alternative image of how the future can unfold (Mohmoud, Liu, & Hartmann, 2009).

Supply chain = a network of (physical and decision making) activities connected by material, information and money flows that cross organisational boundaries (Chopra & Meindl, 2013).

Trade-off = a technique of reducing or forgoing one or more desirable outcomes in exchange for increasing or obtaining other desirable outcomes in order to maximize the total return or effectiveness under given circumstances (BusinessDictionary, n.d.).

2. Theoretical background

This research report will investigate the trade-offs that organisations have to make when going from the current situation to a traceability scenario in which a higher level of traceability is desired. In order to better understand food traceability this chapter is concerned with all logistic and organisational factors that have an influence on the 'level of food traceability'.

The introduction chapter showed different reasons why traceability is becoming more important in the food industry. It also mentioned three possible strategies to adopt traceability in an organisation. The decision on which traceability strategy to use determines the 'level of food traceability' (the time needed for tracing products; the tracing unit that defines the level at which the traced object is uniquely identified and the reliability of the traceability analysis). According to van de Vorst (2005) this decision has significant implications for the design of the supply chain (chain infrastructure, chain control, chain information and chain organisation). Also Bosona and Gebresenbet (2013) mentioned this, where they refer to the factors of: relationship between partners, capacity (human or technological) of managing transactions, quality and production processes, and packaging materials and methods. According to Tielemans (2004) there are four factors that affect the 'level of food traceability': organisational processes, physical structure, information technology systems and organisational aspects.

Table 5: Different factors that determine the 'level of food traceability'

Tielemans (2004)	Bosona and Gebresenbet (2013)	Van de Vorst (2004)
- Organisational processes (for example choosing to measure real usage of ingredients); - Physical structure (for example building an extra silo); - Information technology systems (for example the implementation of a systems to follow batches); - Organisational aspects (for example changing responsibilities)	- Capacity (human or technological) of managing transactions; - Quality and production processes; - Packaging materials and methods.	- Chain (physical) infrastructure; - Chain control (planning and control of processes); - Chain information (degree of chain transparency and the use of ICT); - Chain organisation.

These three lists above indicate the logistic and organisational factors of traceability. The three enumerations of factors do have some similarities. All three authors have in common that they refer to the physical infrastructure, where Bosono and Gebresenbet (2013) call this human or technological capacity. This technological capacity refers also to data capturing and information exchange what is also appointed by the other two authors (Tielemans, 2004; Vorst, van der, 2004). Next, all three indicate processes. Bosona and Gebresenbet specify packaging materials and methods as an additional process. Where the list of factors of van de Vorst focuses on the supply chain, the others are more focused on the internal organisation.

In order to come up with one list of factors for this research, these three lists above are combined into one list with four concrete formulated factors: *operational processes and control* (section 2.1); *physical infrastructure* (section 2.2); *data capturing and information exchange* (section 2.3) and *supply chain* *organisation* (section 2.4). In this report the logistic and organisational factors together are called the logistic and organisational structure of traceability.

2.1 Operational processes and control

Before going into the organisational processes and control of an organisation, key terms in supply chain management regarding traceability should be explained. Traceability can only work if there exist a traceable resource unit (TRU). *"Traceable resource unit is the name given to an entity that is traceable. TRUs are entities with similar characteristics that have gone through the same process"* (Karlsen, Dreyer, Olsen, & Elvevoll, 2013). Key components when talking about TRUs are defined as a batch, a trade unit (TU) and a logistic unit (LU). A batch is defined as *"a quantity that has gone through the same process at a specific place and time period before moving to another place. A production batch is the traceable resource unit that raw materials and ingredients go into before they are transformed into products placed in new trade units (TU) and logistic units (LU)"* (Karlsen, Dreyer, Olsen, & Elvevoll, 2013). Second, a trade unit (TU) is *"the smallest traceable unit that is exchanged between two parties in the supply chain"* (e.g. a box, a bottle or a pack of bottles) (Karlsen, Dreyer, Olsen, & Elvevoll, 2013). The last one is a logistic unit (LU) which can carry several TUs and it belongs to a *"grouping that a business creates before transportation or storage"* (e.g. pallet, container, etc.) (Aung & Chang, 2014). All three units can be a TRU, it depends on the choices of an organisation how they developed their logistic activities in order to define if a unit is fully traceable or not. An example of a typical material flow in one link of a supply chain is illustrated in Figure 4. The figure clarifies the differences in key terms of a batch, TU and LU.

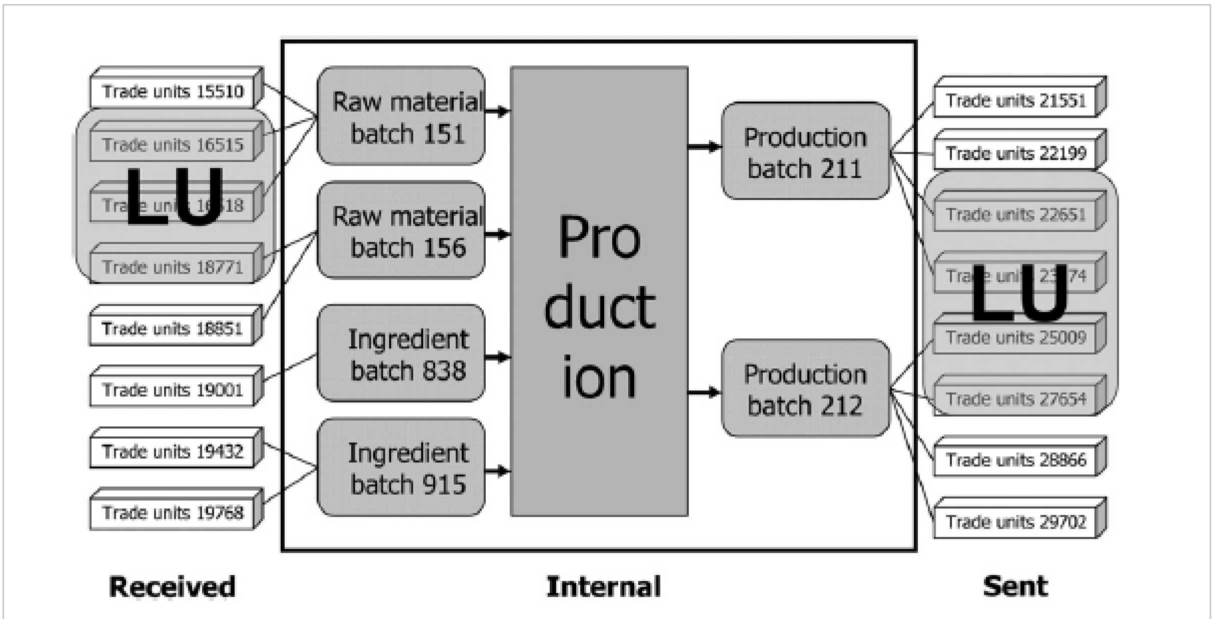

Figure 4: Relationship between batches, trade units (TU) and logistic units (LU) in one link of the supply chain. (Olsen & Aschan, 2010)

What the optimal TRU is depends on the characteristics of a product type. In the meat industry it is possible and obligatory for example in the case of cows to be able to trace every cow back to the origin. On the other hand, chickens are identified by a group of chickens who lived in the same hutch or are identical on the basis of the same family group. In agriculture most of the time a TRU is based on a crop cultivated on the same field (Tielemans, 2004).

Tielemans (2004) divided the design of a process in four aspects. He focuses on the primary processes of goods and starts with *incoming products*. During the whole process *storage* takes place of incoming products, semi-finished products and finished products. Incoming products are changed into finished products through *production*. When finished products are ready to leave the organisation, they are considered as *outgoing products*.

2.1.1 Incoming products

Moe (1998) defined traceability as: *"the ability to track a product batch and its history through the whole, or part, or a production chain from harvest through transport, storage, processing, distribution and sales or internally in one of the steps in the chain for example the production step"*. That definition emphasises the importance to identify the incoming products and to determine the right TRU. According to Pizutti and Mirabelli (2015) the identification of batches is necessary at least in two stages; at the beginning of each process and at the end. It depends on how the incoming raw material batch is received and how it will change during processes in order to define a typical batch as a TRU. In addition is also depends on the characteristic of the product type itself (Tielemans, 2004). As mentioned earlier, cows for example can be traced back individually while in agriculture for instance a TRU is based on a crop cultivated on the same field.

2.1.2 Storage

After raw material batches have entered the factory and batches are checked-in, batches should be stored. When products are flowing through an organisation, three different types of storage can be distinguished (Pizzuti & Mirabelli, 2015). The first one is 'input' storage. When products arrive at the factory, they have to wait before going into the production process. The second one is 'in-line' storage, when semi-finished products need to wait before they continue further processing. At the end of the production process when products are packaged and are prepared for delivering, the storage is called 'output' storage.

There exist different ways to store batches, and the chosen strategy determines the precision of traceability. Tielemans (2004) defined four strategies of storing batches by using the example of a silo:

- *One ingredient batch with cleaning*: choosing for this method, one batch is used per silo. If the ingredient batch is fully used and a silo is empty, the silo will be cleaned after. In this case ingredient batches can be fully separated.
- *One ingredient batch without cleaning*: also in this case an ingredient batch is fully used before the next ingredient batch will be added to the silo. Compared to the previous strategy the silo will not be cleaned between different batches – which will affect the reliability of the traceability analysis. For example, assume that an ingredient batch is contaminated but fully used in one silo, if that silo is not cleaned after, there is an opportunity that also the next ingredient batch will be contaminated by the previous one, due to not cleaning the silo between different batches.
- *More ingredient batches with fixed-time-periods*: in this case new ingredient batches are continuously added to the silo and it doesn't matter if the old ingredient batch has already

been fully used or not. Ingredient batches are mixed in this case. In order to prevent recalling enormous amounts of products in case of an incident, fixed-time-periods are used. After a specific time, the silo will be cleaned and a new period of adding ingredient batches will start. In case of an incident only batches from that fixed-time-period should be recalled, instead of recalling all ingredient batches.

- *More ingredient batches without cleaning*: also in this case ingredient batches are continuously added to a silo, whether the silo is empty or not. There will be no cleaning points between different batches and no fixed-time-periods exist. In case of an incident it cannot be say with certainty which finished products are contaminated. Only the concentration of elderly added contaminated ingredient batches will reduce but there is always a risk that later batches are contaminated by previous ones.

2.1.3 Production

The way how production is organised and set up could affect the level of traceability, especially with regard to processed food. The set-up of production processes and taking into account traceability is complicated and expensive (Pizzuti & Mirabelli, 2015).

Transformations

Transformations in the processed food industry make traceability complicated. *"Transformations are points within a company or between companies in the supply chain where resources are joined, transferred, added and/or split up or mixing zones"* (Donnelly, Karlsen, & Olsen, 2009). Donelly et al. defined four different transformations as can be seen in the table below.

Table 6: Different transformation, from Donnelly, Karlsen and Olsen (2009).

Type of transformations	Relationship	Synonymous expression used in other texts	Definition
Joining	Many to one	Joining, addition, merging, mixing, blending, pooling, aggregated, mincing and assembling.	Joining together of different units of a main resource.
Transfer	One to one	Transfer	Transferral of a resource without it is being split up or mixed.
Addition	Many to one	Addition, joining, merging, mixing and blending.	One main resource is being mixed with other resources in less quantities.
Splitting	One to many	Splitting, segregation, disaggregated and disassembling.	A resource is being split up into multiple units.

Buhr (2003) divides transformation into aggregation and dispersion and explained that aggregation and dispersion are critical points in production processes. In the food industry, raw material batches are sourced from different suppliers. The way how these raw material batches are combined together and how these mixing processes are recorded affect the recall size of a batch (Donnelly, Karlsen, & Olsen, 2009; Bosona & Gebresenbet, 2013). Mixing will cause information losses and is an inherent problem for traceability (Donnelly, Karlsen, & Dreyer, 2012). As stated before, mixing makes it difficult to give reliable information when talking about food traceability. Mixing of ingredients batches could take place in different phases. For example batches are mixed during storage. Sometimes with the aim to create a bigger batch with homogenous characteristics, or sometimes just because a silo is filled again with a new batch, and the new batch has been put together with the older one (Tielemans, 2004). It depends on the product itself which method is preferred. For example grain is delivered by farmers into silos whereas milk is more usually collected by milk tankers. Milk tankers will be regularly cleaned during natural 'stop' points, which is not the case for grain. These 'stop' points in the milk industry makes it possible to distinct one delivery from another one and therefore it is possible to register different milk collections (Donnelly, Karlsen, & Dreyer, 2012).

In another case, mixing could take place in the production phase. Different semi-finished products are combined together into one storage compartment for instance. Or during a continuously process where two different batches are put into the processing line at the same moment. If production batches are defined based on a pre-scribed time, and if it turned out that ingredient batch 2 was wrong, there is always a possibility that this contaminated ingredient batch also contaminated new batches, which were put into the line after. On the other hand, if it is known that only batch 2 is contaminated, then all previous batches do not have to be recalled. The only way to solve this problem is to stop a production process after a specific time and clean the production processing line. Only then no older ingredient batches could contaminate new ingredient batches. Mixing strategies will determine if there is an ability of direct traceability or indirect traceability (Tielemans, 2004).

Registration of production processes

Bosona and Gebresenbet (2013) mentioned that how precisely the mixing processes are administrated affects the size of a recall. There are different ways in how producers can administer the amount of added ingredient batches to a production run. Tielemans (2004) mentioned four different ways:

Four ways exist to administer the amount of added resources to a production run (Tielemans, 2004):

- *Registration of batches to production run based on real-usage*: for this method it is exactly known how much of each ingredient batch is used for a typical production run. Therefore precise measurement devices are needed and the operating costs to administer precisely the amount of ingredient batches to a production run will be high.
- *Registration of batches to production run based on time-calculation*: this method is used when there exist mixing processes and it cannot be checked with certainty if a typical ingredient batch is fully used or not. The registration of batches added to a production run is based on time calculation, not on real-usage.
- *Registration based on back flushing/normative usage*: when this method of registration is used, the registered amount of added resources to a batch is based on a pre-scribed recipes. This method will not measure the real-usage and therefore it will have an effect on the reliability of the traceability analysis.
- *Registration based on stock usage*: when using this method the incoming ingredient batches that are received at the factory are directly checked-in in a database, no other relevant information will be captured. Only the check-in time when the received ingredient batch is put on stock is registered.

2.1.4 Outgoing products

When products are stored, processed and ready to go to the next supply chain part, the finished products are stored in warehouses before they are picked and transported to the next supply chain part.

Warehouse management
The place where goods are buffered and stored is called a warehouse (Shiau & Lee, 2010). Large companies use central distribution centres to store their finished products (Tielemans, 2004). These warehouses are focused on logistic processes instead of quality management. The factory considers a production run as a homogeneous batch with the same characteristics and therefore that production run will be considered as a TRU. Finished products of the production run will be put on pallets, and are sent to warehouses. But these warehouses consider each individual pallet as a TRU. The administration of pallets and the administration of production run batches that is kept on pallets should be better connected (Tielemans, 2004).

Order picking
According to Shiau and Lee (2010), *"order picking involves the process of clustering and scheduling the customer orders, assigning stock on locations to order lines, releasing orders to the floor, picking the items from storage locations and the disposal of the picked items".* This part of the internal process is a last step in delivering a product to the next part. It will also be the last step in a system of a single company for tracking and tracing (Tielemans, 2004). Also here it is important to distinguish a production run batch from a LU. More pallets could carry one production run, but one pallet could also keep several production runs. The registration and administration and the distinction between a production run and a pallet should be made very precisely which entails a lot of time. When full traceability is desired in which a traceability analysis should also be about delivered products to supermarkets (based on batch level), a precise administration to distinct pallets from production batches should be made as well. In practise the registration of delivered pallets to a shop is not based on production batches (Tielemans, 2004).

The registration of delivered products to shops is done by human factors which therefore also give some room for errors. Only if registration of delivered products is set up by automatic technical systems, such as radio frequency identification (RFID) systems, organisations can fully trust on their administration in which production run batches are delivered to supermarkets (Tielemans, 2004).

2.1.5 Concluding remarks to traceability

This section about operational processes and control is divided in four different parts as described above. Whether it is about incoming products, storage, production or outgoing products - combining different raw material batches in all phases do have an influence on the level of traceability. Different strategies of storing and different strategies of process administration have been discussed. The combination of chosen strategies determines the recall size at the end. Whether a strategy is chosen to wait to fill a silo before the previous batch is fully used, or to choose for a strategy of continuous filling makes a real difference in traceability. The decision to choose for a certain strategy could also determines the needed capacity of the current physical infrastructure, which is described in the next section.

2.2 Physical infrastructure

The physical infrastructure is one of the factors that determines the 'level of traceability' (Tielemans, 2004). Tielemans defines the organisational infrastructure as 'physical structure' where van de Vorst (2004) refers to a broader '(physical) chain infrastructure'. Infrastructure is defined as: *"relatively permanent and foundational capital investment of a country, firm, or project that underlies and makes possible all its economic activities. It includes administrative, telecommunications, transportations, utilities, and waste removal and processing activities"* (BusinessDictionary, 2016). Tielemans (2004) illustrated in Figure 5 a general view of a flow of goods in a food processing organisation. Looking to this flow of goods different forms of physical infrastructure can be distinguished. One is transportation, which is needed for the transportation flow of incoming raw materials, internal transportation, and transportation of finished products to the next supply chain part. All white blocks illustrate processes of incoming products, production processes, packaging processes and delivering processes. The triangles illustrate moments of storing raw materials, semi-finished products and finished products. Overall the physical infrastructure can be divided in *storage*, *production processing lines* and *transport*.

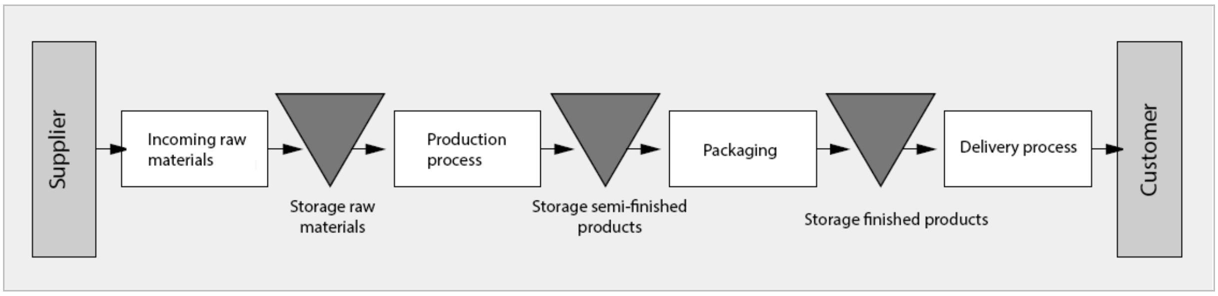

Figure 5: An illustration of a flow of goods in a food processing organisation (Tielemans, 2004)

2.2.1 Storage

In the food industry many ingredients to process food are liquids (vegetable oil, milk, etc.), crystals (e.g. sugar, salt), powders (cacao, powdered milk, flour, yeast, etc.) or grains (Comba, Belforte, Dabbene, & Gay, 2013). In many cases these ingredients are stored in huge silos or tanks, which are almost never completely emptied and therefore several batches are contemporary kept in the same container. *"Whenever the stored material is drawn from a container to be delivered to a production station or to a new storage container, the retrieved material results in a combination of material from the different batches that have been previously fed into the container"* (Comba, Belforte, Dabbene, & Gay, 2013). Especially this decision of storage influences the level of traceability when the amount and location of a possible contaminated batch should be identified in case of an incident.

A good example of a traceability decision regarding the physical infrastructure can be found in the case of Vrumona (Tielemans, Josten, Bakhuizen, & Erents, 2004). In the old situation Vrumona used one silo for several production runs in order to make syrup. When an ingredient batch was not fully used, they still ran another production run with the residual ingredient batch. Although incidents almost never took place, Vrumona decided to build an extra silo. From that moment they were better able to separate batches during production runs and to decrease the recall size in case of an incident.

As Moe (1998) defined in his traceability definition, also information about storage is important. Except for the purpose of traceability, the information of time that a food product is kept on storage is an important tool to guarantee quality features of a food product, and is sometimes also mandatory to record (Pizzuti & Mirabelli, 2015). But also other information such as temperature and the structure in which products are located are examples of relevant information due to the perish ability characteristic of food. Food safety breakdowns (Stringer & Hall, 2007) that can take place are: *inadequate instructions for preparation or use*, *failure to follow preparation instructions* or *inappropriate storage conditions*. Examples of inappropriate storage conditions could be for example cross contamination or microbiological spoilage. These effects may cause through a lack of instruction, poor training, lack of facilities or poorly maintained facilities (Stringer & Hall, 2007).

