Traceability creation in the food (packaging) industry
a study of traceability technologies and systems

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Traceability creation in startups with RFID and ERP

A study in the food (packaging) industry

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Traceability creation in the food (packaging) industry:

A study of traceability technologies and systems

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Abstract

This master thesis describes a study of how traceability can be created by a startup in the food (packaging) industry. A two-by-two matrix is created in which capacity to capture data is placed on the X-axis, and readability is positioned on the Y-axis. Low capacity to capture data is linked to the traceability technology Barcode. High capacity to capture data is linked to Radio-Frequency Identification (RFID). Low readability is linked to a Supply Chain Management (SCM) system. High readability is linked to an Enterprise Resources Planning (ERP) system. A qualitative research containing semi-structured interviews as the main data source is conducted to find that a combination of RFID as a technology and ERP as a system for traceability is most effective. The findings also reveal that distinct departments of an organization use different criteria for selecting a traceability solution. For the economic aspects of traceability, it is found that a combination of barcode and a supply chain management system is most effective. For marketing research, supply chain management, quality management, and engineering, a combination of RFID and ERP is found to be most effective.

Management Summary

This research takes place at Ecodraft, a subsidiary of Cardiff Group NV that focuses on the development of plastic kegs. The kegs are made to contain distinct types of fluids, such as consumable liquids (e.g. beer, wine, cocktails, and juices). The organization is business-to-business (B2B) focused, with small, middle, and large breweries all over the world as target customers. The product is also sold to individual homebrewers via the organization's web shop. This management summary provides a concise overview of the problem, method, results, and recommendations of this research.

Problem: Food quality and safety have received a lot of public media attention in the past decades. There have been many cases in the food (packaging) industry where product deficiencies led to contamination or even to fatalities. These cases highlighted the demand for traceability to regain customer confidence in the safety of the food (packaging) industry (Pouliot & Summer, 2008). Due to laws that require food (packaging) to be traceable through the whole chain it is necessary for Ecodraft to develop a way to guarantee traceability of its products (EuropeanCommission, 2007). Currently, Ecodraft has not made its product traceable, even though the law requires Ecodraft to. Ecodraft expects that traceability will impact the whole organization and that distinct departments give their preference to a traceability technology and system based on varied selection criteria. Ecodraft wants to know how traceability can best be created according to the employees of distinct departments of the organization. This leads to the following main research question:

How can a startup in the food (packaging) industry create traceability of its products, in a way that is most effective for the entire organization?

Two sub-questions arose from this main question: How is traceability defined? and Which technologies and systems can best be used for traceability?

Method: A systematic literature review is used to secure the scientific rigor and reproducibility of the findings arising from the review (Rowe, 2014). In the empirical part of this study, multiple data sources are used to ensure triangulation (Easterby-Smith, Thorpe, & Lowe, 1991). Triangulation reduces the impact of biases that can arise when using a single method (Denzin, 2006; Eisenhardt, 1989). Semi-structured interviews are used as the main data source for this study. Semi-structured interviews are open interviews that enables the interviewer to start with a small framework of themes which expands during the interview (Eisenhardt, 1989). The number of respondents for the interviews is determined by using the concept data saturation (Glaser and Strauss, 1967; Guest, Bunce, and Johnson, 2006). Observations and production meetings are used in this study to gather information concerning traceability in organizations. The data from these sources are analyzed using qualitative analysis, which contains the coding of the transcribed interviews, a within-respondent analysis, and a cross-respondent analysis. The purpose of this research is to break through standard ways of thinking to discover new insights, which is why open coding is used (Corbin and Strauss, 1990). “Open coding is the interpretive process by which data are broken down analytically” (Corbin and Strauss, 1990, p. 423). The analysis on this coded data is performed to generate theory.

Results: It is found that it is generally most effective for organizations to have a high capacity to capture data (e.g. Radio-Frequency Identification (RFID)) and to have high readability (e.g. Enterprise Resources Planning (ERP) system) for traceability. The coordinates extracted from the codebook of the interviews is shown in the following two-by-two matrix:

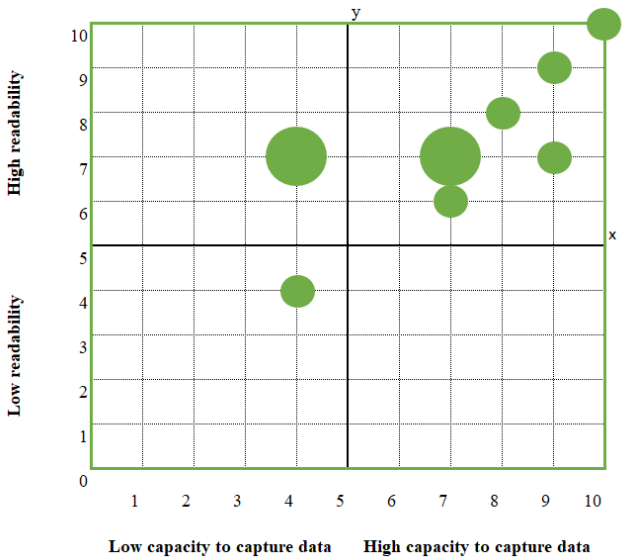


Figure 1: Two-by-two matrix general purpose

Another finding of this study is the most effective way to create traceability for each department. For economic aspects of traceability, it appears to be most effective if a low capacity to capture data (e.g. barcode) is used in combination with low readability (e.g. Supply Chain management (SCM) system). For marketing research, supply chain management, quality management, and engineering it appears that a high capacity to capture data (e.g. RFID) and high readability (e.g. ERP) are most effective. The coordinates of each department are placed in the following two-by-two matrix:

= Economics
= Marketing Research
= Supply Chain Management
= Quality Management
= Engineering

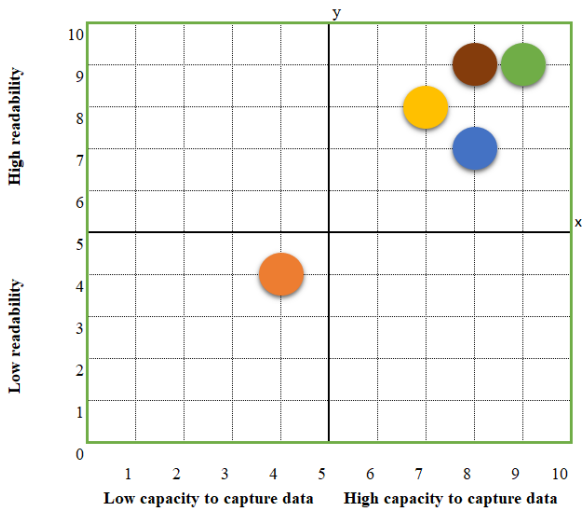


Figure 2: Two-by-two matrix distinct departments

Recommendations: Based on the current findings, it can be recommended to Ecodraft to create traceability using the technology RFID and the system ERP, unless Ecodraft lays the focus on the economic aspects of traceability. In that case a combination of barcode and SCM is recommended.

Acknowledgements

In 2015, I signed up for the master Innovation Management at the Eindhoven University of Technology. To complete this master, I had to perform a study on a topic related to my education program. The topic of this research is creating traceability in a startup in the food (packaging) industry. Traceability is the ability to identify sources of input materials, applications, as well as the ability to conduct full backward tracing and forward tracking to determine the specific location and life history of a product (component) in the supply chain by means of records.

I was looking forward to this new challenge after finishing the bachelor Industrial Engineering and Management Sciences, also at the Eindhoven University of Technology. During the bachelor program, my internship was at Sabic, manufacturing company, active in metals and polymers. In this organization, my first interests for this research topic were developed. The news about food scandals which led to enormous increased demands from consumers and business partners for traceability and documentation of food products, increased my interests in traceability even more and helped me decide that traceability would be the topic of my research.

Soon, my research could start at a startup in Genk (Belgium) named Ecodraft by Cardiff Group NV. Full of enjoyment, I cooperated with the employees of Ecodraft and its business partners to create traceability. A lot of knowledge is gathered by closely working together with these experienced professionals.

My current level of success could not have been achieved without a staunch support group. First, I want to thank my family and friends for all the support and understanding. Secondly, thank you to the supervisors of both Eindhoven University of Technology as well as Ecodraft for their unwavering support.

Table of Contents

Abstract
Management Summary
Acknowledgements
List of Figures
List of Tables
List of Abbreviations
1. Introduction
2. Company Description 3
2.1 Ecodraft 3
2.2 Startups 5
2.3 Food (packaging) Industry 5
3. Project Definition 7
3.1 Problem Identification 7
3.2 Research questions and sub-questions 9
4. Literature review 12
4.1 Review Method 12
4.1.1 Protocol Development 12
4.1.2 Search Strategy 12
4.1.3 Data Extraction 13
4.2 Traceability 13
4.2.1 Origins of traceability 13
4.2.2 Definition of traceability 14
4.2.3 Benefits of traceability 15
4.2.4 Traceability Regulations 17
4.2.5 Traceability technologies 18
4.2.6 Traceability systems 20
4.2.7 Scientific fields of traceability 21
4.2.8 Conclusion 21
5. Method 25
5.1 Data sources 25
5.2.1 Coding 28
5.2.2 Within-respondent analysis 30
5.2.3 Cross-respondent analysis 31