2.2.2 Production processing lines

Production processes can take place in two different forms. One is a process in which different ingredient batches or semi-finished products are mixed or combined together. The other one is called physico-chemical or microbiological processes, in which heating, cooling, concentration and pasteurisation take place (Comba, Belforte, Dabbene, & Gay, 2013).
Also during production processes it is important to monitor parameters in order to indicate breakdowns. According to Stringer and Hall (2007) several food safety breakdowns can be indicated in the phase of food processing: "*inadequate heating, inadequate cooling, ineffective chemical treatment, inadequate washing or cleaning of raw material, ineffective segregation, cross-contamination from materials and other processing defects"* (Stringer & Hall, 2007). These types of breakdowns emphasize the need to monitor and record heat, cooling and chemical treatments (Stringer & Hall, 2007).

2.2.3 Transport

Where traceability is about identifying TRUs, Senneset et al. (2010) stated that the level of traceability should be on the level of a returnable transport item (RTI). RTI is explained as: *"all the means of assembling goods for transport, storage, handling and product protection in the supply chain which are returned for further usage, including, for example, returnable pallets as well as forms of reusable crates, totes, trays, boxes, roll pallets, roll cages, barrels, trolleys, pallet collars, racks, lids and refillable liquid or gas containers"* (Johansson & Hellstrom, 2007). According to the EC Regulation 1935/2004: *"traceability shall be ensured for materials and articles intended to come into contact with food"*. That means that carriers of unpacked food itself and thus also RTIs should be traceable as well.
All the food safety breakdowns that are mentioned before could also take place during transport (Stringer & Hall, 2007). Therefore it is important to monitor and record conditions that can affect food safety during transport.

2.2.4 Concluding remarks to traceability

The physical infrastructure does have an influence on the level of food traceability. The design of the physical infrastructure when batches are received, processed and stored is most of the time based on efficiency instead of separating batches. During storage and processing, batches are continuously mixed (Tielemans, 2004). Separating batches will help to minimise the total amount of a recall (Comba, Belforte, Dabbene, & Gay, 2013). The only way to better separate batches is to enlarge the physical infrastructure with more logistic units (for example building an extra silo in the case of Vrumona) or setting up more production lines (Tielemans, 2004; Comba, Belforte, Dabbene, & Gay, 2013)

2.3 Data capturing and information exchange

Once data is captured, information should be shared and exchanged internal as well as external. *"Information sharing refers to a firm, sharing critical and proprietary information to the supply chain partners*" (Chen, Wang, & Yen, 2014). Information sharing is even attributed to the most critical factor of a successful supply chain alliance. Information about food products can be about the product (type and amount) itself or the process (type and duration) a product went through it, as can be seen in Figure 6 (Food Standards Agency, 2002).

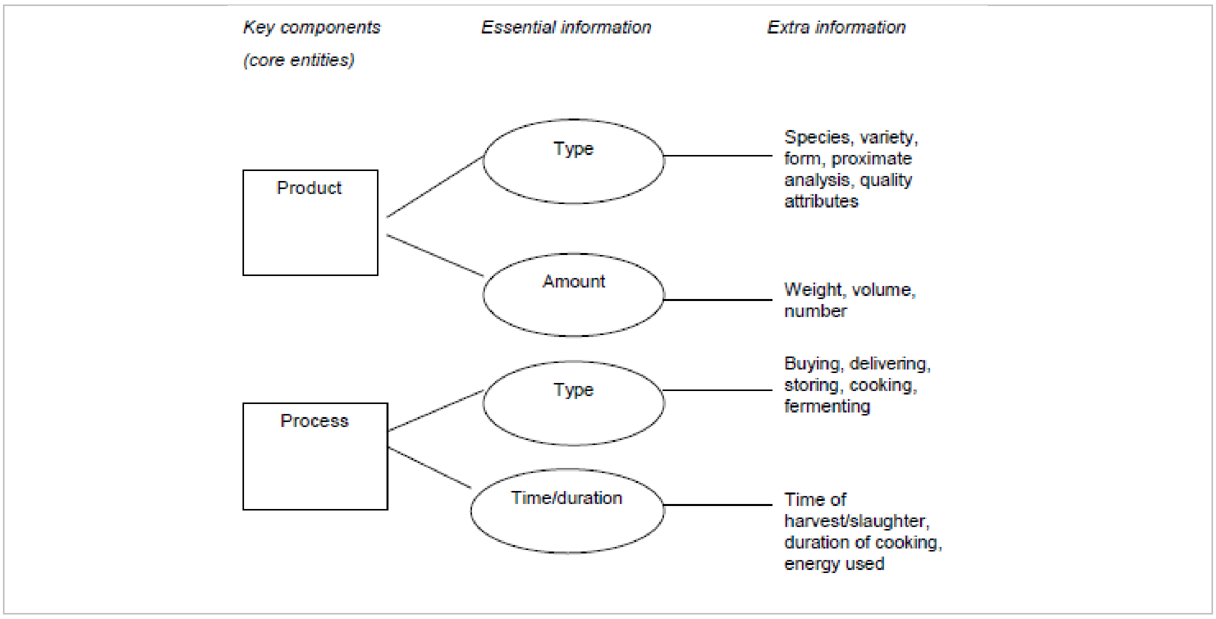

Figure 6: A division made in relevant information for food products (Food Standards Agency, 2002)

According to Tielemans (2004) data capturing and information exchange can be divided into three dimensions. First there should be an *identification* to be able to follow typical batches. Second *registration and administration,* to give insight in the history of a typical batch or to administer the right information. And third, the importance of *communication* between supply chain parties.

2.3.1 Identification

When information is exchanged there should be a medium to identify the information of product and process characteristics for each batch. Product identification is fundamental in a traceability system (Foras, Thakur, Solem, & Svarva, 2015). The identification takes place with automatic identification and data capturing (AIDC) technologies (Food Standards Agency, 2002). Different AIDC systems do exist, where the most simple ones are optical systems. Other possibilities are the use of Radio Frequency Identification (RFID) systems and feature identifications systems (Food Standards Agency, 2002). These more complex systems enable food retailers more efficient management of inventories, improving customer service level and increasing on-shelf availability compared to the use of barcodes (Hobbs, 2006).

Optical systems

One example of an optical system is bar-coding (Food Standards Agency, 2002). When using bar-coding, a physical code is placed on a batch, a logistic-unit or a product. A scanner will read the barcode and can translate this barcode into relevant information. In the past, most of the time the barcode type EAN-13 was used, with the capacity to store a batch number and article number. But to store more information, for example the expiration date, a batch number, the serial number and transport unit, EU-13 was not sufficient anymore. Therefore a new standard was developed, which is called EAN-128. An even more extensive version is the use of portable data files (PDF) which also belongs to a barcode, but can even store more information. To identify the information from a barcode, there should always be a physical scanning moment in which human intervention is needed (Tielemans, 2004).

Radio Frequency Identification (RFID) systems

The advantage of RFID systems compared to the use of optical systems is that there is no visual contact moment needed to identify information (Tielemans, 2004; Kumari, Narsaiah, Grewal, & Anurag, 2015), and it doesn't need human intervention which can give room for errors and efficiency losses (Bosona & Gebresenbet, 2013). RFID can be explained as: *"a tag that consists of an integrated circuit (that stores the unique identification number), an antenna (to which a microchip is attached) and a memory, and it interacts with a reader that is connected to a computer system. The radio waves reflected back from the RFID tag is converted by the reader into digital information that will be added to the information system of the company"* (Bosona & Gebresenbet, 2013). Another benefit compared to the use of barcodes is the amount of information that can be stored on RFID tags (Tielemans, 2004; Kumari, Narsaiah, Grewal, & Anurag, 2015). With different kind of sensors that could be embedded in RFIF tags, a lot of parameters can be collected, like temperature, pH, gas concentrations, presence of light and shocks or vibrations. At the moment there is even a biosensor tag under development which should be able to detect bacterial contamination (Kumari, Narsaiah, Grewal, & Anurag, 2015). Grunow and Piramuthu (2013) distinguished two kind of benefits when implementing RFID tags: food safety benefits and food supply chain benefits. Benefits related to food safety are real-time visibility for tracking and tracing of perishables, reduced opportunity for spoilage, swift identification and isolation of contaminated items. Example of food supply chain benefits could be customer loyalty due to improved quality or reduced shrinkage. Due to the high cost of RFID tags (compared to barcodes) and the thin margins in the food industry, RFID is primarily used at pallet level in retail applications (Grunow & Piramuthu, 2013). In various industries the costs of RFID technology are an important restrictive factor. Cheaper antenna material with the same performance should make RFID more attractive to use, and at the moment there a lot of developments which should make RFID cheaper in the future (Kumari, Narsaiah, Grewal, & Anurag, 2015).

However, some examples in which RFID technology is used for the purpose of traceability of fresh produce and food products exist. One of these examples is the use of RFID technology in a vegetable supply chain. Cultivation information (harvesting date, harvest sequence number, land code number) is kept on RFID cards. These cards belong to a unique batch and consumers are able to request relevant information from that batch through a web platform. Other examples of RFID technology used for food products can be found in the supply chain of fruits, cheese, chicken, pork products and halal food products in which some of them do have a central database through the whole supply chain (Kumari, Narsaiah, Grewal, & Anurag, 2015). Except the cost challenge, other challenges for the use of RFID technology are security and privacy. There are concerns about counterfeit, unauthorised access to tag memory, unwanted customer tracking and industrial espionage (Kumari, Narsaiah, Grewal, & Anurag, 2015).

Comparable to RFID - to measure parameters - is SenseAware, a device developed by FedEx. FedEx introduced a device which incorporates cellular and GPS radio, a thermometer, a light sensor and a accelerometer. It can provide real-time information about location, temperature, humidity, exposure to light and barometric pressure (Grunow & Piramuthu, 2013).

Feature identification systems

"Feature identification relies on collecting intrinsic data about an item from its natural features or properties, which can be used to provide a unique (or near unique) form of identification" (Food Standards Agency, 2002). Examples of feature identification systems could be vascular pattern determination or iris scans for instance. The use of DNA is another example of a feature identification system (Food Standards Agency, 2002). Identification with the use of DNA is adopted in some cases in the meat industry and DNA samples can be collected during the entire life cycle of an animal from blood, hair, meat, saliva etc. (Food Standards Agency, 2002). When an animal is slaughtered, a DNA sample is taken from the animal. That sample consist of DNA material that is stored in a database. The database will capture typical information from the DNA sample and if needed, information can be found back at a later stage when needed (Tielemans, 2004). At the moment there are even developments in which it should be made possible to extract a DNA sample after a meat product has been cooked. Another development at the moment will makes it able to adopt DNA identification for plants.

2.3.2 Registration and administration

Whatever method is used to identify the information, all information should be captured and stored at a central database. That database should not only provide information about product articles but should also be able to make a distinction in batches and logistic-units (Tielemans, 2004). The ability of a traceability system to track and trace every single unit depends on the internal data management system (Pizzuti & Mirabelli, 2015). These internal data management systems could be for example Enterprise Resource Planning (ERP) systems or a warehouse management system (WMS).

Enterprise Resource Planning

An Enterprise Resource Planning (ERP) systems can be explained as: *"comprehensive packaged software solutions seek to integrate the complete range of business's processes and function in order to present a holistic view of the business from a single information and IT architecture"* (Klaus, Rosemann, & Gable, 2000). An ERP system helps a company with real-time information that shows a company what is going on. Companies can use this information to improve operational decisions (Chopra & Meindl, 2013).

Warehouse Management System

According to Shiau and Lee (2010) a warehouse management system (WMS) is *"a database driven computer application, which is used by logistics personnel to improve the efficiency of the warehouse by directing cutaways and to maintain accurate inventory by recording warehouse transactions"* (Shiau & Lee, 2010). In a WMS, different phases can be identified, namely receiving processes, storage processes, order picking and shipping. Where shipping not only means loading orders into a ship but also into trucks, trains or any other carrier (Rouwenhorst, et al., 2000).

These existing systems are destined for production, purchasing, sales, laboratory and financing, and not specially made for traceability (Vorst, van der, 2004; Food Standards Agency, 2002). In addition, these systems are used separately and several systems do exist in a single organisation. There is more need for using cross-reference systems (Food Standards Agency, 2002). There exist software that is special developed for food traceability like QualTrace, EQM and FoodTrack (Bosona & Gebresenbet, 2013).

2.3.3 Communication

Where the previous section discussed the registration and administration systems internally this section will be about the communication and information exchange between supply chain parties. Information can be exchanged between supply chain parties through inter-organisational information systems (IOIS), which is explained as: "*a workflow that involves communication between at least two organisations having different information systems and therefore it is necessary to have the same approach for sharing or to electronically exchanging data or information between those systems*" (Anica-Popa, 2012). These systems reduce costs and increase the productivity of organisations. The main obstacles of these systems are the different information systems included in IOIS; and social and organisational factors. One of the first technologies that was used to conduct e-business transactions was Electronic Data Interchange (EDI) (Anica-Popa, 2012). Whereas EDI enables firms with mature IT capabilities to exchange data, another variant Extensible Markup Language (XML) uses particularly the internet to exchange data.

Electronic Data Interchange (EDI)
Electronic Data Interchange (EDI) is used to exchange electronic data between business partners and trading partners. Thakur and Donelly (2010) explained EDI as: *"a set of standards for structuring information that is to be electronically exchanged between and within business organisations and other groups. EDI implies a sequence of messages between two parties, either of whom may serve as originator or recipient"*.

Extensible Markup Language (XML)
With Extensible Markup Language (XML), organisations are being able to display data in a web browser or to interchange data between IOIS. A definition given from Anica-Popa (2012) explained XML as followed: *"a set of rules for defining semantic tags that break a document into parts and identify the different parts of the document. It is a meta-markup language that defines a syntax in which other field-specific markup languages can be written"*. The benefits when using XML compared to electronic data interchange are: reduced possibilities of human errors, faster data exchange and reduced costs (Anica-Popa, 2012).

EDI and XML are both used to exchange data but each has its own pros and cons. The EDI file is shorter due to the record-field-like layout of data segments and elements. XML is more easily to understand, due to tags, but this makes the file bigger and more verbose (Thakur & Donnelly, 2010).

Exchange strategy
Whether an EDI, XML or other system is used, the strategy of information exchange determines the level of traceability. According to Tielemans (2004) there exist three strategies to exchange

information through a supply chain. Also Bosona and Gebresenbet (2013) formulated two different ways to exchange information:

- *Centralized registration through the whole supply chain*: in this case, supply chain parties or a third party keeps all the information in a central database where all the information is captured and stored (Tielemans, 2004);
- *Decentralied registration for each individual supply chain*: each supply chain part will capture and store information about batches and products in its own database. When a batch is going to the next stage, only relevant information will be exchanged (Tielemans, 2004; Bosona & Gebresenbet, 2013);
- *Information captured per product*: information will be captured and stored on a typical logistic-unit. All the information will go through the supply chain which is kept on the logistic-unit itself (Tielemans, 2004; Bosona & Gebresenbet, 2013). Information captured per product is widely used for fresh fish, meat and organic products and to identify non-GMO products (Bosona & Gebresenbet, 2013).

2.3.4 Concluding remarks to traceability

There is a lack of standardisation regarding food traceability (Vorst, van der, 2004; Bosona & Gebresenbet, 2013). Standardisation takes place in each organisation but the problem arises between organisations. Different organisations use different standards, which reduce the ease and ability to exchange data. A lack of standardisation is also observed between different countries. There are different solutions introduced for a traceable supply chain but especially the lack of standardisation creates compatibility problems. A sector-specific data terminology (structured data lists, vocabularies and ontology) is recommended as an effective way to tackle this problem. There is an increasing need for the industry to use standards so that multiple information technology solutions can be provided with systems that can 'talk to each other' (Donnelly, Karlsen, & Dreyer, 2012). One of the problems mentioned by Foras et al. (2015) is data security. Organisations only want to share information when it is stored in protected repositories. It is even a particular concern when supply chain parties want to collaborate. They want to be sure that exchanged information is secured and that information access is privileged (Denolf, Trienekens, Wognum, Vorst, & Omta, 2015).

2.4 Supply chain organisation

"Supply chain organisation is the way relationships between partners are built and coordinated" (Denolf, Trienekens, Wognum, Vorst, & Omta, 2015). There is an increasing demand from consumers to be better informed about product characteristics such as origin, or used amount of pesticides. The increasing demand of information forces companies to share more information with each other. Therefore companies need to change their supply chain organisation in order to better share all the information (Kähkönen & Tenkanen, 2010). According to Dabenne et al. (2014) the level of detail in traceability does not depend on a single company but relies on the agreements made within the group of companies.

The formal way of binding the supply chain is coordinated by *written contracts*. These will define the term of inter-organisational agreements and are used as a legal instrument. A good predictor of successful supply chain relationship is the *duration of the relationship* itself. In particular the duration of the relationship is also an indicator of *trust* between supply chain parties. And fourth, *power* will affect the structure of the supply chain and the relationship between parties. Written contracts, duration of the relationship, trust and power will all affect the organisation of the supply chain (Denolf, Trienekens, Wognum, Vorst, & Omta, 2015).

2.4.1 Written contracts

A formal way of binding supply chain parties is the use of written contracts (Denolf, Trienekens, Wognum, Vorst, & Omta, 2015). *"A contract is a voluntary and legally binding agreement made between two parties"* (Goodhue, 2011). In agriculture, contracts can be divided into three categories: resource-providing contracts, production-management contracts and marketing (market-specification) contracts (Goodhue, 2011).

The marketing contract is used for a wide variety of agricultural products. A marketing contract only defines the conditions of sale in which the price, and the amount of sold products are determined beforehand. Marketing contracts can also specify "*the minimum requirements or a range of acceptable values for specified quality attributes or by providing financial incentives for improved quality*" (Goodhue, 2011).

In production-management contracts, the aspect of growing processes as well as the growers' compensation are addressed. The grower retains ownership of the product till it has been delivered to the buyer. The buyer of agricultural goods only participates in some management decisions. Together with the grower they decide the variety choice and the time of planting and harvest in order to meet the product quality for production and to have a sufficient supply regarding the production schedule (Goodhue, 2011).

In case of a resource-providing contract a buyer of agricultural goods does already have the ownership of the agricultural goods during the growing process, and provides the key production inputs. Therefore the buyer also fully participates in management decisions. There could be many reasons why a buyer uses a resource-providing contract: "*because of the reduction of moral hazard, the mitigation of adverse selection, farmers' liquidity constraints, and the control of intellectual property"* (Goodhue, 2011). In practice production-management contracts and resource-providing contracts are combined into a 'production contract' (Goodhue, 2011).

It can be assumed that the way in which supply chain parties formulated their written agreements do have an effect on the organisation of the supply chain itself. Differences in ownership will give differences in responsibilities.

2.4.2 Duration of the relationship

When talking about relationships between organisations, the definition of inter-organisational relationships can be used: *"inter-organisational relationships are the relatively enduring transactions, flows, and linkages that occur among or between an organisation and one or more organisations in its environment"* (Oliver, 1990). In the paper of Ren et al. (2010) they explain the problem of forecast sharing. They refer to the transaction between a buyer and supplier in which there is only once a transaction as in the spot-buy market. When they only transact once, it will eliminate the value of a long-term relationship and the parties involved ignore their reputation. In practice, many relationships are long-term relationships. *"In these supplier relationships, both the buyer and supplier are concerned about how their current strategic behavior affects their future interactions, and value long-term cooperation over one-shot business transactions"* (Ren, Cohen, Ho, & Terwiesch, 2010). Long-term relationships depend not only on the form of a contract but also on having repeated relationships. Long-term relationships give opportunities for supply chain parties: *"to review the credibility of the* *other party, reward truth telling, punish otherwise, and therefore provides the right incentive for truthful information sharing"* (Ren, Cohen, Ho, & Terwiesch, 2010).

2.4.3 Trust

There exist a lot of definitions that define trust. According to Hand and Dong (Han & Dong, 2015) the most frequent used definition of trust comes from Lewick and Bunker (1996): *"trust is conceptualised as a belief; expectancy or feeling that is deeply rooted in personality and has its origins in an individual's early psychosocial development".* And the result of trust is that: *"firms' belief that another company will perform actions that will result in positive outcomes for the firm as well as not take unexpected actions that result in negative outcomes"* (Chen, Wang, & Yen, 2014). Multiple factors affect trust, for example experience and cognition from trustors, emotions, competency, ability and reputation from trustees, etc. The last factor was already confirmed by Ren et al. (2010), and explained that a long-term relationship can increase the reputation of the other supply chain actor and will lead to build trust. Together with resource commitment, trust is presented as a fundamental variable holding firms together (Hadjikhani & Thilenius, 2005). Hadjikhani and Thilenius investigated the relationship between commitment and trust and they proved that increased trust in a relationship leads to higher commitment. Han and Dong (2015) formulated a model where the model explains that many positive experiences are needed to gain trust. On the other hand, only some negative experiences could already cause a big loss of trust. Supply chain parties are less hesitant in sharing information and more willing to invest in joint activities when they trust each other (Kähkönen & Tenkanen, 2010), but trust will be diminished when conflicts take place which may be a result of power imbalance. In a situation of power imbalance, frequent communication may create tension: *"which make the less powerful actor perceive the more powerful one as overbearing"* (Kähkönen & Tenkanen, 2010).

2.4.4 Power

Power position influences the information sharing and market orientation of a firm (Kähkönen & Tenkanen, 2010). Power is defined as: *"the ability to control, the ability to influence, the ability of a firm to affect decision making and/or buying or the ability of an actor to impose its will on others"* (Kähkönen & Tenkanen, 2010). Together with relational characteristics such as trust and conflicts, power affects the depth of a cooperation and the amount of information that is exchanged (Kähkönen & Tenkanen, 2010). Power imbalance can even have a negative relation with the adoption of collaborative business models. Kähkönen and Tenkanen refer to two other papers (Geyskens et al, 1999; Weele and Rozemeijer, 1999) which explain that in case of using power in a coercive way an actor will be less satisfied and that partnerships can only grow when there is a certain balance of power between the relationships. But an imbalance of power will not always be negative (Hernández-Espallardo & Arcas-Lario, 2003). Situations can exist in which firms have too limited resources and knowledge. In that situation these firms can benefit from management activities implemented by the leader. In other situations firms can be persuaded by a powerful firm to collaborate and therefore the network on its own will be entirely improved.

In several studies a connection is made between the buyer-supplier relationship and its network (Kähkönen & Tenkanen, 2010). The essential sources of power are resources, competences and capabilities. The first one - resources - influence power in the way resources are needed from others and the way alternative resources can be obtained. Information is also an essential source of power. Information about customer preferences or material applications for instance can lead to possible commercial advantages or increasing bargaining power from other players. Therefore firms may be reluctant to share information since other parties could gain competitive advantages in the market and so they fear losing their power (Kähkönen & Tenkanen, 2010).

2.4.5 Concluding remarks to traceability

As Bosona and Gebresenbet (2013) already explained, traceability information will capture, store and transmit adequate information from all stages in the supply chain. It means that supply chain parties should communicate with each other to exchange the right information. In this section it became clear that the organisation of the supply chain and the way how organisations interact with each other depend on several factors. It could be assumed that these factors are also related to each other. A longer duration of the relationship could help to build trust for instance. Or a written contract could determine the power of one organisation to impose the other one to share its (traceability) information.

2.5 Theoretical framework

The sub-factors of the logistic and organisational structure which are described in this theoretical background are now also included in the conceptual model. Figure 7 shows how the conceptual model is adapted into a theoretical framework including all sub-factors of the logistic and organisational structure.

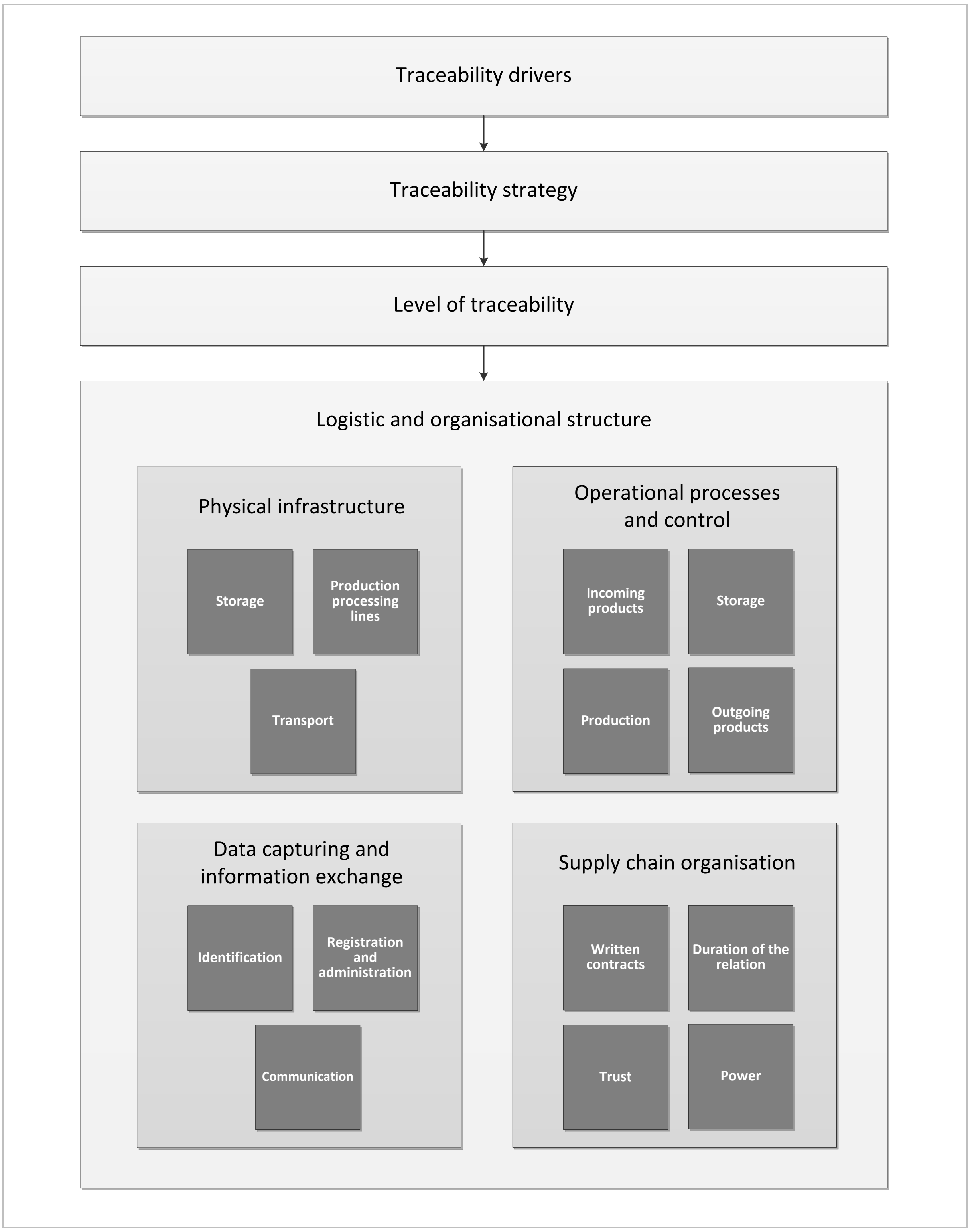

Figure 7: Theoretical framework

The four factors of the theoretical framework are also related to each other. For example: for the supply chain organisation it will be easier when all parties of the supply chain have similar technical capabilities. Coordination will be more difficult when operational processes differ or results in conflicting practises among supply chain parties (Denolf, Trienekens, Wognum, Vorst, & Omta, 2015). Also other relations can be indicated between the four factors and these relationships will be illustrated in Table 7.

Table 7: Relation between factors of the logistic and organisational structure

	Physical infrastructure	Operational process and control	Data capturing and information exchange
Operational process and control	Separating batches is a possible approach to minimise the total amount of a recall. The only way to better separate batches and to have at least the same amount of output is to enlarge the physical infrastructure with more logistic units or setting up more production processing lines.		
Data capturing and information exchange	Information should be kept and exchanged about storage, processing characteristics and transport. Information about all these parts is important due to the perish ability characteristic of food.	Information should be kept and exchanged about transformation of batches. Whether batches are separated or not, if administration is not done correctly a traceability analysis will not be reliable.	
Supply chain organisation	Different written contracts exist - contracts in which a buyer provides none of the resources - or contracts in which a buyer provides all resources - and everything in between. The more a buyer provides the resources the better he is able to manage the traceable resource unit (enlarging the physical infrastructure makes it able to better separate batches).	Operational processes and control will determine how far batches will be separated. It has already been mentioned that in agriculture a TRU could be based on one field. To keep that separation level of one field, all parties should use the same level of separation.	It has already been mentioned that supply chain parties are dealing with the amount and detailed level of information that should be exchanged between partners. Factors of trust, power, etc. do affect this data and information exchange among supply chain parties.

3. Methodology

This chapter describes the methodology that is used for the empirical research. It explains how respondents were selected and how research was operationalised. The chapter ends with an explanation how data has been analysed.

3.1 Case selection (sampling)

The case study focused on the Dutch potato supply chain. Data has been collected in two ways. On the one hand, interviews have been conducted with potato supply chain parties itself. On the other hand experts were interviewed because they were able to pinpoint the interaction between potato supply chain parties from a broader perspective. In order to get an overview of the whole Dutch potato supply chain, the aim was to conduct interviews at every stage of the supply chain. Therefore 11 interviews took place with Dutch potato supply chain parties and 2 interviews took place with experts as can be seen from Table 8.

Table 8: Role of respondents

Potato supply chain parties	Experts
- Farmer (1) - Cooperative (1) - Intermediate trader (1) - Processors (6) - Retailers (2)	- Experts (2)

In total 13 interviews were conducted. Most interviews were held with processors because it was assumed that the level of traceability is most affected by the logistic and organisational structure of the processing industry. In total respondents from two different processing companies were interviewed. The process of a processor can be divided in three parts: incoming products, operations and outgoing products. It has been tried to interview respondents from every part of the process. Experts were interviewed from two different organisations: the NAO (Dutch abbreviation for Dutch potato organisation) and the VAVI (Dutch abbreviation for the association of processed potatoes).

Table 9 gives an overview of all conducted interviews, the respondents and their role within the supply chain, their function in the organisation, the organisation name and the date the interview was conducted. Two processing companies and two retail organisations prefer to be anonymous.

Table 9: Interview respondents table

Role in the supply chain	Function role of respondent	Name organisation	Date of interview
Farmer	- Farmer (FA1)	Cox Herreats	17.06.2016
Cooperative	- Product Advisor (WM2)	Agrico	27.06.2016
Intermediate trader	- Quality Manager (WM1)	Wilhelm Weuthen	01.06.2016

Role in the supply chain	Function role of respondent	Name organisation	Date of interview
Processor (PC1)	- Supply Chain Improvement Specialist (PI1) - Supply Chain Fulfilment Specialist (PI2) - Intern focused on potato storage (PI3)	Anonymous	17.06.2016 17.06.2016 17.06.2016
Processor (PC2)	- Manager Supply Chain Support (PI4) - Manager Logistics (PI5) - Manager Industrial Automatization (PI6)	Anonymous	16.06.2016 23.06.2016 05.07.2016
Retailer	- Category Manager (RE1)	Anonymous	21.06.2016
	- Category Manager (RE2)	Anonymous	23.06.2016
Experts	- Field supervisor (EX1)* - Secretary seed potatoes (EX1)* - Policy Advisor (EX1)*	NAO	06.06.2016
	- General secretary (EX2)	VAVI	20.06.2016

** The interview with the organisation NAO was conducted in presence of three experts at the same time.*

3.2 Operationalisation

After the selection of organisations from the Dutch potato sector, and the selection of respondents based on their role in the supply chain and their ability to oversee (the relationship with the previous chain party and the next chain party of) the supply chain, the respondents were invited by e-mail or phone to participate in the research with a short explanation of the research purpose. When the respondent was willing to participate, an appointment was made to conduct the interview on location. In one case (Respondent RE2) the interview was taken by phone.

The interview outline was set up based on the outcome of the theoretical framework. That framework consists of all factors and sub-factors that determine the level of traceability. Finally an interview structure has been found where the factor of *physical infrastructure* and *operational processes and control* were combined into one subject - it became clear that these two factors are strongly related to each other. The other two subjects were about *data capturing and information exchange* and *supply chain organisation* and the questions of these factors were each covered by its own subject.

The first interview outline has been used for respondent WM1. With remarks and comments from that first respondent, the outline has been adjusted into a final outline. That final outline has been used for all other 12 interviews. Only in some cases the interview outline was slightly different. For example no questions about the transformation of batches were asked to a retailer. Simply because the products a retailer receives are the same products as he will sell to the consumer. Batches will not be transformed at the retailer, as is the case during the production phase.

The final interview outline can be found in Appendix IV.

3.3 Data analysis

All interviews were recorded and a full transcript of each interview has been made afterwards. The transcripts were used as a basis for the data analysis. In total there were 13 transcripts to analyse.

To analyse all transcripts, the method described by Gorden (1998) has been used. Therefore coding categories were defined. The theoretical framework has been used as a basis to define four categories, including sub-categories. Each category gets its own colour and each sub-category gets its own code (Table 10). Since a semi-structured interview outline has been used - and therefore also some other interesting responses came up during the interviews - a fifth 'optional' category has been included for all interesting responses which cannot be assigned to one of the four categories. It finally resulted in 13 transcripts in which each transcript has been marked with colour codes and sub-category codes.

Table 10: Colour coding table

Coding category	Colour	Coding sub-category	Code
Physical infrastructure	Yellow	Storage	(ST)
		Production processing lines	(PP)
		Transport	(TR)
Operational processes and control.	Pink	Incoming products	(IP)
		Storage	(ST)
		Production	(PR)
		Outgoing products	(OP)
Data capturing and information exchange	Blue	Identification	(ID)
		Registration and Administration	(RA)
		Communication	(CO)
Supply chain organisation	Green	Written contracts	(WC)
		Duration of the relationship	(DR)
		Trust	(TR)
		Power	(PO)
Optional	Orange	Other relevant outcomes	

Gorden (1998) described three approaches to analyse interview transcripts. In the first approach the transcript is cut up with scissors and the relevant words, phrases, or sentences are put into boxes, labelled with the appropriate categories. However it is a time-consuming process and fragments are removed from their context which makes the first approach impractical. The decision was made to choose for the second approach of analysing according to Gorden (1998) and to read through a transcript, underline each fragment of relevant information, and label it with the category colour and category code. This approach has two advantages: transcripts aren't cut and each relevant fragment is kept in its original context. Gorden (1998) also explained a third approach where a typical coding sheet is used. That coding sheet is a table with rows and columns. Each column represents a respondent, and each row represents a category. Therefore each cell represents the answer of a respondent about a certain subject. The answers from all respondents regarding a certain subject can then be read horizontally. The coding sheet could give a good overview off all answers per subject, and can show the similarities or contradictions among all respondents. Because all respondents do have a different role in the supply chain (a farmer has other storage units compared to a processor or a retailer, or the incoming products for a processor are different than that from a retailer) results from all 13 interviews could not be compared in one coding sheet, because each respondent deals with another part of the supply chain. Therefore the decision was made to use the second approach without the use of a coding sheet.

All interview transcripts can be found in the ‘book of transcripts’.

4. Results and analysis

This chapter presents and analyses the results from empirical research in order to answer research question 3 and 4.

3. *How will logistic and organisational factors change in the supply chain of the Dutch potato sector when going from the current situation to a traceability scenario with a higher level of traceability?*
4. *What are the trade-offs that organisations in the supply chain of the Dutch potato sector have to make when going from the current situation to a traceability scenario with a higher level of traceability?*

The results are presented in tables. Respondents are asked about the logistic and organisational factors that should be changed in order to increase the level of traceability. These changing factors are shown in the first row of the table. The decision whether to change a factor or not depends on the trade-off. As the definition stated, trade-off is about increasing or obtaining desirable outcomes in exchange for reducing or forgoing other desirable outcomes. The increasing or obtaining desirable outcomes are about a higher level of traceability (time needed to trace; tracing unit; reliability of the traceability analysis) - which can be found in the left column. The reducing or forgoing desirable outcomes are placed in the right column. The table below can be seen as an example how the changing factors and trade-offs are presented in this chapter.

CHANGING LOGISTIC OR ORGANISATIONAL FACTOR *- Changing sub factor -* Changing element explained	
Shorter time to trace	Lower desirable outcome 1
Smaller tracing units	Lower desirable outcome 2
More reliable traceability analysis	Lower desirable outcome 3

When changing factors do have a relation with each other - in other words one changing factor also influences other factors - the tables are grouped together into one section. This chapter is divided into 5 sections as can be seen in the table below.

Table 11: Results and analysis chapter overview

Section	Changing factor	Explanation
4.1 Results and analysis 1	1. Physical infrastructure	More separated transport
	2. Physical infrastructure	More separated storage
	3. Operational processes and control	Separated batches in production
	4. Operational processes and control	Stop points in production
4.2 Results and analysis 2	5. Data capturing and information exchange	Online crop registration
4.3 Results and analysis 3	6. Data capturing and information exchange	Working according HUM
4.4 Results and analysis 4	7. Data capturing and information exchange	Knowing the customer
4.5 Results and analysis 5	8. Data capturing and information exchange	One central traceability system

Finally, some respondents mentioned some changing factors without referring to increasing or obtaining desirable outcomes or without mentioning reducing or forgoing desirable outcomes. Sometimes respondents only mentioned the increasing desirable outcomes, sometimes only reducing desirable outcomes, or sometimes none of the above. Although this research report is about the trade-offs to come to a higher level of traceability - changing factors without further trade-off explanation are also described in this chapter. Even though respondents did not always mention the trade-offs, they explained how some logistic and organisational factors should change in order to obtain a higher level of traceability. The chapter consists of five sections in which in total 8 different changing factors are explained.

4.1 Results and analysis 1

Changing factor 1. **PHYSICAL INFRASTRUCTURE** | MORE SEPARATED TRANSPORT
When potatoes are harvested, they will be transported to a potato storage. Harvesting can take place from different fields at the same time whereby yields of different fields can be combined together into one truckload (WM1; PI5). On average six truckloads are needed for one potato field (PI2).

Smaller tracing units. To obtain a higher level of traceability, truckloads should only keep the yield of one farmer (PI3) or even further from a single potato field (WM1; PI5).

PHYSICAL INFRASTRUCTURE *- Transport -* Transport from field to potato storage is separated to (1) one farmer or even further to (2) a single potato field	
Smaller tracing units	Less efficient transport Higher costs Being less sustainability

Less efficient transport. When one truckload can only transport one potato field, transport will be less efficient (EX1). Also if the truckload is not fully used, the truck must return to the potato storage (whether it is at the farmer itself, an external storage location or a factory). The truck cannot use its empty space for (1) another farmer or (2) another potato field and should therefore drive more often (WI1; PI5).

Higher costs. When trucks must drive more often, transport costs will be higher (WI1; PI5).

Being less sustainability. When trucks should drive more often, transportation from the potato field to the potato storage will be less sustainable (WI1).

In case transport from potato field to potato storage will be based on a single potato field, respondent FA1 thinks that there will be a development of increasing hectares for a single potato field. With more hectares per potato field, less semi-loaded trucks are needed and transportation from potato field to potato storage will be more efficient (FA1).

Changing factor 2. **PHYSICAL INFRASTRUCTURE** | MORE SEPARATED STORAGE

Nowadays more potato fields are combined together into a single compartment of a potato storage (FA1; WM1), (for instance 10 fields in one compartment (WM1)). As good as possible potatoes with the same quality characteristics are grouped together with the aim of having a homogeneous batch of raw potatoes. This grouped batch of raw potatoes that is stored into one compartment is being considered as one raw potato batch (WM1; WM2). But if transport will be based on (1) farmer level or even further, based on (2) a single potato field, storage of potatoes should be separated on the same level (WI1; PI5).

Smaller tracing units. In order to separate potato batches further, and to use smaller batches (FA1; WM1; PI2; PI3), two solutions can be found: placing bulkheads in the current potato compartments (WM1; PI2) or using potato boxes (FA1).

PHYSICAL INFRASTRUCTURE *- Storage -* Potato storage is separated to (1) one farmer or even further to (2) a single potato field	
Smaller tracing units	Lower air circulation capacity of stored potatoes More time needed to move potatoes Higher costs

Lower air circulation capacity of stored potatoes. Air circulation of stored potatoes is important in order to prevent quality losses of potatoes during storage. When placing bulkheads in the current potato compartments in order to further separate potato fields the quality of storing conditions will decrease. The new placed bulkheads disturb the current circulation of air and will therefore have an impact on the air circulation capacity of stored potatoes according to respondent PI2 - which will cause quality losses of stored potatoes.

More time needed to move potatoes. Another solution to further separate potato storages is the use of potato boxes. It will cost more time to move potato boxes instead of moving potatoes which are kept in bulk (FA1).