5.2.4 Placing results in a two-by-two matrix 33
5.3 Theory generation 35
6. Results 37
6.1 Descriptive statistics 37
6.2 Capacity to capture data 38
6.3 Readability 41
6.4 Results placed in the two-by-two matrix 44
6.5 Linking concepts with literature 47
7. Discussion & Conclusion 50
7.1 Managerial implications 50
7.2 Theoretical implications 51
7.3 Further research and limitations 54
7.4 Conclusion 55
References 57
Appendix 65
I. Themes, codes, and associated definitions 65
II. Original codebook 67
III. Conditional formatting of codes' averages 69
IV. Conditional formatting grouped by first usage. 71
V. Conditional formatting grouped by frequency of use 72
VI. Conditional formatting grouped by impact 73
VII. Conditional formatting of scaled data 74
VIII. Interview protocol 76
IX. Interview example 79

List of Figures

Figure 1: Two-by-two matrix general purpose .....
Figure 2: Two-by-two matrix distinct departments .....
Figure 3: Reusable Keg 3
Figure 4: One-way keg 3
Figure 5: Patented double bag system 4
Figure 6: Barcode Example 6
Figure 7: RFID example 6
Figure 8: Food Symbol 8
Figure 9: Cause and Effect Diagram 9
Figure 10: Two-by-two matrix of Estimated Traceability 24
Figure 11: Empty two-by-two matrix regarding traceability 34
Figure 12: Histogram Capacity to capture data vs First usage 40
Figure 13: Histogram Capacity to capture data vs Frequency of use 40
Figure 14: Histogram Capacity to capture data vs Impact 41
Figure 15: Histogram Readability vs First usage 43
Figure 16: Histogram Readability vs Frequency of use 43
Figure 17: Histogram Readability vs Impact 44
Figure 18: Two-by-two matrix General Purpose 45
Figure 19: Two-by-two matrix Distinct departments 46

List of Tables

Table 1: Respondents' Functions 27
Table 2: Codebook General Purpose 29
Table 3: Consolidated Codebook General Purpose 30
Table 4: Matrix of Within-Respondents' Analysis (Summary) 31
Table 5: Cross-Respondent Analysis (Conditional Formatting) 32
Table 6: Cross-Respondent Analysis (Grouping Respondents) 33
Table 7: Cross-Respondent Analysis (Scaled Data) 33
Table 8: Determination of Coordinates (Sub) Codes 35
Table 9: Descriptive Statistics 38
Table 10: Linking Concepts with Literature 49

List of Abbreviations

Bovine Spongiform Encephalopathy	(BSE)
Business-to-business	(B2B)
Business-to-customer	(B2C)
Charge Coupled Device	(CCD)
Chief Executive Officer	(CEO)
Country-Of-Origin Labeling	(COOL)
Enterprise Resources Planning	(ERP)
European regulations	(EG)
Food and Drug Administration	(FDA)
Hazard Analysis and Critical Control Points	(HACCP)
International Organization for Standardization	(ISO)
Minimum Viable Product	(MVP)
Protected Designation of Origin	(PDO)
Protected Geographical Indication	(PGI)
Radio Frequency Identification	(RFID)
Shareholders' Agreements	(SHA)
Supply Chain Management	(SCM)
Unique Selling Point	(USP)
Work-In-Process	(WIP)

1. Introduction

This research takes place at Ecodraft, a subsidiary of Cardiff Group NV that focuses on the development of plastic kegs. The kegs are made to contain distinct types of liquid, among others those consumable for humans, such as beer, wine, cocktails, and juices. Due to laws that require food (packaging) to be traceable through the whole chain it is necessary that Ecodraft has a way to guarantee traceability of its products (EuropeanCommission, 2007).

Food quality and safety have received a lot of public media attention in the past decades. There have been many cases in the food (packaging) industry where product deficiencies led to contamination or even to death. The research by Jansen-Vullers, van Dorp & Beulens (2003) shows how vulnerable the food industry is regarding food quality. International regulations and directives regarding food quality assurance are created because of this vulnerability. Food safety issues have been a key topic on political agendas for some years. Some early outcomes are the EU whitepaper on safety and the foundation of the European Food Safety Agency (Grunert, 2005). In addition, segments of the public have become interested and critical about the way food is produced, packaged and distributed (Grunert, 2005).