Higher costs. There should be made an investment for a new physical infrastructure where bulkheads are placed in current compartments to make smaller compartments or where potato boxes are used instead of storage compartments (PI5). The use of potato boxes is more expensive than storing potatoes in bulk (EX1). Respondent PI6 gave the example of building an extra silo for the use of oil. He stated that to better separate batches, more silos are needed, and therefore an investment should be made.

Respondent PI1 and PI3 mentioned another positive effect of using smaller batches during storage at a farmer. A planner wants to have the optimal potato (based on the desired quality of the customer, good potatoes for a high quality label, lower quality potatoes for a low quality label). Therefore the processor wants to know the quality of potatoes before the potatoes will enter the factory. Therefore a sample is taken from the compartment of a potato storage (in the current situation more potato fields are put into the same compartment). But that sample gives an indication of the average quality of the whole compartment instead of the quality of one field. But the actual quality in the compartment itself could differ because more potato fields are kept in the same compartment and every potato field could have different quality characteristics. It could be for example that potatoes in the front are good, and that potatoes from another field who are located in the back do have a lower quality (PI1; PI3). When raw potato batches are more separated, processors will also receive more homogeneous batches with less variation in quality. Thus, there are more positive effects than just traceability when separating potato batches based on one farmer or a single potato field.

The trade-off explanation is about storage which is located at a farmer, a warehouse merchant or an external storage location. When potatoes are received at the factory, they should be stored as well. At a factory, potatoes are stored in special potato storage cells. Respondent PI5 explained in case batches should be separated more, that the processing company (PC2) also needs more storage cells in order to work with smaller batches and to make a distinction based on farmer level (PI5). The respondent (PI5) mentioned as well that investments are needed to expand the current physical infrastructure with more potato cells and affects costs.

Changing factor 3. **OPERATIONAL PROCESSES AND CONTROL** | SEPARATED BATCHES IN PRODUCTION
Figure 8 shows what is happening in the processing industry at the moment. The respondents (PI1; PI2; PI3; PI5) explained that more than one raw potato batch is used in a production run. Respondent PI5 explained that it is not possible to run a production with one farmer, so that at the same time two batches from different farmers are used to continuously put potatoes into the processing line. Another respondent (PI2) explained that they combine batches in order to deliver a good product on average (PI2) or as respondent WM1 explained, to meet the specifications. The processor (PC1) uses most of the time two different batches (PI2; PI3), with a maximum of five (PI3).

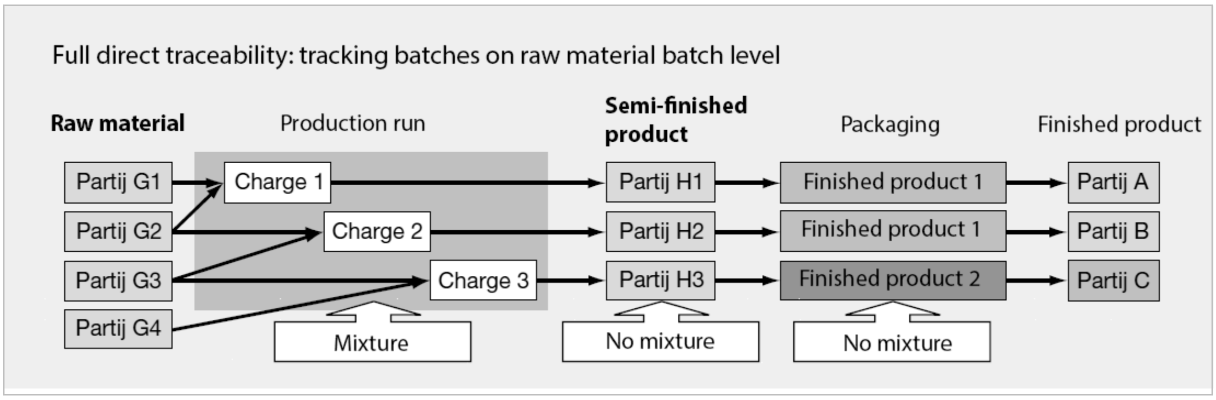

Figure 8: Illustration of the current situation in which raw potato batches are blended for production (Tielemans, 2004)

In the previous trade-off explanations transport and storage is separated to (1) one farmer or even further to (2) a single potato field. To obtain a higher level of traceability less blending should exist (WM1; PI2; PI3; PI5). Raw potatoes are transported and stored on farmer level or field level as described above - and should be put into the production on the same separation level.

Smaller tracing units. Respondent WM1 explained the aim of less blending. *"To change the level of traceability, you have to blend less in order to pinpoint where it has gone wrong"* (Respondent WM1).

OPERATIONAL PROCESSES AND CONTROL *- Production -* Raw potato batches (from (1) one farmer or (2) a single potato field) are put into production separately	
Smaller tracing units	Less consistent quality of output Less optimal use of raw potato batches More complex production process

Figure 9 shows the situation in which a higher level of traceability is desired. Nowadays several batches are combined into one production run. To obtain a higher level of traceability, a production run is only starting with one raw potato batch and no other batches are used at the same time (PI2). It could be the case that more batches are used for one production run, but then stop points between two different raw potato batches will be used (see *Changing factor 4 - STOP POINTS*).

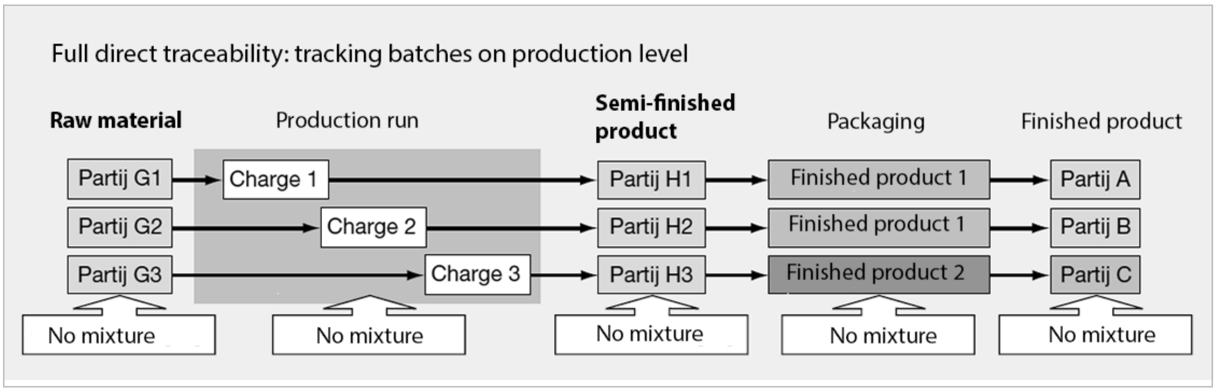

Figure 9: Illustration in which a higher level of traceability is desired and no blending of different raw potato batches in production exist (Tielemans, 2004)

Less consistent quality of output. It is not possible to create the most optimal potato from one farmer and to use it for the production of a whole year. The quality characteristics of the potatoes from one farmer will not always be the same through the year (WI1; PI3): *"(…) you have to blend less (...). But that is in conflict with the aim of having a final product that is as homogeneous as possible"* (Respondent WM1). Respondent EX2 mentioned the same. *"Because McDonalds' French fries should taste the same in February as they do in September or July"* (Respondent EX2). In addition this output trade-off is also mentioned by respondent RE1 who explained that it is not possible to produce high volumes for a typical product with potatoes from one farmer. Only if the product is a speciality with a lower volume of selling, it is possible to create a product from one farmer (RE1).

Less optimal use of raw potato batches. Nowadays processed batches consist of different raw potato batches. One of the reasons is a constant homogeneous output as explained previously. Good quality raw potato batches are blended with batches that do have a lower quality (PI3; EX1). According to respondent PI3, the positive effect of this blending strategy is that also lower quality potatoes are used for finished products: *"You cannot say: 'these potatoes are too short and therefore we don't use them'. You bought them from a farmer, and you have to use them. That's the reason why you use a blend"* (Respondent PI3). When every production run consists of one raw potato batch, and blending doesn't exist anymore, these raw potato batches that don't meet the quality specifications cannot be used anymore. Low quality potatoes cannot be blended anymore with high quality batches. Respondent

WM2 explained that sometimes the processing industry is even not happy with high quality potatoes when they have to produce for a low quality label. Nowadays, in case the processing industry should produce a product label that is considered as low quality, the high quality potatoes will be mixed up with low quality potatoes in order to produce a processed batch that fits the low quality label (WM2).

<u>More complex production process.</u> Having much more and smaller raw potato batches which should be put into the processing line will be much more complex than the traditional way (PI1), and managing the processes will be very complex (PI5). Respondent PI1 explained that they first have to make a step to plan the production based on potato storage and not to separate it further. *"We argued that we first have to do our planning based on one potato storage instead of separating it further. "For now, let's not make it too complex""* (Respondent PI1).

<u>Changing factor 4. **OPERATIONAL PROCESSES AND CONTROL** | STOP POINTS IN PRODUCTION</u>
As respondent PI5 explained different raw potato batches are putted into the processing line at the same time to have a continuously flow of potatoes that goes through the processing line. It could be the case (PC2) that a production run captures 4 days and that raw potato batches are used from 10 or 12 different farmers (PI5).

Another way to increase the level of food traceability is to make stop points into a single processing run between different raw potato batches (PI1; PI2; PI3; PI5). Figure 10 below is a good illustration of the situation nowadays. It can be seen that several raw potato batches are used for a single production order. When one batch is used, the next one will be put into the line. In practise this switching point from one raw potato batch to another one is not that strict and a new batch will already be put into the line when the previous batch is starting to run out. When one potato cell is almost empty, the other potato cell has already been opened to put a new batch of raw potatoes into the line - with the aim that the amount of potatoes that goes through the processing line will be held constant (PI5; PI6). When stop points are used, there is no flow anymore from one raw potato batch to another and no mixing between different batches can occur. It also means that there are less potatoes on the processing line when a potato cell is almost empty. Only a new storage cell can be opened after the previous one is totally empty and after some waiting time in between (PI5).

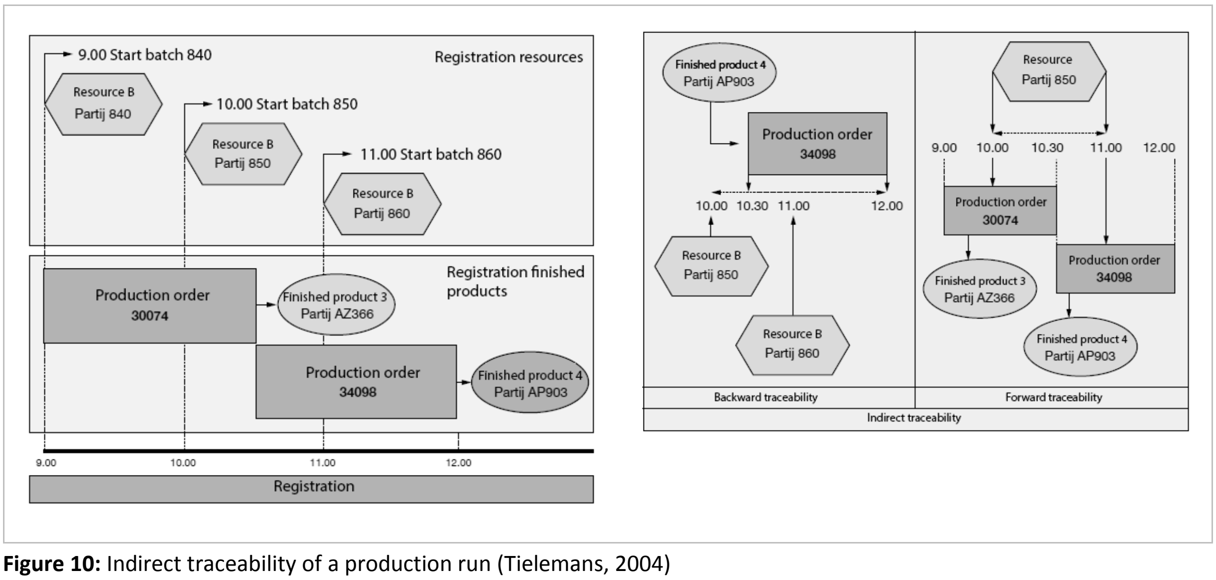

Figure 10: Indirect traceability of a production run (Tielemans, 2004)

Smaller tracing units. With stop points between different batches, smaller production batches will occur (PI1; PI5). *"If you want to improve traceability for smaller amounts, you would have to leave some space between every separate batch within your production planning. You could, for example, start with the first batch of raw potatoes, create a gap by waiting a minute, and then continue with the second batch"* (Respondent PI1).

OPERATIONAL PROCESSES AND CONTROL *- Production -* Stop points between raw potato batches during a single production run	
Smaller tracing units	Less consistent quality of output Less efficient production process Higher costs

Less consistent quality of output. For the production of potatoes it is important to have a continuously flow of potatoes that goes through the production processing line. When there is no continuously flow of potatoes anymore, there is some room for production characteristics to change. For example, when no new potatoes enter the deep-fried process, the oil temperature could increase. A new batch of potatoes that goes into the deep-fried process later will be fried with a higher temperature and quality characteristics of this new batch will differ from the previous one (PI5). It is therefore the reason as respondent PI5 explained that the processing company (PC2) at least needs batches of two different farmers at the same time to have a continuously flow of potatoes on the processing line. When it will be the case that processing conditions are changing as a consequence of these stop points, more labour is needed because changes of production characteristics should be managed by people (PI5).

Less efficient production process. Production will also be less efficient if these stop points between raw material batches exist (PI1). *"You just want to have a continuous process"* (Respondent PI1). Respondent PI5 also explained that the configuration of the processing conditions should be changed between every batch. More time needed for configuration means less time available for production.

Higher costs. The current situation of employees is not based on checking all potato storage cells. More employees are needed to check continuously whether a potato storage cell is totally empty or not (PI5). More employees affects higher costs. Second, processing lines should be made empty between two different batches, it will be less efficient as already stated and therefore it will also be too costly (PI5).

Also in the current situation - where two batches at the same moment can be used - because one is almost empty and therefore the other one has already been put into the line - it is still possible to do a traceability analysis (PI1; PI3; PI6). Respondent PI6 uses the 'reaction technique' while the other respondents (PI1; PI3) don't give it a name but explain the same methodology by calculating the time before finished products came out of the processing line: *"So by means of the production order we can see which order it has been and we will print a code on each bag and each box. The information is about: where it has been made, which production line and at what time. So you can see one and a half hour was needed from putting the potatoes into the processing line to the packaging process. With that information we can look back one and a half hour and see which potatoes were punt into the line* *before they were packed"* (Respondent PI1). The only difference compared to the situation in which there are stop points is that stop points ensure that there is a strict distinction possible between two batches. That strict distinction is not possible in the current situation. Respondent PI2 explained that, in the current situation with a continuous process - in which a batch is flowing out and a new batch is already entering the same line at the same time - a safety margin of one hour is used.

This trade-off explanation is about the distinction in which different batches are put into the processing line. Both processors (PC1; PC2) already make a distinction in different batches when they store a potato batch into a potato cell. It means that only a potato cell is filled again with new potatoes if the potato cell is totally empty - no older potatoes from a previous batch may be left in the potato cell before it is filled again with new potatoes (PI2; PI5). Thus, mixing takes place because more storage cells are opened at the same time, not because the potatoes are mixed in the potato cells itself.

4.2 Results and analysis 2

Changing factor 5. **DATA CAPTURING AND INFORMATIN EXCHANGE** | ONLINE CROP REGISTRATION
During the cultivation process farmers have to fill in a crop registration form (WM1; PI5; EX1; FA1). That form belongs to a single potato field and registers the potato variety, the moment of planting, the amount of seed potatoes planted, the pesticide variety, the amount and dates of pesticides used, the date of harvesting and all other operations a farmer has gone through to grow his crop (FA1; PI5; EX1; EX2). That registration form can be filled in online or on paper. In case of respondent WM1, still some farmers fill in their crop registration form on paper. Respondent EX2 thinks that more than 50% of the exchange of all crop registration forms is done according an automatic system. To increase the level of traceability, all farmers should work with an online crop registration form (WM1; EX2).

Shorter time to trace. According to respondent WM1 working with an online crop registration form means less time needed to conduct a traceability analysis compared to a situation in which the online crop registration form is exchanged and captured on paper.

DATA CAPTURING AND INFORMATION EXCHANGE *- Communication + Registration and administration -* All farmers work with an online crop registration form
Shorter time to trace

An online crop registration form has also another positive side effect - an exceedance can be detected immediately. The information a farmer puts into an online crop registration form is immediately visible for a processor and thus an exceedance could directly be detected. The time that a crop registration form on paper has reached the processor is much longer.

An online crop registration form does not automatically means that a traceability analysis will become more reliable. A farmer can make a mistake when administer all relevant information, or a farmer will not give the right information on purpose, about the amount of used pesticides for instance (PI2). It is possible to fill in other values than the farmer actually used during the cultivation process (FA1; WM1) on purpose or not, whether it is on paper or online. But farmers are under control of a controlling body

(FA1; WM1; EX2). In addition a farmer could also be checked by the warehouse merchant or the cooperative. In most of the cases a farmer will buy pesticides or seed potatoes from the warehouse merchant or the cooperative. Afterwards the warehouse merchant or cooperative buys the raw potatoes from the same farmer and can therefore check if the amount of pesticides sold and amount of seed potatoes delivered fits with the hectares or potato yield (WM1; WM2). In most of the cases long-term relationships exist (80%) between farmers and processors, and therefore farmers and processors do trust each other (PI2). On the other hand respondent EX2 mentioned that there could be distrust about the use of information exchanged. Information could be used for other purposes - benchmarking for example. *"How could it be the case that you yield 50 tons of potatoes from one hectare, whilst information shows someone else, one the same kind of clay, is yielding 80 tons of potatoes"* (Respondent EX2).

4.3 Results and analysis 3

Changing factor 6. **DATA CAPTURING AND INFORMATION EXCHANGE** | WORKING ACCORDING HUM

The next changing factor may be changed in the communication between the processor and the warehouses - also called freezing houses. (In the potato industry warehouses will keep the potato products under zero degrees and therefore these warehouses are called freezing houses.)

Shorter time to trace. Respondent PI4 mentioned two ways of communication between processors and freezing houses. They consider a Handling Unit Management (HUM) system and a non-HUM system. A HUM system gives the processor real-time information if their products are still on stock in the freezing houses, or that products are already send to the customer. *"If it is according HUM, we are directly able to see that this product comes from this pallet and we can also see where it went through. For others we cannot see this information and we always have to send a file. "Guys, you have had this delivery from us, and these 10 pallets with these numbers. Where did they go?" And then they have to get this information from their systems and send it to us afterwards. Speaking about track and tracing and traceability, and the timeliness of it, there is a clear difference"* (Respondent PI4).

DATA CAPTURING AND INFORMATION EXCHANGE *- Communication + registration and administration -* All freezing houses work with a HUM system	
Shorter time to trace More reliable traceability analysis	Being less flexible

More reliable traceability analysis. In addition the same respondent mentioned that the use of a HUM system makes a traceability analysis more reliable. If the administration of incoming and outgoing products in a freezing house is done manually (non-HUM system), there is more room for errors (PI4). Respondent PI4 explained that there is still room for errors also in case of a HUM system - for instance, the automatic printer of barcodes is not working and someone puts a barcode on the wrong package. But in general a HUM system is much more reliable than a non-HUM system.

Nowadays (for the processing company of respondent PI4) there are still some freezing houses who are not working according a HUM system (it is not clear if it is also the case for processing company 2). To increase the level of traceability, all freezing houses should work according a HUM system (PI4).

Being less flexible. Sending relevant information about storage locations and received products by XML will contribute to a faster traceability analysis according to respondent PI4. But the same respondent also stated that it decreases flexibility: *"You can say to a cowboy right now that at this moment you need space for 3,000 and ask whether it is all right? "Yes that is all right". And I will drive up there tomorrow. But if you say no, we are going to start up a HUM construction, that will mean that I need an engineer here and a logistic engineer who will set up the interface and lead the project. He will also have to train people here and coordinate it with the IT-department. So your own internal preparation time is important too. It will ask for some flexibility"* (Respondent PI4).

The same respondent mentioned that the duration of the relationship is an important factor when setting up a HUM system. Only when there are long-term relationships with freezing houses, it is possible to set up such systems. Second, there are not so many freezing houses. Therefore the respondent thinks that they don't have the power to obligate the non-HUM freezing houses to set up a HUM system (PI4).

4.4 Results and analysis 4

Changing factor 7. **DATA CAPTUING AND INFORMATION EXCHANGE** | KNOWING THE CUSTOMER
According to respondent RE2 no information is kept whether a certain batch from a retailers' DC, has gone to supermarket X or supermarket Y. "*We can see exactly the stock level of a supermarket, when they received their stock, up-to-the-second. But it is not possible to trace on the level of batches"* (Respondent RE2). To be more traceable according to respondent RE2, information should be available about the destination of a certain batch from DC to supermarket. *"It will be the challenge to capture the information further in the supply chain - to capture what has been send to which supermarket"* (Respondent RE2). Or even further whether a product from a certain batch is bought by consumer X or consumer Y (RE2).

Respondent PI2 also mentioned the gap of information between the processor and the customer. A problem exists when their products are sold through a wholesaler. *"The biggest problem is that we sell a lot through wholesale. After wholesale, we don't know where our product ends up? If you start a take-a-way fast food restaurant, you can just buy our French fries from a wholesaler, like Sligro. But how do we reach you, in case our product is deficient?"* (Respondent PI2). From the perspective of a wholesaler, information about clients is very confidential (EX1; PI2) and therefore no information about sold products from wholesaler to customer is exchanged between the wholesaler and the processor (PI2).

DATA CAPTURING AND INFORMATION EXCHANGE
- Identification + Communication + Registration and administration -
Knowing the customer/consumer who bought the product

Talking about traceability information from retailer to consumer and whether a retailer is able to know which consumer bought which product, two big changes should be made (RE2). At this moment most of the packages in the supermarket consist of a EAN-14 barcode which captures a limited number of information (RE2). In order to keep the information which customer bought which product, all packages should be changed into an EAN-23 barcode because more information should be kept. Second, it has a huge impact on all current systems. All systems have to be adjusted in order to keep more information - to administrate which batches has gone to which customer (RE2).

4.5 Results and analysis 5

Changing factor 8. **DATA CAPTURING AND INFORMATION EXCHANGE** | ONE CENTRAL TRACEABILITY SYSTEM

By different respondents it is mentioned that there should be one system in order to have a better overview of all relevant traceability information. Respondents mentioned a better central system in one organisation (PI1; PI2) as well as one central system for a whole supply chain (EX2; WM2).

Shorter time to trace. Respondent PI1 mentioned that systems should combine the information better. It should be directly visible, based on time, to see when raw potato batches are added to a certain production run. Nowadays, it takes a lot of time to get the right information from the right people. This point is also mentioned by respondent PI2. The same respondent explained that at this moment the Q.A. department should obtain all relevant information from different people with separated systems. It works much better when there is 'one source' where all relevant information is kept in one place (WM2; PI2). The problem nowadays is the existence of all separated systems where people should connect these systems by themselves instead of one system where all relevant information is connected (WM2; PI2).

But also one system through the whole supply chain is mentioned by respondent WM2 and EX2. The cooperative (WM2) argued a system where information from farmers will be shared within the whole supply chain.

DATA CAPTURING AND INFORMATION EXCHANGE *- Communication + Registration and administration -* The existence of one system where there is a direct traceability overview
Shorter time to trace

The same respondent (WM2) who argued one system through the whole supply chain, doesn't think that one system through the whole supply chain will be the future. A farmer has to agree on sharing his information through the whole supply chain, and from a perspective of a farmer, it will be seen as a threat. In his eyes the exchanged information can be misused by other parties (WM2). The expert (EX2) thinks that traceability information could also be used for commercial purposes. *"A customer would like to know the cost price. Therefore he needs a lot of knowledge and information. In the future he will ask more and more under the guise of: "I need that information for my own systems, because of safety". But he can also take advantage of it."* (Respondent EX2).

Misuse of information has to do with trust (part of 'supply chain organisation'). But trust cannot be formulated as a reducing or forgoing desirable outcome in a trade-off. You cannot say: *'as a result of a central traceability system, supply chain parties are starting to distrust each other'*. In particular the distrust nowadays is the reason that one system through the whole supply chain doesn't exist at the moment - it is not clear if one central system will decrease or increase the current level of trust further. If a common and central traceability system through the whole supply chain will be the future depends on the supply chain itself and whether supply chain parties are willing to collaborate more with each other (EX2). It is also the question who will control the system, who is responsible and who is going to pay for a central system in the whole supply chain (WM2)?

Also respondent PI2 doesn't see a trade-off for the existence of one internal system to have directly insight in all relevant traceability information. The current network of all internal systems and the connection between these systems has developed itself during the past. At the moment current systems will be changed on the short term in order to pro-active inform their customers about the origin of products. A better internal connected system doesn't affect decreasing or forgoing desirable outcomes according to the respondents who argued a better internal connected system - it will only be easier to request information. In addition, information about the origin of products can be used as a unique-selling point (PI2).

The table below shows all 8 changing factors, gives a short explanation of each changing factor and shows the trade-offs - the increasing outcomes and the decreasing outcomes as a result of the changing factor. During the interviews also some positive side effects were mentioned which are also included in this overview.

Table 12: Changing logistic and organisational factors including trade-offs

	Changing factor	Explanation	Increasing outcome	Decreasing outcome
1	Physical infrastructure	Transport from field to potato storage is separated to (1) one farmer or even further to (2) a single potato field	Smaller tracing units	Less efficient transport, Higher costs, Being less sustainable
2	Physical infrastructure	Potato storage is separated to (1) one farmer or even further to (2) a single potato field	Smaller tracing units, Less quality variation in raw potato batches*	Lower air circulation, More time to move potatoes, Higher costs
3	Operational processes and control	Raw potato batches (from (1) one farmer or (2) a single potato field) are put into production separately	Smaller tracing units	Less consistent quality of output, Less optimal use of raw potato batches, More complex production process
4	Operational processes and control	Stop points between raw potato batches during a single production run	Smaller tracing units	Less consistent quality of output, Less efficient production process, Higher costs
5	Data capturing and information exchange	All farmers work with an online crop registration form	Shorter time to trace, Immediately detection of exceedance*	

	Changing factor	Explanation	Increasing outcome	Decreasing outcome
6	Data capturing and information exchange	All freezing houses work with a HUM system	Shorter time to trace, More reliable traceability analysis	Being less flexible
7	Data capturing and information exchange	Knowing the customer/consumer who bought the product		
8	Data capturing and information exchange	The existence of one system where there is a direct traceability overview	Shorter time to trace	

** Positive side effect*

5. Conclusion

This chapter presents the conclusion of the research. It will give an answer to the sub-questions based on the literature review and empirical research. The answer to the sub-questions makes it able to answer the central research question which is discussed in the second section of this chapter.

5.1 Sub-questions

Four sub-question are formulated to obtain the research objective. The first two sub-questions were answered by doing theoretical reviews and sub-question 3 and 4 were answered by doing empirical research.

1. *What are drivers for a traceable food supply chain?*

There are many concerns, drivers and opportunities described in literature that explain why the food supply chain is going to be more traceable. (1) *Safety and quality concerns* where companies try to make food crisis better manageable. Second, there is a range of specialized products (hormone-free, organic, antibiotic-free and other non-observable product attributes) which cause a need to have a more traceable supply chain. (2) *Regulatory drivers* where regulation exist to prevent food safety issues and companies are forced to comply to these rules. (3) *Social drivers* where there is a need to know the origin of products and how products are made, a need for typical information because of allergenicity, food intolerance or lifestyle choice, a need to identify GMO and non-GMO chains and a need to identify carbon labelling and the conception of food miles. (4) *Economic drivers* about effective recall management and achieving competitive advantages. (5) *Technological opportunities* in which technical innovation makes it able to be better traceable.

2. *What logistic and organisational factors affect food traceability?*

Different factors could have an impact on the 'level of food traceability' which are described in literature. In total four different logistic and organisation factors are defined. (1) *Physical infrastructure* in which storage, production processing lines and transport belongs to relevant sub-factors. (2) *Operational processes and control* which is divided in incoming products, storage, production and outgoing products. (3) *Data capturing and information exchange* where important sub-factors are: identification, registration and administration and communication. (4) *Supply chain organisation* where relevant traceability sub-factors are: written contracts, duration of the relationship, trust and power. These factors and sub-factors that describe the logistic and organisational structure are also related to each other.

3. *How will logistic and organisational factors change in the supply chain of the Dutch potato sector when going from the current situation to a traceability scenario in which a higher level of traceability is desired?*

With regard to a changing logistic and organisational structure, the respondents together came up with 8 different changing factors. Some factors are related to each other, while others could be changed without any consequences for other factors.

Table 13: Changing logistic and organisational factors

	Changing factor	Explanation	Explanation
1	Physical infrastructure	Transport	Transport from field to potato storage is separated to (1) one farmer or even further to (2) a single potato field
2	Physical infrastructure	Storage	Potato storage is separated to (1) one farmer or even further to (2) a single potato field
3	Operational processes and control	Production	Raw potato batches (from (1) one farmer or (2) a single potato field) are put into production separately
4	Operational processes and control	Production	Stop points between raw potato batches during a single production run
5	Data capturing and information exchange	Communication, registration and administration	All farmers work with an online crop registration form
6	Data capturing and information exchange	Communication	All freezing houses work with a HUM system
7	Data capturing and information exchange	Communication, registration and administration	Knowing the customer/consumer who bought the product
8	Data capturing and information exchange	Communication, registration and administration	The existence of one system where there is a direct traceability overview

The first four factors are related to each other. These factors increase the level of traceability by making a better distinction in raw potato batches - separating raw potato batches based on (1) a farmer or (2) a single potato field - during transport, storage and production. The level of separating should be the same during the whole process from transport to storage, to production. It is not useful to first transport potatoes separately based on a single potato field and later on to store potatoes based on farmer level - it makes no sense. Therefore determining the level of separation for the first phase (transport) also determines the level of separation for the second phase (storage) and so on. The last four factors could be changed without any consequence for other factors.

4. *What are the trade-offs that organisations in the supply chain of the Dutch potato sector have to make when going from the current situation to a traceability scenario in which a higher level of traceability is desired?*

The decision whether to change a factor or not depends on the trade-off. Based on the changing factors as stated above, 5 trade-off statements can be defined:

Trade-off 1. **PHYSICAL INFRASTRUCTURE** | Transport from field to potato storage is separated to (1) one farmer or even further to (2) a single potato field

Organisations have to choose whether they want to have *smaller tracing units*, in exchange for *less efficient transport*, *higher costs* and *being less sustainable*.

Trade-off 2. **PHYSICAL INFRASTRUCTURE** | Potato storage is separated to (1) one farmer or even further to (2) a single potato field

Organisations have to choose whether they want to have *smaller tracing units* in exchange for *lower air circulation capacity of stored potatoes*, *more time needed to move potatoes from storage to production* and *higher costs*.

Trade-off 3. **OPERATIONAL PROCESSES AND CONTROL** | Raw potato batches (from (1) one farmer or (2) a single potato field) are put into production separately

Organisations have to choose whether they want to have *smaller tracing units* in exchange for *less consistent quality of output*, *less optimal use of raw potato batches* and a *more complex production process.*

Trade-off 4. **OPERATIONAL PROCESSES AND CONTROL** | Stop points between raw potato batches during a single production run

Organisations have to choose whether they want to have *smaller tracing units* in exchange for a *less consistent quality of output*, a *less efficient production process* and *higher costs*.

Trade-off 5. **DATA CAPTURING AND INFORMATION EXCHANGE** | All freezing houses work with a HUM system

Organisations have to choose whether they want to have a *shorter time to trace* and a *more reliable traceability analysis* in exchange for *being less flexible*.

Five trade-offs are defined while at least 8 changing factors are mentioned earlier. Respondents who pinpointed changing factors not always find trade-offs for these changing factors. For some changing factors there exist no reducing or forgoing desirable outcomes. For instance, the implementation of a better internal central traceability system is just a way of time before systems are better connected into one system – it doesn't have negative consequences when it is implemented according respondent PI2.

5.2 Research question

What scenario with regard to traceability may be adopted in the supply chain of the Dutch potato sector and what will be the trade-offs when going from the current situation to a traceability scenario in which a higher level of traceability is desired?

Starting point of this research showed different drivers why the food supply chain is becoming more traceable. The desired 'level of traceability' asks for a certain logistic and organisational structure in order to obtain that level of food traceability. When the supply chain, and in this research specific, the Dutch potato supply chain wants to increase the level of food traceability, the logistic and organisational structure may be changed as well. Interviews with supply chain parties from farmer to retailer and interviews with experts were used to pinpoint these changing factors in case a higher level of traceability is desired. Whether to change the logistic and organisational structure or not depends on the trade-offs to become more traceable. In total 8 different changing logistic and organisational factors should be changed in to obtain a higher level of food traceability; and 5 trade-offs are defined.

There could exist several scenarios of how the future can unfold regarding traceability in the Dutch potato supply chain. In this research two scenarios are set up: a scenario I in which raw potatoes are separated on farmer level; and a scenario II in which potatoes are separated on field level as can been seen on the next page. The level of separation has consequences for transport, storage and production and cause a difference in the level of traceability between scenario I and scenario II. If the level of separation has been increased from scenario I to scenario II - from separating potatoes based on farmer level to field level - the tracing units have become even smaller and therefore the level of traceability has increased more while almost all other desirable outcomes have become even worsen.

Only the decreased level of flexibility remains constant between scenario I and scenario II because the changing factor of working according HUM does not change between these scenarios and do therefore not contribute to a further decreasing level of flexibility. An overview of the current situation, traceability scenario I and traceability scenario II is given below.

CURRENT SITUATION		
Current time to trace Current tracing unit Current reliability of a traceability analysis	Current logistic and organisational structure	Current desirable outcomes

TRACEABILITY SCENARIO I		
+ Shorter time to trace + Smaller tracing units + More reliable traceability analysis	Transport and storage based on *farmer level* Stop points All farmers use an online crop registration form All freezing houses work according HUM Knowing the customer One traceability system	- Less efficient transport - Higher costs - Being less sustainability - Lower air circulation capacity of stored potatoes - More time needed to move potatoes - Less consistent quality of output - Less optimal use of raw potatoes - More complex production process - Less efficient production process - Being less flexible

TRACEABILITY SCENARIO II		
+ Shorter time to trace ++ Smaller tracing units + More reliable traceability analysis	Transport and storage based on *field level* Stop points All farmers use an online crop registration form All freezing houses work according HUM Knowing the customer One traceability system	- - Less efficient transport - - Higher costs - - Being less sustainability - - Lower air circulation capacity of stored potatoes - - More time needed to move potatoes - - Less consistent quality of output - - Less optimal use of raw potatoes - - More complex production process - - Less efficient production process - Being less flexible

The table on the previous page doesn't mean that there do not exist other possible scenarios. Several more scenarios could exist in which more combinations of changing factors could be found. The literature review and the interviews showed that the level of separation of raw potatoes has an important impact on the tracing unit - which determines the level of traceability - and therefore the decision has been made to formulate two scenarios based on the separation level. Off course with all other changing factors, much more combinations are possible to formulate several traceability scenarios.

6. Discussion

This chapter will discuss the answer to the research question, and how the results can be interpreted. Second, the chapter discusses the limitations of the conducted research. Finally some recommendations for further research are given.

6.1 Interpretation of results

All respondents were asked about the changing factors of the logistic and organisational structure to become more traceable. Almost all factors and sub-factors of the theoretical framework were pinpointed. Sub-factors of the *supply chain organisation* were not explicated mentioned as changing factors. Although they were not directly pinpointed, some respondents mentioned that the supply chain organisation (*trust*, *duration of the relationship* and *power*) could become a challenge when a higher level of traceability is desired. It could be for example that farmers are not willing to exchange all crop registration through the whole supply chain because of distrust that information will be used for other purposes than traceability.
None of the respondents mentioned the sub-factor of *written contracts*. It does not mean that written contracts do not influence the level of traceability - they were just not explicit mentioned by the 15 respondents.
It has already been mentioned in the literature review that there is an increasing need for the industry to use standards so that multiple information technology solutions can 'talk to each other'. That point of improvement is confirmed by the respondents. They explained that there is a need for one system in which there is a total view of all relevant information and that the problem nowadays is the existence of all separated systems where people should connect these systems by themselves.

Nobody can look into the future or can predict what kind of changes are made by organisations in the Dutch potato supply chain to obtain a higher level of traceability. Asking the respondents about traceability and the changing factors to become more traceable, many respondents explained that traceability has to do with risk analysis. Regarding food safety a potato doesn't have a lot of risks, potatoes will always be cooked, and there are almost never microbiological problems - it is considered as a relative safe product (EX1). A processor will always assess the change that something goes wrong in combination with the impact of that risk. *"The basic of track and trace is off course your risk. What is the risk profile of your product? When there are no heavy metals or toxic components, and you have your control and cleaning checks in place - you will decrease the risk significantly. Thus, the risk of the product is low. And based on that we set up our traceability system"* (Respondent PI5). Respondent RE2 explained that the current situation doesn't ask for a changing environment. *"Working following the current system nowadays hasn't changed our mind into: "we have to change our system, and therefore we will make the supply chain more secure, and we are going to make recalling cheaper""* (Respondent RE2). Respondent PI1 doesn't think that stop points - as described as a changing factor - will exist in the future. From the perspective of the respondent (PI1) there are no issues nowadays regarding the current traceability level. There will always be a consideration whether to invest money in order to improve traceability or to invest in a new machine to improve processes. Improving processes could directly increase the efficiency of processes while improving traceability will not contribute to a higher level of efficiency (PI6), (it can even be concluded that being more traceable will be less efficient). Although potatoes belong to a low risk product it became clear that Quick Service Restaurants (QSRs) pay attention to traceability and that they ask for a faster traceability analysis than is required by current regulation. Regulation states that a traceability analysis should be done in 4 hours, while some QSRs ask for a traceability analysis in 2 hours. Except that consideration, traceability could also be used as a unique-selling point. Respondent PI2 explained that in countries as the United Kingdom, Austria and Germany there is an increasing interest of knowing the origin of products and is therefore a reason to become more traceable. It is up to the customer of a processor to determine the level of traceability and to decide how precise batches have to be separated in order to define a traceable resource unit. It is finally a QSR or retailer who has to make the decision whether they accept a final product that is less homogeneous in exchange for a higher level of traceability (PI2). If the decision has been made to obtain a higher level of traceability – and to separate batches based on field level, also other consequences should be taken into account, like less efficient transport, higher costs and being less sustainable - because trucks could only keep one potato field and thus there will be more semi-loaded trucks. As a consequence there could be a development of increasing hectares for a single potato field. More hectares per potato field makes it possible to have less semi-loaded trucks and that will decrease the impact of separating raw potatoes based on field level - less impact on the efficiency of transport, less impact on transport costs and less impact of being sustainable.

Some changing factors were explained by respondents without mentioning increasing traceability outcomes or decreasing other desirable outcomes. Therefore five trade-off statements were formulated while at least 8 changing factors were argued. It could be assumed that although there were sometimes no decreasing outcomes mentioned - a changing factor may involve some investments or costs. For instance the example given by the retailer to extend the barcode on consumer packages in order to be able to connect the customer with a specific batch number. Such changes do have an impact on all current systems and packages and off course involves higher costs and investments although the respondent didn't mention a trade-off regarding this changing factor.

Respondent WM2 explained that individual raw potato batches are only put together in the processing industry. Seed potatoes will never be blended. Fresh potatoes are always from one farmer, and most of the time also from one field (WM2). A lot of trade-offs that are described in the conclusion part are based on the consequences of blending strategies from the processing industry. Therefore most of the trade-offs described are applied to the processing industry and not to the industry that deals with fresh potatoes.

6.2 Limitations

The reader should bear in mind that the study is based on 13 interviews with 15 respondents. It has been tried to find a group of respondents who represent the whole supply chain of the Dutch potato sector - from farmer to retailer and QSR. The respondents who were interviewed are working at well-known organisations in the Dutch potato supply chain. Although only two out of four well-known processors are interviewed, it could be assumed that in this competitive market these organisations will follow each other based on the latest developments. A respondent of the processing industry explained that the logistic and organisational structure regarding traceability will not be that different from competitors. In case other processors are changing the logistic and organisational structure regarding traceability, the respondent explained that they adapt their logistic and organisational structure too, and vice versa: if they will change their logistic and organisational structure, that other organisations will follow as well. It has been tried to interview at least one respondent from every part of the supply chain. Unfortunately no interview has been taken with a respondent from a well-known QSR (McDonalds, Burger King or KFC). From respondents of the processing industry, experts and from own experiences to try to contact a QSR, it turned out that it was impossible to find a respondent who is representing a QSR. As an alternative I tried to contact Smullers, which is the organisation that belongs to NS Retail and which is selling French fries at several railway stations in the Netherlands. Second, I tried to contact LaPlace which is selling French fries at shopping centres, festivals or events. Smullers was not willing to participate in the research and LaPlace didn't react on the interview request. Especially QSRs are asking the processing industry for traceability analysis's, sometimes even stricter than current regulation requires. Especially therefore an interview with a QSR could have been interesting for this research.

Finally it should be mentioned that the 8 described changing factors and the 5 formulated trade-offs are the result of 13 different interviews with 15 respondents in total. It doesn't mean that there are not more factors which should be changed in order to obtain a higher level of food traceability, or not many more trade-offs that do exist. These changing factors, sub-factors and trade-offs are just the result of all 13 interviews.

6.3 Relevance of research

Many papers describe that the trade-offs to become more traceable are unclear. Van de Vorst (2004) mentioned in his paper that one of the bottlenecks for a full, fast and reliable traceability in the supply chain are the little economic incentives for traceability. *"It is unclear what the exact benefits of traceability will be and it is also unclear what the costs of traceability are"* (Vorst, van der, 2004). Bosona and Gebresenbet (2013) explained that *"allocating the cost and benefits among the partners of food supply chain needs extra effort"*. Donelly et al. (2012) stated that *"further research is required on assessing the cost and benefits for individual sectors of implementing varying levels of traceability"*. In a paper of Karlsen et al. (2013) they refer to another study carried out by Karlsen, Sorensen et al. (2009): *"Motivation is a critical factor for implementing traceability, and that motivation is closely linked to the identification of benefits and costs associated with traceability. Consequently, identifying costs and benefits is essential when companies decide to implement traceability."*

This research provides more insight in the trade-offs when a higher level of traceability is desired. Several statements, which are described above mentioned the importance to clarify the exact benefits and costs of traceability - in which this research explained by trade-off statements which increasing traceability outcomes are at the expense of other desirable outcomes. Each individual supply chain part whether it is a farmer, a warehouse merchant or processor may have insight in their own trade-offs when they want to be more traceable. But are they taking into account the trade-offs for the other supply chain parties? In particular this research focused on the whole supply chain - which is important when changing the logistic and organisational structure. Organisations should be aware of the consequences for the whole supply chain when they desire to become more traceable - in which this research report provides an overview of all consequences of traceability in the whole supply chain.

6.4 Recommendations for further research

The research was focused on the supply chain of the Dutch potato sector from farmer to retailer. Interviews took place with parties that are concerned with processed potatoes (farmer, intermediate trader, processors) and parties which are more concerned with fresh potatoes (cooperative and retailers). As respondent WM2 explained, there is a difference observable between processed potatoes, in which blends do exist, and fresh potatoes, in which blending do (almost) not exist. Further research about traceability in the Dutch potato supply chain should better focus one of the two different industries - processed potatoes or fresh potatoes - because of the impact of using blends in combination with traceability. Only investigate the potato processing industry or only investigate the fresh potato industry regarding traceability.

Further research should also make trade-offs more specific. For example the trade-off about stop points between different batches. It will have a positive effect on the tracing unit, while it decreases efficiency as can be concluded from this research. Further research should go more into deep to calculate the change in tracing unit and the change in efficiency between the current process and a process in which stop points exist between every raw potato batch from every farmer. For example, calculate how many products can be produced in the current situation compared to the amount of products that can be produced if there are stop points between every potato batch from an individual farmer – and how will that affect the size of tracing unit. And how will that solution differ if the potatoes may be separated further, based on a single potato field?

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Appendix

Appendix I Dutch potato supply chain

Because the research objective is focused on the Dutch potato supply chain this appendix will describe the Dutch potato supply chain in order to better understand which parties are involved, the relation and interdependencies between parties and the distribution of power.

The potato industry is an important industry for the Netherlands. The Netherlands has the largest potato processing industry in the world after the United States (Smit, Driessen, & Glasbergen, 2008). One-third of the value added in arable farming in the Netherlands is coming from potatoes.

Parties in the supply chain

The supply chain of the potato sector starts with breeding companies who are responsible for growing seed potatoes. Thereafter a seed potato grower use these seed potatoes to multiply them. These seed potatoes will most of the time go to (seed potato) merchants, packers or processors. Only in some cases (10-15 percent) breeding companies sell their seed potatoes in a free market directly to a grower (hereafter called farmer). In all other cases farmers buy their seed potatoes from (seed potato) merchants, packers or processors (Smit, Driessen, & Glasbergen, 2008; Kocsis, Weda, & Nol, 2013). Farmers who obtain their seed potatoes from their eventual customers, have to sell at least a part of their yield that comes from these seed potatoes back to their customers (Smit, Driessen, & Glasbergen, 2008). These customers can be traders, packers or processors.

From there processed potatoes or fresh potatoes will reach the consumer by retailers, food service or fast food restaurants (Smit, Driessen, & Glasbergen, 2008). An overview of the potato (product) flow can be found in the picture below (Figure 1).

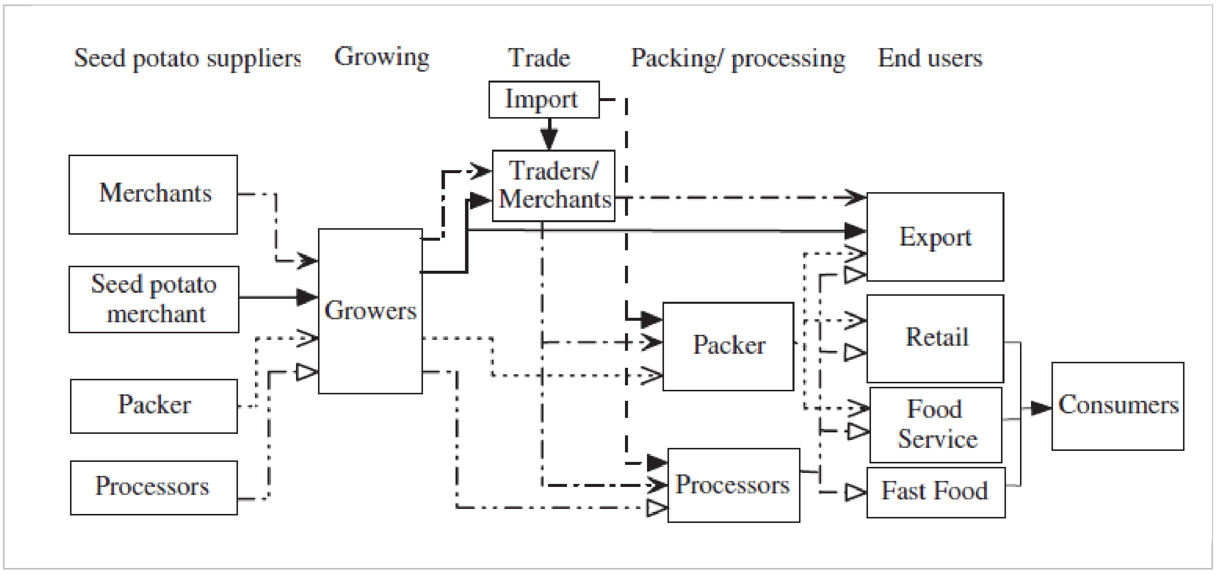


Figure 1: Potato (product) flow (Smit, Driessen, & Glasbergen, 2008)

A farmer has different options in selling its product to a customer. The first option is where a farmer buys its seed potatoes directly, he will grow his crop and sell it afterwards at the moment when the market conditions for the product appear to be favourable. This is called unconstrained (free) growing. On the other hand, market conditions could also be unfavourable which will imply that a farmer will get a low price for his potatoes and therefore this method is risky. The second option is to join a cooperative where the supply of seed potatoes is managed by the cooperative as well as the selling of potatoes. The last option has already been mentioned and in this case a farmer will get its seed potatoes from the customer. An arrangement is made between a farmer and a customer where they decide on forehand if the total yield will be sold to the customer, or that only a part of it will be sold. A contract between a farmer and a trader, packer of processor could be for one year, but many times these relationships continues for a longer time (Smit, Driessen, & Glasbergen, 2008).

Looking to the distribution of all the parties involved there are many growers and farmers, there is even an overcapacity, where there are relatively few buyers, which make the growers and farmers belong to the less power full group (Smit, Driessen, & Glasbergen, 2008). The four biggest processors, Aviko, McCain, Lamb Weston Meijer and Farm Frites together are responsible for 87 percent of the total potato processing industry in the Netherlands (Kocsis, Weda, & Nol, 2013). Aviko is the biggest processor of potatoes for supermarkets. This limited number of processing companies sell to the retail industry, food-service companies and fast food corporations (Smit, Driessen, & Glasbergen, 2008). In particular the retail sector and fast-food sector do also have a powerful position in the market because this group do not consist of many players. And especially this group buys a large amount of potatoes and is therefore able to determine who supplies them, and is most of the time able to determine the price (Smit, Driessen, & Glasbergen, 2008). Except the processing industry there is also a part in the supply chain that sells fresh cooled potato products. CêlaVita and PeKa Kroef do have 80% of the total market share in this market (Kocsis, Weda, & Nol, 2013).

Certification

In the Dutch market several safety and quality certificates are used including for example VVa (Smit, Driessen, & Glasbergen, 2008) or GLOBAL-GAP (AgriHolland, 2016). Many contracts require the farmer to grow its potatoes according to these safety requirements. These certifications also deal with systems of tracking and tracing and should ensure that the origin of products could be determined when a food safety or food quality problem occur. Most of the potatoes are supplied under contracts (75-90 percent) between farmers, traders and processors, the remainder is partially or entirely ‘free’ (Smit, Driessen, & Glasbergen, 2008).

Appendix II Regulation on food traceability

It could be assumed that at least every company meets the minimal legal requirements for food safety and food traceability. As explained in the introduction chapter, there were many food incidents and food scandals in the past. As a consequence, from 1990, traceability was put on the agenda of the European Commission. Food traceability became part of food regulations as a result of the increasing interest in food traceability (Karlsen, Dreyer, Olsen, & Elvevoll, 2013). The first food regulation focused on the livestock sector. New rules and legislations contained required traceability labelling for beef products and a mandatory cattle identification (Hobbs, 2006). Later on a broader legislation was made in the EU. This section will give a short overview of important international (European) rules and legislation that apply to food traceability.

Council directive 89/396/EEC
This directive requires that all foodstuffs who are on the EU market should be marked to identify a lot or batch which is packaged and produced under practically the same conditions. That requirement does not apply for agriculture products which are sold or delivered to temporary storage, transported to producers or when collected for operational preparation - in other words when not used for direct consumption. The identification of a lot or batch is also allowed if the label consists of a 'use by' date, if it at least consists of a day and month (EC, 1989).

White paper on food safety
In 2000, the European Commission developed a 'White paper on food safety' (EC, 2000) to reflect on the priority for a high level of food safety in Europe and introduced an European Food Authority. To ensure a high level of human health and consumer protection they formulate the 'Principles of Food Safety'. One of the principles gives attention to food traceability: they make clear that traceability of food and feed are needed for a successful food policy; and they expressed the importance to introduce adequate procedures to facilitate food traceability. Procedures are needed to be able to withdraw feed and food from the market that could cause risk for consumers; or to obligate suppliers to keep records of raw materials and ingredients to identify the source in case of a food crisis.

General Food Law 178/2002/EG
On January 28th 2002, the European Commission adopted these principles and requirements of food law into Regulation (EC) No. 178/2002. That document describes different articles concerning food safety. Article 18 of that document (EC, 2002) gives the regulation of traceability. The article describes that all food, feed, food-producing animals, and any other substance intended to be for production, processing and distribution should be traceable. Second, it obligates food and feed business to use systems to store information about food, feed, food-producing animals, and any other substance intended to be from their suppliers. Third, it also obligates to us an adequate labelling system to facilitate traceability, through relevant documentation or information in accordance with the relevant requirements of more specific provisions. The whole regulation of this article by the European Commission applies from the 1st of January in 2005. The full article that describes this regulation from the European Commission can be found in the Appendix II.

ISO 22005 Food Safety Standard

In the ISO 22005 Food Safety Standard it is stated that it is obligated that each company know their immediate suppliers and customers based on the principle of one-up and one-down. In addition it states that one weak link in the supply chain can result in unsafe food, which can present a serious danger to consumers and have costly repercussions for the suppliers. *"Food safety is therefore the joint responsibility of all actors involved"* (Storoy, Thakur, & Olsen, 2013).

Since 2005, all players in the food supply chain should meet the legislation of the General Food Law. All parties involved (the primary sector, producers, distributors and retail) should manage the supply chain in order to meet the minimal safety level to insure safety for consumers (Tielemans, 2004).

Although legislation differ for each part of the world, many organisations are global players and they have to comply to the rules and legislations of each part of the world in which they act (Vorst, van der, 2004).

Appendix III Article 18 of General Food Law 178/2002/EG

Article 18

Traceability

1. The traceability of food, feed, food-producing animals, and other substance intended to be, ore expected to be, incorporated into a food or feed shall be established at all stages of production, processing and distribution.

2. Food and feed business operators shall be able to identify any person from whom they have been supplied with a food, a feed, a food-producing animal, or any substance intended to be, or expected to be, incorporated into a feed or feed.‘

3. To this end, such operators shall have in place systems and procedures which allow for this information to be made available to the component authorities on demand.

4. Food and feed business operators shall have in place systems and procedures to identify the other business to which their products have been supplied. This information shall be made available to the component authorities on demand.

5. Food or feed which is placed on the market or is likely to be placed on the market in the Community shall be adequately labelled or identified to facilitate its traceability, through relevant documentation or information in accordance with the relevant requirements of more specific provisions.

6. Provisions for the purpose of applying the requirements of this Article in respect of specific sectors may be adopted in accordance with the procedure laid down in Article 58(2).

Appendix IV Interview outline

INTERVIEWVRAGEN

TRACEABILITY IN DE NEDERLANDSE AARDAPPELINDUSTRIE

JUNI 2016

Interview outline - final version 2.0 (25.05.2016).docx

BEGELEIDENDE TEKST

Ik heb in het *begeleidend schrijven* al het een en ander uitgelegd over mijn onderzoek naar 'traceability in de Nederlandse aardappelindustrie', maar zal nu in het kort nog even uitleggen wat mijn scriptie inhoudt.

De scriptie maakt onderdeel uit van mijn masteropleiding Management, Economics and Consumer studies aan de Wageningen Universiteit. De scriptie gaat over 'traceability in de Nederlandse aardappelindustrie'. Zoals ik eerder in het begeleidend schrijven heb verteld wordt traceability een steeds belangrijker onderwerp in de voedingsindustrie.

Traceability vraagt om een bepaalde logistieke en organisatorische structuur van zowel organisatie als de voedselketen zelf. In mijn theoretisch onderzoek heb ik gekeken naar deze logistieke en organisatorische factoren die van invloed kunnen zijn op traceability in de voedingsindustrie (zie bijlage). Mijn onderzoek is gericht op welke logistieke en organisatorische factoren er veranderen voor de Nederlandse aardappelindustrie als in de nabije toekomst traceability ook steeds belangrijker wordt in deze industrie.

Daarom houd ik interviews met organisaties uit de hele keten van pootaardappel tot aan consument: telers, boeren, aardappelverwerkers, tussenhandelaren, retailers en voedingsservice bedrijven. Vragen voor het interview gaan over de logistieke en organisatorische factoren welke ik heb weergegeven in de bijlage. Het interview zal ongeveer *een x-aantal minuten* in beslag nemen. Interviewvragen heb ik vooraf opgesteld met ruimte tussendoor om ook andere vragen te kunnen stellen. Ik heb vooraf een tweetal vragen:

1. Mag ik het interview opnemen? Ik zou dit graag doen zodat ik alle aandacht kan leggen op het stellen van vragen en mij niet hoef bezig te houden met het noteren van alle antwoorden. Ik zal enkel en alleen tussendoor een aantal aantekeningen maken voor eventuele extra vragen.

2. Indien gewenst zullen antwoorden volledig anoniem zijn.

Achteraf zal ik een volledig interviewtranscript maken. Interviewtranscripten worden niet in het eindrapport opgenomen en dienen enkel en alleen voor de analyse.

VRAGEN TER INTRODUCTIE

0.1 Wat is uw dagelijkse functie bij organisatie X en welke taken voert u daarbij uit?

0.2 Indien X een traceability analyse uit wilt voeren wat kunt u dan zeggen over…

0.2.1 … de tijd waarin een bepaalde partij geïdentificeerd kan worden?

0.2.2 … de omvang van deze partij?

0.2.3 … de betrouwbaarheid van de analyse?

VRAGEN MET HET ONDERWERP 'ORGANISATIONAL PROCESS' AND 'PHYSICAL INFRASTRUCTURE'

1.1 Kijkend naar de hele aardappelketen…

1.1.1 … welke goederen en producten komen organisatie X binnen ten behoeve van productie welke een onderdeel uitmaken van het eindproduct?

1.1.2 … welke bedrijfsprocessen (opslag, transformaties, transport) vinden er vervolgens plaats in organisatie X?

1.1.3 … wat is de output (verpakte tafelaardappelen, verwerkte aardappelproducten zoals friet, chips etc.) van deze bedrijfsprocessen?

1.1.4 … wat voor problemen kunnen zich voordoen als het gaat om voedselveiligheid?

1.1.5 … waar in deze bedrijfsprocessen bevinden zich kritieke punten betreft voedselveiligheid?

Met bovenstaande vragen kan een illustratie (Bijlage vraag 1.1) gemaakt worden van de af te spelen bedrijfsprocessen in organisatie X en waar in het proces zich de kritieke punten bevinden als het gaat om voedselveiligheid. De tekening moet aanleiding geven tot het verder bediscussiëren van onderstaande punten met betrekking tot traceability: partijdefinitie, opslag, transformatie en transport.

1.2 Hoe definieert X de partij-omvang van de binnengekomen producten?

1.3 Als het gaat over de momenten van opslag van binnenkomende producten dan wel halffabricaten…

1.3.1 … hoe worden binnenkomende producten dan wel halffabricaten opgeslagen?

1.3.2 … welke opslagstrategie (een partij per silo; een partij per silo zonder schoonmaak; meerdere partijen per silo en periodiek legen; meerdere partijen per silo en geen periodieke leging) hanteert X om haar partijen op te slaan?

1.3.3 … welke mogelijke informatie met betrekking tot de eigenschappen (temperatuur, vochtgehalte, locatie etc.) van opslag worden er gemeten?

1.3.4 … waar wordt deze informatie opgeslagen?

1.3.5 … wat gebeurt er met deze informatie?

1.4 Als het gaat over transformaties (mixen, overplaatsing, toevoeging, opsplitsing) …

1.4.1 … welke vormen van transformaties (mixen, overplaatsing, toevoeging, opsplitsing) vinden er plaats?

1.4.2 … welke transformatiestrategie (*batch-mix method of semi-process method*) hanteert X?

1.4.3 … welke procesregistratie (registratie van werkelijk verbruik op productieorder; registratie van werkelijk verbruik niet op productieorder; backflushing/normatieve verbruiksboeking; grijpvoorraad) hanteert X om bij te houden hoeveel van welke partij een transformatie heeft ondergaan?

1.4.4 … welke mogelijke informatie met betrekking tot de eigenschappen (temperatuur, vochtgehalte, locatie etc.) van transformatie worden er gemeten?

1.4.5 … waar wordt deze informatie opgeslagen?

1.4.6 … wat gebeurt er met deze informatie?

De bijlagen bij bovenstaande vragen 1.4 moeten uitnodigen voor een discussie betreft transformatiestrategie, procesregistratie etc. Figuur 2, 3, 4, 5, 6 en 7 moeten nagaan welke transformatiestrategie X hanteert. Figuur 8 heeft betrekking op de procesregistratie.

1.5 Als het gaat over transport zowel intern als extern…

1.5.1 … hoe worden binnenkomende producten, halffabricaten en eindproducten getransporteerd?

1.5.2 … welke mogelijke informatie met betrekking tot de eigenschappen (temperatuur, vochtgehalte, locatie etc.) van dit transport worden er gemeten?

1.5.3 … waar wordt deze informatie opgeslagen?

1.5.4 … wat gebeurt er met deze informatie?

1.6 Als het gaat over de opslag van eindproducten, is er een onderscheid waarneembaar tussen de dragers van de eindproducten en de gedefinieerde partij?

1.7 Indien een hoger level van traceability geacht wordt…

1.7.1 … wat zal er aan bovenstaande deelgebieden (opslag, productie, transport) moeten veranderen om dit hoger level van traceability te behalen?

1.7.2 … wat zijn de consequenties van deze veranderingen?

VRAGEN MET HET ONDERWERP 'DATA CAPTURING AND INFORMATION EXCHANGE

2.1 Als het gaat over het te ontvangen product Y van de vorige ketenpartner?

2.1.1 … welke informatie ontvangt organisatie X van de vorige ketenpartner over product Y?

2.1.2 … met welke systeem (*optische systemen, RFID, natuurlijke kenmerken*) is deze informatie van de vorige ketenpartner geïdentificeerd?

2.1.3 … hoe is deze informatie door de vorige ketenpartner overgedragen en hoe is deze opgeslagen in organisatie X?

2.1.4 … wat wordt er met deze informatie gedaan?

2.2 Als het gaat over het over te dragen product Z aan de volgende ketenpartner?

2.2.1 … welke informatie ontvangt de volgende ketenpartner over product Z?

2.2.2 … met welke systeem (*optische systemen, RFID, natuurlijke kenmerken*) is deze informatie voor de volgende ketenpartner te identificeren?

2.2.3 … hoe wordt deze informatie overgedragen aan de volgende ketenpartner?

2.3 Indien een hoger level van traceability geacht wordt…

2.3.1 … wat zal er aan bovenstaande deelgebieden (de uit te wisselen informatie, informatieopslag, informatie-uitwisseling, informatiegebruik) moeten veranderen om dit hoger level van traceability te behalen?

2.3.2 … wat zijn de consequenties van deze veranderingen?

VRAGEN MET HET ONDERWERP 'SUPPLY CHAIN ORGANISATION'

3.1 Als het gaat over de samenwerking met de vorige ketenpartner…

3.1.1 … welke schriftelijke afspraken zijn er gemaakt betreft het uitwisselen van informatie of in geval van een incident (recall tijd, recall size, betrouwbaarheid) ?

3.1.2 … hoe lang zijn deze schriftelijke afspraken al gemaakt, en voor hoe lang gelden deze afspraken?

3.1.3 … welke informatie wordt ontvangen van de vorige ketenpartner betreft product Y, en welke informatie wordt (bewust of onbewust) niet ontvangen van de vorige ketenpartner?

3.1.4 … hoe betrouwbaar is de informatie van binnenkomende producten Y die verkregen worden van de vorige ketenpartner?

3.1.5 … in hoeverre kan X druk uitoefenen op de vorige ketenpartner om informatie te verkrijgen?

3.2 Als het gaat over de samenwerking met de volgende ketenpartner…

3.2.1 … welke schriftelijke afspraken zijn er gemaakt betreft het uitwisselen van informatie of in geval van een incident (recall tijd, recall size, betrouwbaarheid) ?

3.2.2 … hoe lang zijn deze schriftelijke afspraken al gemaakt, en voor hoe lang gelden deze afspraken?

3.2.3 … welke informatie wordt doorgegeven naar de volgende ketenpartner, en welke informatie wordt (bewust of onbewust) niet doorgegeven naar de volgende ketenpartner?

3.2.4 … hoe betrouwbaar is de informatie over product Z die ontvangen wordt door de volgende ketenpartner?

3.2.5 … in hoeverre kan de volgende ketenpartner druk uitoefenen om op organisatie X om informatie te verkrijgen?

3.3 Indien een hoger level van traceability geacht wordt…

3.3.1 … wat zal er aan bovenstaande deelgebieden (schriftelijke afspraken, vertrouwensrelatie, machtspositie) moeten veranderen om dit hoger level van traceability te behalen?

3.3.2 … wat zijn de consequenties van deze veranderingen?

VRAGEN TER AFSLUITING

4.1 Kijkend naar traceability, heeft zich in het verleden een incident voltrokken waarbij organisatie X of de hele aardappelindustrie traceability heeft moeten inzetten…

4.1.1 … welke gebeurtenis vond er plaats?

4.1.2 … op welk detailniveau heeft er een recall plaatsgevonden?

4.1.3 … hoe snel was een partij, dan wel productgroep geïdentificeerd?

4.1.4 … heeft de identificatie van een dergelijke partij problemen met zich meegebracht?

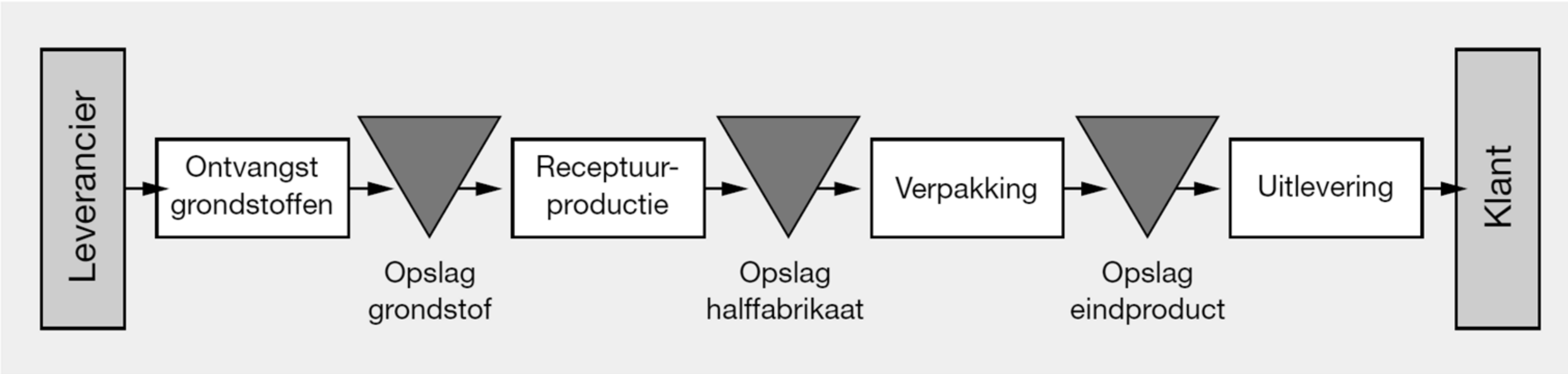
AFSLUITENDE TEKST

Dank voor het interview. Heeft u zelf nog vragen en of opmerkingen bij de gestelde vragen over het onderzoek naar traceability in de Nederlandse aardappelindustrie?

Heeft u nog contacten binnen de aardappelindustrie welke ik een zelfde interview kan en mag afnemen?

Mocht u later nog vragen hebben, dan kunt u te allen tijde contact opnemen met het bekende mailadres of telefonisch via +31 (0)6 517 58 204.

BIJLAGE BIJ VRAAG 1.1

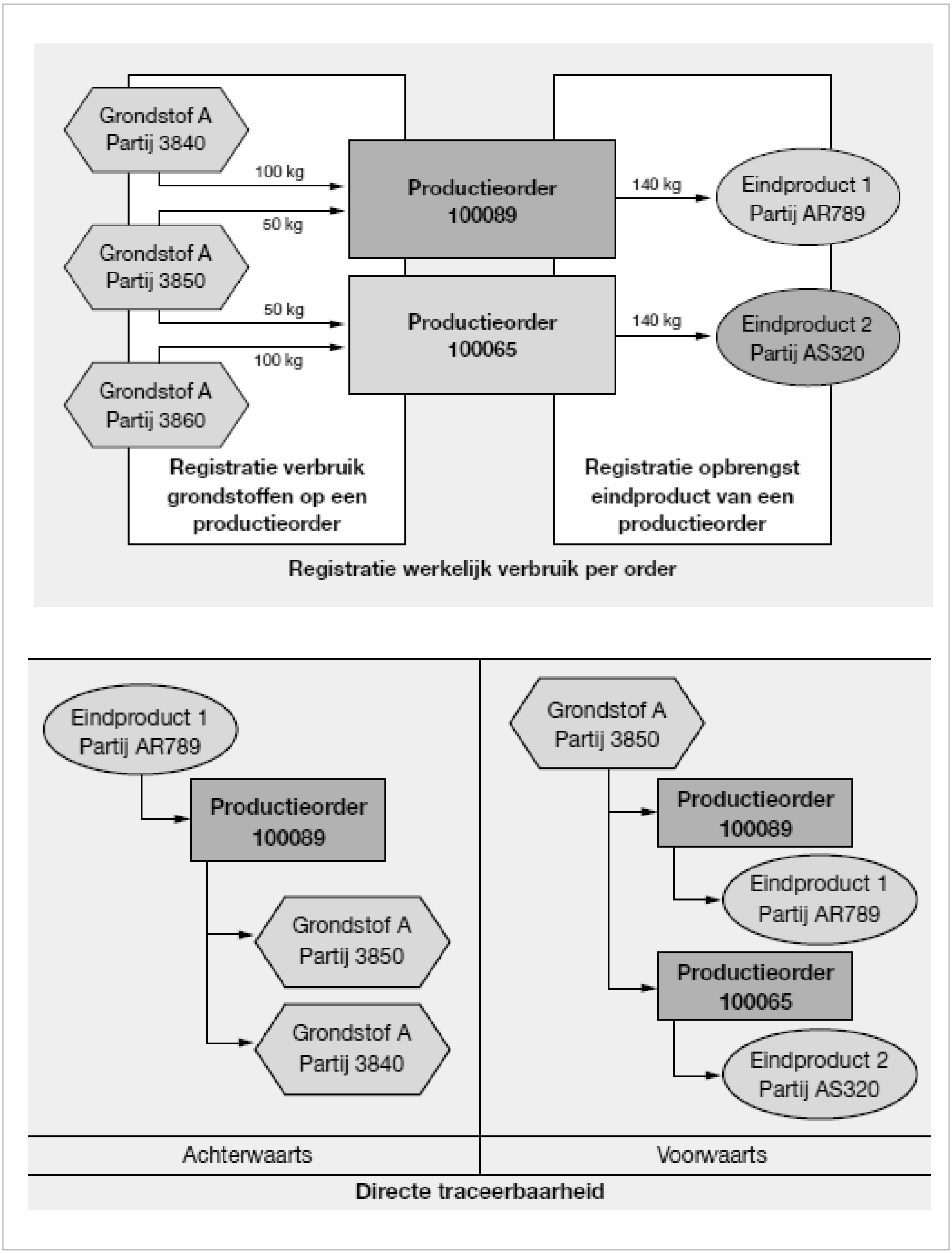


Figuur 1: Algemene illustratie van bedrijfsprocessen volgens Tielemans

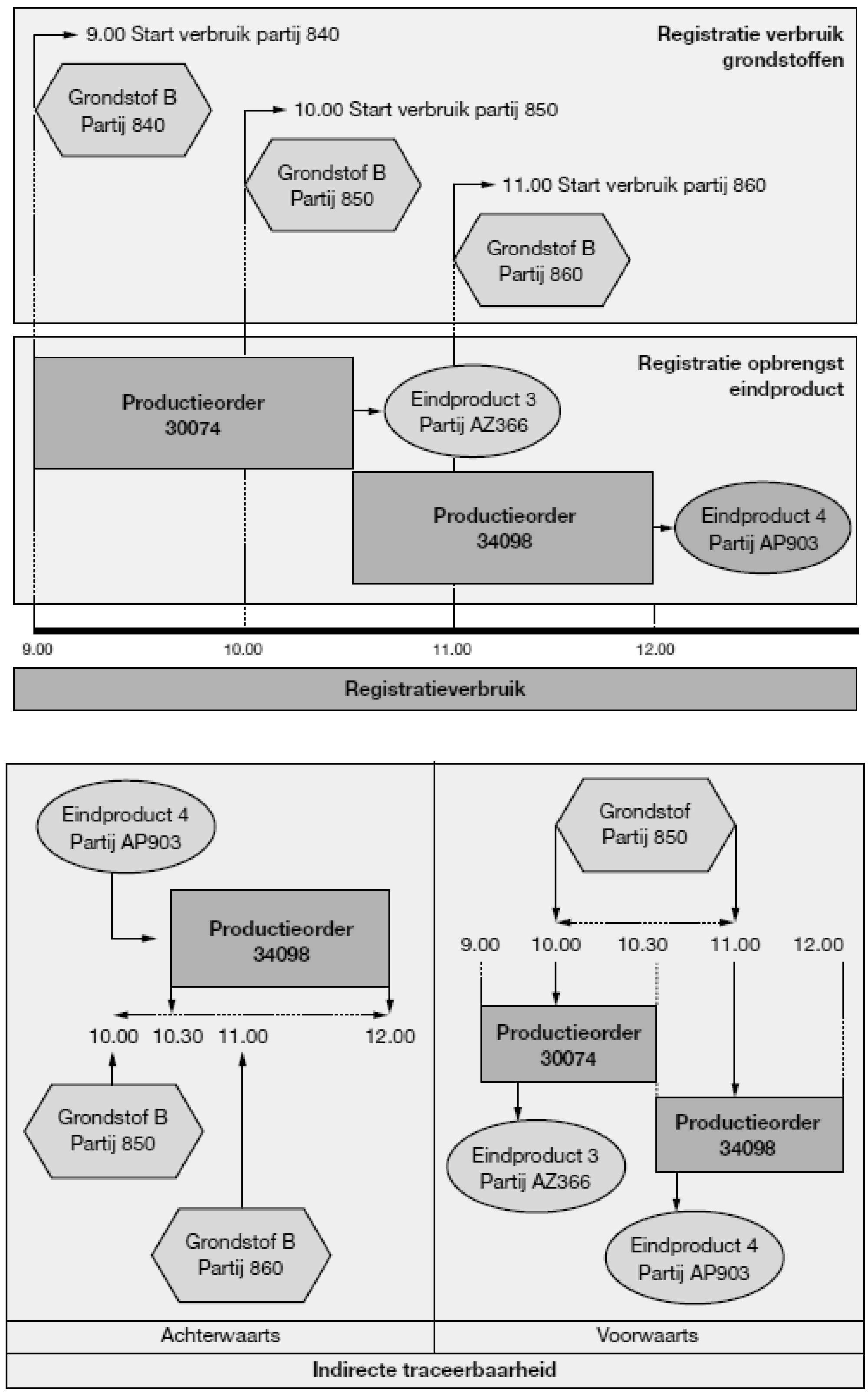
BIJLAGE BIJ VRAAG 1.1

Figuur 2: Illustratie van bedrijfsprocessen van organisatie X

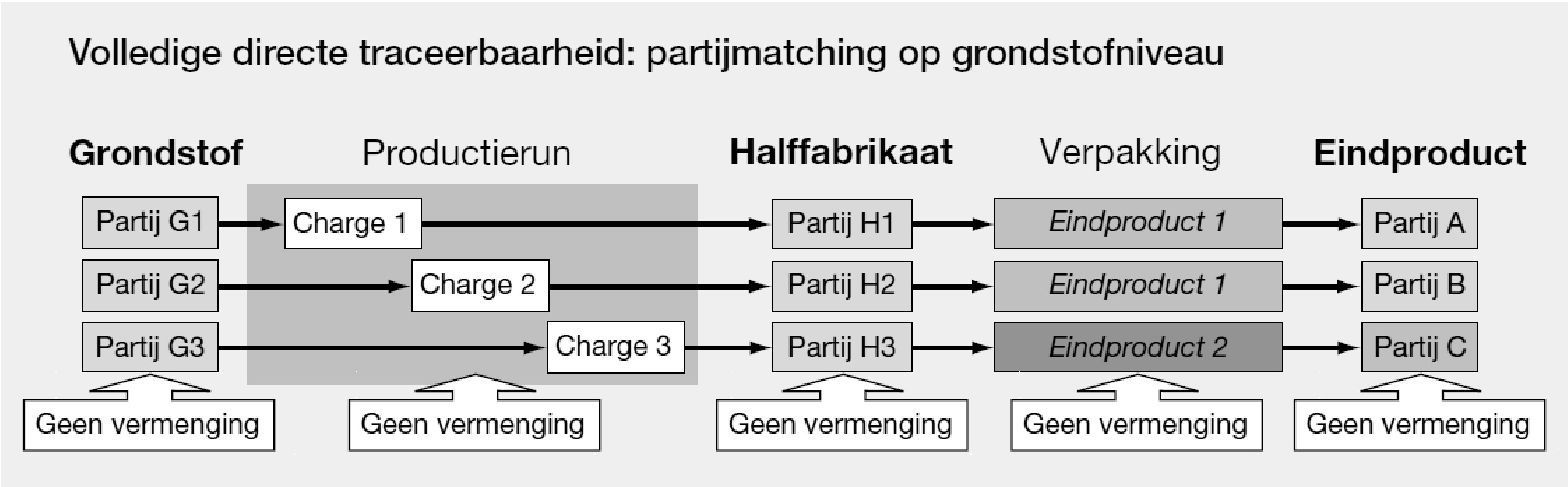
BIJLAGE BIJ VRAAG 1.4 (1)



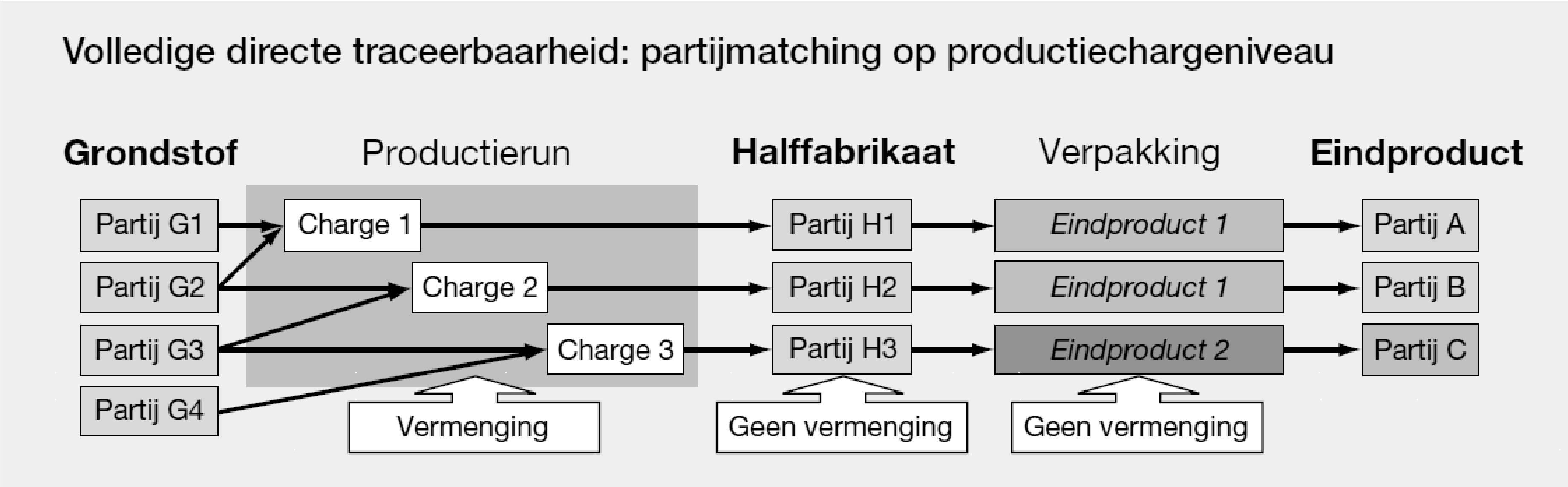
Figuur 3: Illustratie van batch-mix method



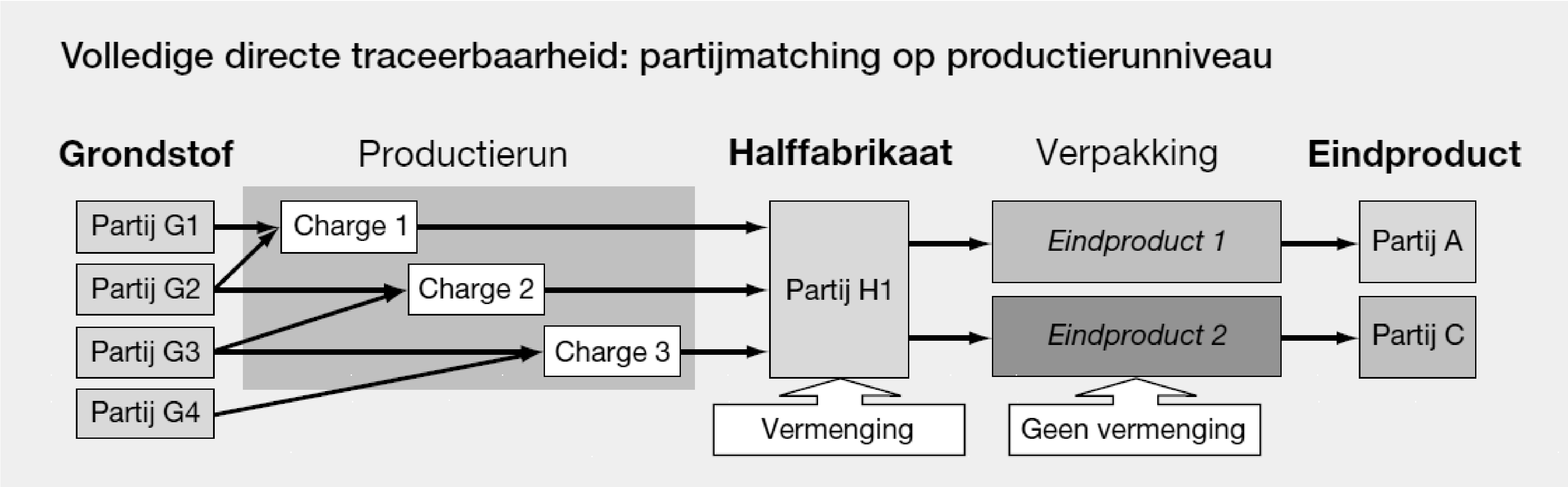
Figuur 4: Illustratie van semi-process method



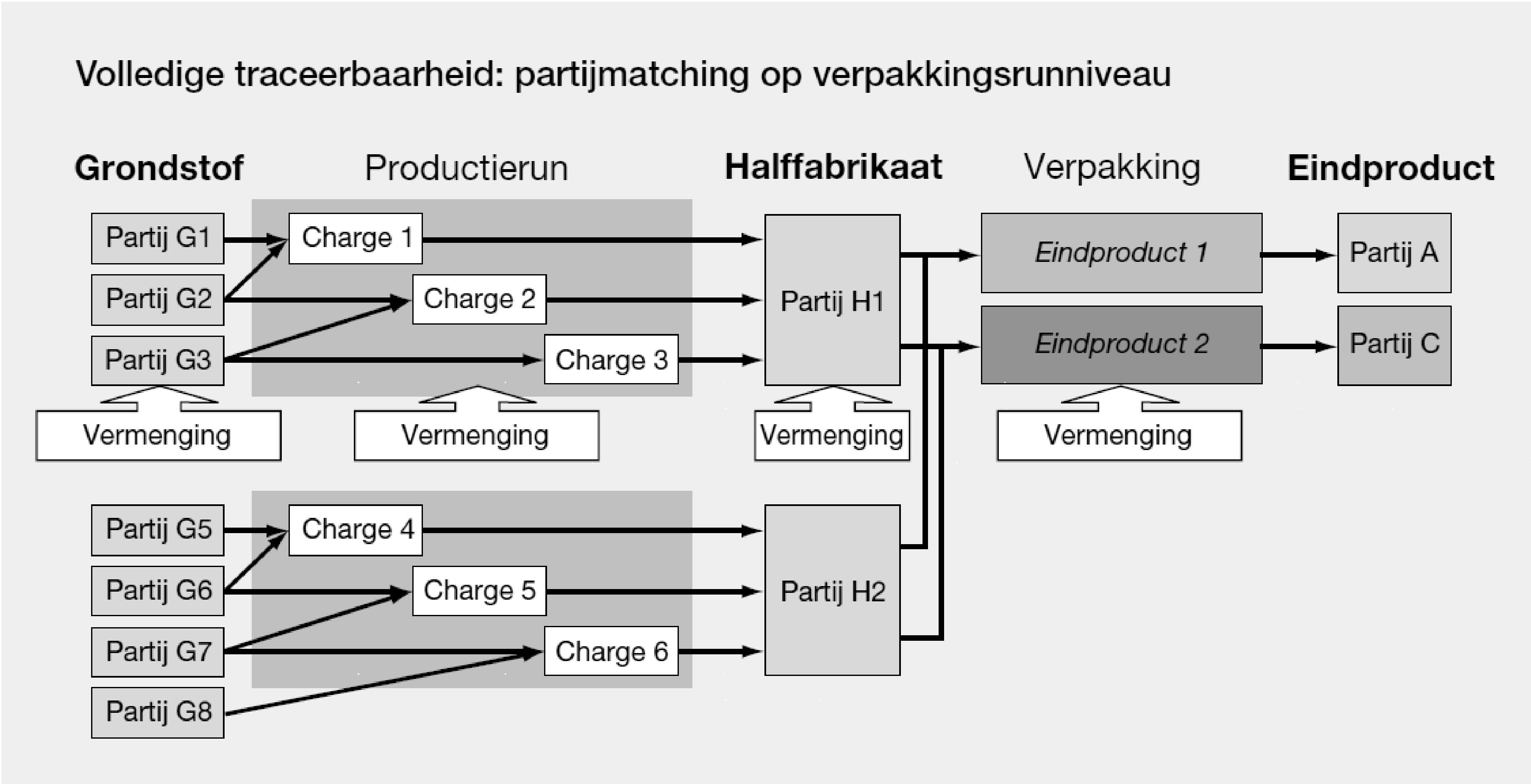
Figuur 5: Voorbeeld geen vermenging



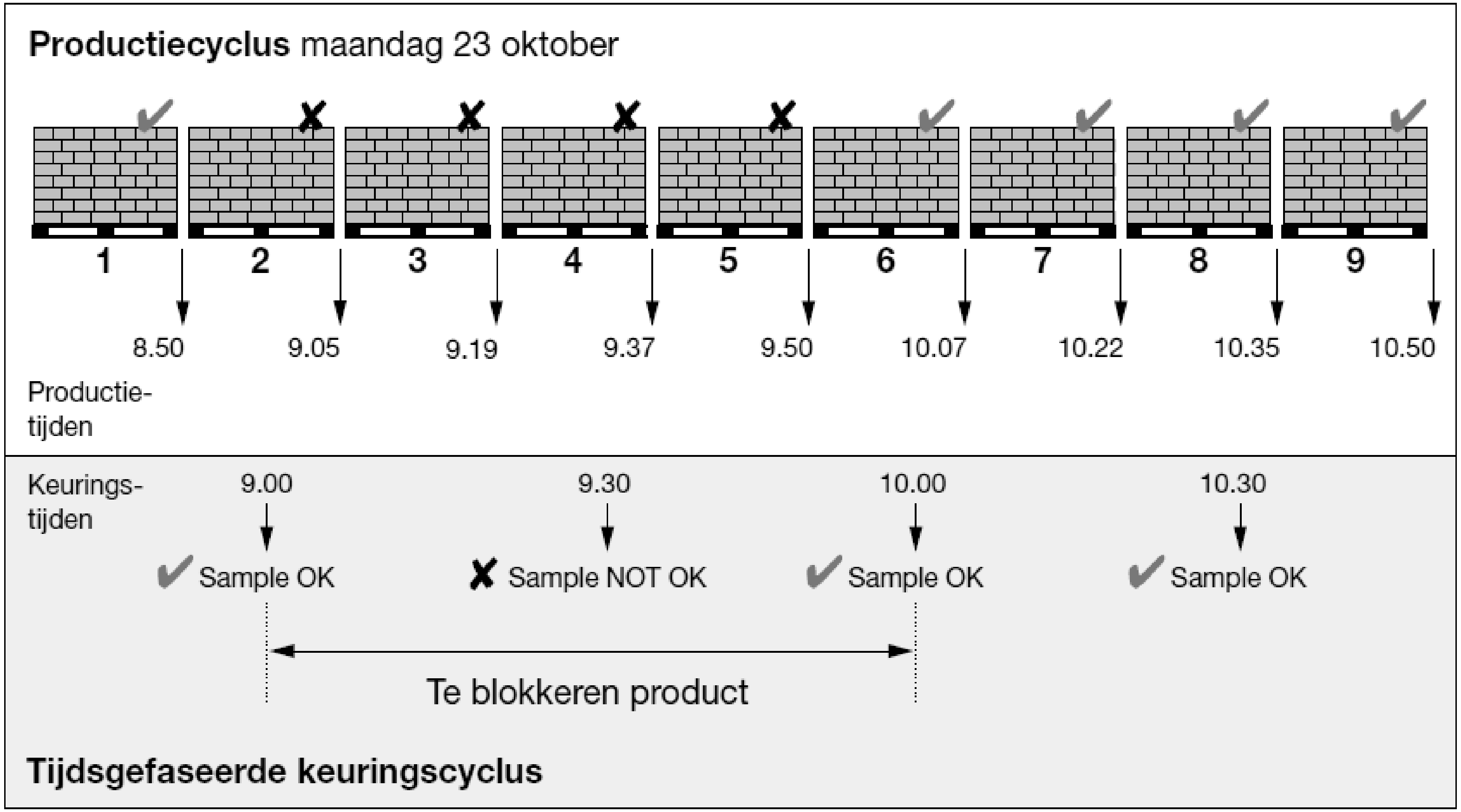
Figuur 6: Voorbeeld vermenging 1



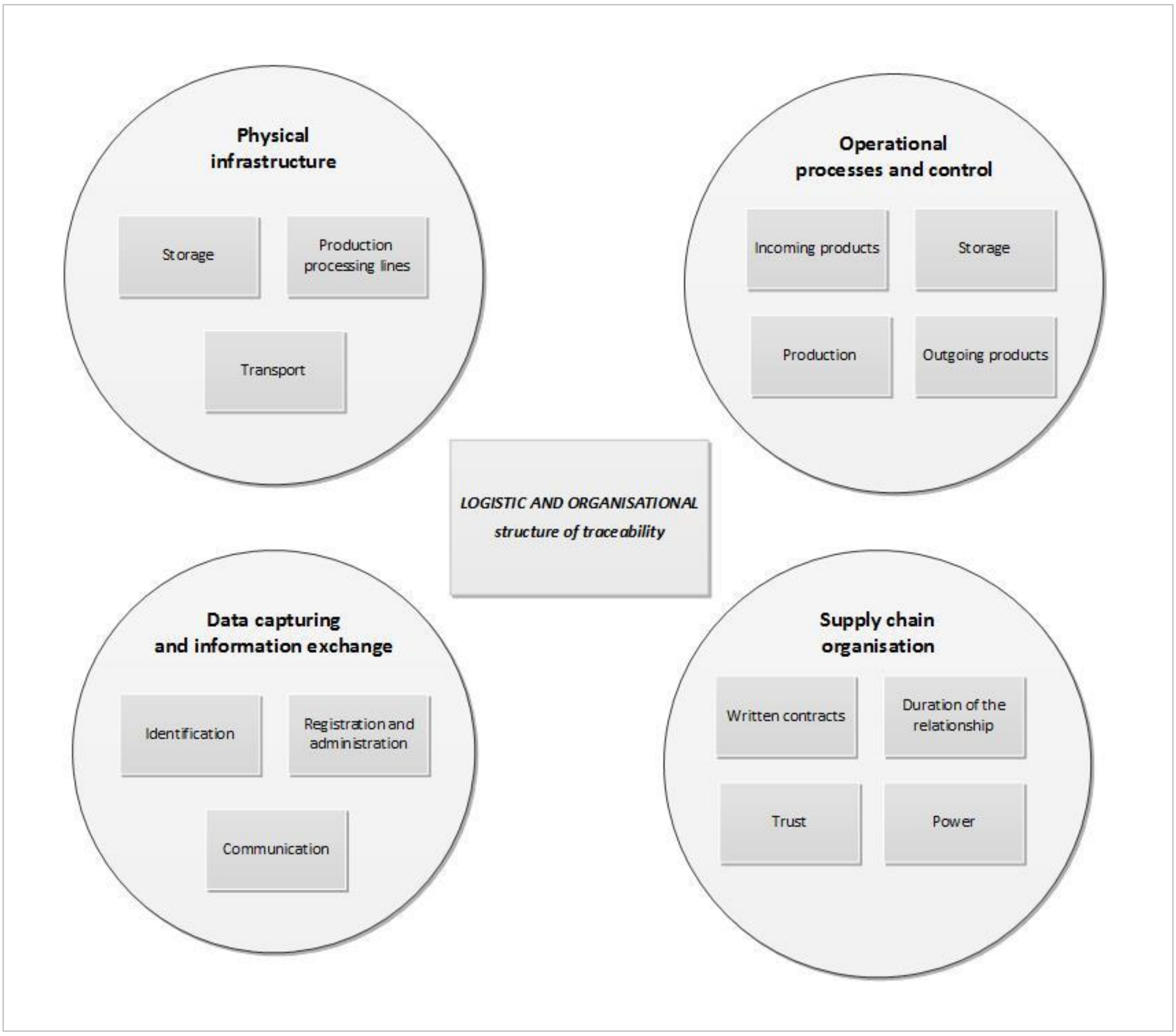
Figuur 7: Voorbeeld vermenging 2



Figuur 8: Voorbeeld vermenging 3



Figuur 9: Voorbeeld van een productiecyclus



Figuur 10: Theoretisch raamwerk

Appendix V Translation of citations

Citation 1

[Dutch]

"Is het HUM, kunnen wij precies zien, meteen nu kan ik kijken van dit product is die pallet, en is daar naartoe gegaan. En bij het andere kunnen we het niet zien, en moeten we altijd een bestand opsturen. 'Jongens, jullie hebben van ons deze levering gehad, daarin zaten deze 10 pallets met deze nummers, waar zijn die naartoe gegaan?' En dan moeten hun dat uit hun systemen gaan halen. En weer naar ons toe gaan sturen. Zeker in het kader van je track en tracing en je traceability en tijdigheid daarin is dat wel een duidelijk verschil." - PI4 -

[English]

If it is according HUM, we are directly able to see that this product comes from this pallet and we can also see where it went through. For others we cannot see this information and we have always have to send a file. 'Guys, you have had this delivery from us, and these 10 pallets with these numbers were in there. Where did they go?' And then they have to get this information from their systems and send it to us afterwards. Speaking about track and tracing and traceability, and the timeliness of it, there is a clear difference. - PI4 -

Citation 2

[Dutch]

"Je kan nou tegen een cowboy zeggen dat ik op dit moment een plek voor 3.000 nodig heb en vraag of goed is? 'Ja dat is goed'. En dan rijd ik er morgen naartoe. Maar als je zegt nee, en we gaan zo'n HUM constructie met elkaar opstarten betekent wel dat ik hier intern een engineer nodig heb, een logistiek engineer die dat interface opzet, die dat project leidt. Die de mensen hier traint, die zorgt voor een stukje instructie die afstemming doet met de ICT afdeling. Dus jouw eigen interne voorbereidingstijd is ook wel belangrijk. Dus het vraagt wel wat van je flexibiliteit". - PI4 -

[English]

"You can say to a cowboy right now that at this moment you need space for 3,000 and ask whether it is all right? 'Yes that is all right.' And I will drive up there tomorrow. But if you say no, we are going to start up an HUM construction, that will mean that I need and engineer here and a logistic engineer who will set up the interface and lead the project. He will also have to train the people here and coordinate it with the IT-department. So your own internal preparation time is important too. It will ask for some flexibility." - PI4 -

Citation 3

[Dutch]

"Dus we kunnen zien aan de productieorder welke order dat is en we doen op elk zakje en elke doos ook een code printen met waar dat die gemaakt is, en welke lijn, en welke tijd. Dus qua tijd weet je tussen de inpak en de voorzit zit anderhalf uur tussen. Dus dan gaan we anderhalf uur eerder kijken welke aardappelen erin zijn gegaan." - PI1 -

[English]

"So by means of the production order we can see which order it has been and we will print a code on each bag and each box with information about where it has been made, which production line and at what time. So you can see that one and a half hour was needed from putting the potatoes into the processing line to the packaging process. With that information we can look back one and a half hour and to see which potatoes were put into the line before they were packed." - PI1 -

Citation 4

[Dutch]
"Je kunt niet zeggen: 'die gebruiken we gewoon nooit, want die is veel te kort'. Die heb je gekocht van die boer, en daar moet je het mee doen. En dat is waarom je die blend gebruikt." - PI3 -

[English]
"You cannot say: 'these potatoes are too short and therefore we don't use them'. You bought them from a farmer, and you have to use them. That's the reason why you use a blend." - PI3 -

Citation 5

[Dutch]
"En om te kunnen veranderen in traceability moet je juist minder gaan mixen omdat je dan preciezer kunt zeggen waar de fout zit. Maar dat speelt tegen met het eindproduct om dat zo egaal mogelijk te krijgen" - WM1 –

[English]
"To change the level of traceability, you have to blend less in order to pinpoint where it has gone wrong. But that is in conflict with the aim to of having a final product that is as homogeneous as possible." - WM1 -

Citation 6

[Dutch]
"Wij kunnen precies zien hoeveel een winkel aan voorraad heeft en wanneer hij of zij voorraad ontvangen heeft, op de seconde nauwkeurig. Maar dat valt niet te traceren op batches." - RE2 -

[English]
"We can see exactly the stock level of a supermarket, when they received their stock, up-to-the-second. But it is not possible to trace on the level of batches." - RE2 -

Citation 7

[Dutch]
"Een afnemer zou het liefst inzage hebben in jouw kostprijs. En daarvoor heeft hij heel veel kennis en informatie nodig. Dus hij zal in de toekomst steeds meer gaan vragen onder het mom van: 'dat heb ik nodig voor mijn eigen systemen, inzake veiligheid'. Maar dat kan hij ook misbruiken natuurlijk". - EX2 -

[English]

"A customer would like to know the cost price. Therefore he needs a lot of knowledge and information. In the future he will ask more and more under the guise of: 'I need that information for my own systems, because of safety'. But he can also take advantage of it ." - EX2 -

Citation 8

[Dutch]
"Tot op heden heeft zeg maar het nog niet geleidt, onder de huidige systematiek van werken, heeft tot op heden nog niet geleidt tot het inzicht van: 'we moeten onze systematiek veranderen, want daarmee gaan wij de keten veiliger maken, daarmee gaan we de keten goedkoper maken in het geval van recalls.'" - RE2 -

[English]
"Working following the current system nowadays hasn't changed our mind into: we have to change our system, and therefore we will make the supply chain more secure, and we are going to make recalling cheaper'". - RE2 -

Citation 9

[Dutch]
"We hebben toen gezegd dat we eerst eens moeten plannen per schuur in plaats van dat we al verder gaan opdelen. Dus nog niet te complex maken" - PI1 -

[English]
"We argued that we first have to do our planning based on one potato storage instead of separating it further. "For now, let's not make it too complex"." - PI1 -

Citation 10

[Dutch]
"Als je betere traceability zou willen doen op kleinere hoeveelheden zou je eigenlijk ook per batch een klein stukje ruimte tussen je productieplanning moeten maken. Dan zou je bijvoorbeeld eerst de ene vracht aardappels doen, dan laat ik een gat vallen van 1 minuut ofzo, en dan ga ik met de volgende beginnen." - PI1 -

[English]
"If you want to improve traceability for smaller amounts, you would have to leave some space between every separate batch within your production planning. You could, for example, start with the first batch of raw potatoes, create a gap by waiting a minute, and then continue with the second batch.

Citation 11

[Dutch]
"Je wilt gewoon continu je processing laten draaien." - PI1 -

[English]
"You just want to have a continuous process." - PI1 -

Citation 12

[Dutch]
"Omdat het frietje van McDonalds in februari nog hetzelfde moet proeven als in september of in juli."
- EX2 -

[English]
"Because McDonalds' French fries should taste the same in February as they do in September or July."
- EX2 -

Citation 13

[Dutch]
Hoe kan het dat jij maar 50 ton aardappelen van een hectare haalt, terwijl hier de gegevens van een zelfde soort klei, die komen op 80 ton uit." - EX2 -

[English]
"How could it be the case that you yield 50 tons of potatoes from one hectare, whilst information shows someone else, one the same kind of clay, is yielding 80 tons of potatoes." - EX2 -

Citation 14

[Dutch]
"De uitdaging is dan dat je de… Is dat je verder in de keten vastlegt wat naar de winkel gaat." - RE2 -

[English]
"It will be the challenge to capture the information further in the supply chain - to capture what has been send to which supermarket" - RE2 -

Citation 15

[Dutch]
"Het grootste probleem is dat wij veel via wholesale doen. En wij weten niet waar het daarna terecht komt. Als jij een snackbar gaat beginnen kun jij gewoon bij de Sligro de friet van X (PC1) kopen. Maar hoe bereiken wij jou, als ons product niet goed is?" - PI2 -

[English]
"The biggest problem is that we sell a lot through wholesale. After wholesale, we don't know where our product ends up? If you start a take-a-way fast food restaurant, you can just buy our French fries from a wholesaler, like Sligro. But how do we reach you, in case our product is deficient?" - PI2 -

Citation 16

[Dutch]
"De basis van track en trace is natuurlijk je risico. Wat is het risicoprofiel van je product? En als daar geen zware metalen of giftige stoffen inzitten en je hebt dan nog controleslagen en schoningsslagen, daarna. Dan breng je het risico heel erg naar beneden. Dus het risico van het product is laag. Dus daar hebben we ook zo onze traceability op ingericht. - PI5 -

[English]

"The basic of track and trace is off course your risk. What is the risk profile of your product? When there are no heavy metals or toxic components, and you have your control and cleaning checks in place - you will decrease the risk significantly. Thus, the risk of the product is low. And based on that we set up our traceability system." - PI5 -