Over the years, innovative technologies and systems for the creation of traceability have emerged. These changes combined with the need for traceability give rise to the main question: How can a startup in the food (packaging) industry create traceability of its products, in a way that is most effective for the entire organization?

This raises more specific questions such as: What is traceability? and Which traceability technologies and systems are most effective for the organization? At the start of this research,

neither of those questions is answered while there should be an answer to the main question before Ecodraft can start selling its products.

To ensure generalizability, the contextual conditions in which this research is performed are kept stable across the respondents. This means that the information is only gathered in the context of Ecodraft. Chapter two provides a description of Ecodraft and its products. Chapter three describes the project definition, including the problem identification and the research questions and sub-questions. Chapter four is a literature review, concerning traceability and its relevant technologies and methods. Chapter five outlines the methodology of this research. Chapter six exhibits the results of this research. Chapter seven is a discussion of the results including managerial implications, theoretical implications, further research and limitations, and a conclusion.

2. Company Description

A brief description of Ecodraft is given, including the organization's product, information concerning startups and the food (packaging) industry.

2.1 Ecodraft

Ecodraft by Cardiff Group NV is a Belgian startup in the food packaging industry with about twenty permanent employees. In 2016, Ecodraft moved their office from Zonhoven (Belgium) to Genk (Belgium), which is also the location of the production. In cooperation with some of the leading Belgian breweries and triggered by concrete market demand, Ecodraft develops gamma kegs with distinct technical and commercial assets. Pictures of a reusable keg and a one-way keg are shown in figure 3 and 4, respectively.

Figure 3: Reusable Keg

Figure 4: One-way keg

The engineers of Ecodraft succeeded in the creation of plastic kegs with a double bag system as an alternative to metal kegs. Ecodraft produces both disposable (one-way kegs) and reusable kegs in varied sizes. The double bag system, patented by Ecodraft, is a revolutionary development in the world of beverage distribution. Figure 5 is a visualization of the patented double bag system. Because the system completely separates the pressure medium from the

beverage, influence from the pressure medium on the beverage is prevented. The kegs guarantee optimal conservation of taste and quality.

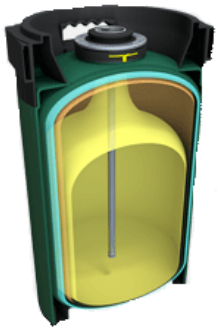


Figure 5: Patented double bag system

Plastic kegs are lighter than metal kegs, which makes them better for export. In addition, compared to the metal variant, the plastic kegs are easier to stack. Another advantage is that the double bag system in the kegs enables a shelf life of two years. This long shelf life also makes the kegs perfectly suitable for export of all premium beverages with low rotation. Market expansion is possible for the product because the kegs are available with different connections, which enables the product to be sold all over the world.

The organization is business-to-business (B2B) focused, with small, middle, and large breweries all over the world as target customers. The product will also be sold to individual homebrewers via the organization's web shop, business-to-customer (B2C) will be used to a lesser extent.

Being environmentally friendly is one of the priorities of Ecodraft. Their reusable kegs are instantly reusable because of the easily replaceable inner bags. No expensive flushing systems with polluting detergents are required. Besides, the full outer keg (top, bottom, outer vessel) is made of interchangeable pieces which guarantees many cycles. For the one-way kegs a worldwide

recycle network is built, which makes it possible to locate and contact the nearest high-density polyethylene (HDPE) recyclers in just a few mouse clicks.

2.2 Startups

A startup company is an entrepreneurial venture that aims to meet a marketplace need by offering or developing an innovative product or service (Davila & Foster, 2007). Typically, these startups are companies such as newly emerged, fast growing small businesses or partnerships with a high chance of failure. The main tasks of a startup in general is to build a co-founder team to secure financial resources and know-how. Most startups begin by building a minimum viable product (MVP) to reach a deeper understanding of the ideas and technologies and to validate, assess and develop the business concept (Moogk, 2012). Many startups have shareholders' agreements (SHA) already early in the process to confirm commitment of the investors and founders (Saharan, 2015). Startups are mostly funded by venture capitals, angel investors, or by founders themselves via bootstrapping. Even though most startups have some type of investors, they still must carefully spend their money because of the many costs that accompany starting a business. One type of startup that often occurs in practice is the re-starters startup (Metzer & Niefert, 2006). These are failed entrepreneurs who restart the same activity in the same sector after some time.

2.3 Food (packaging) Industry

Ecodraft operates in the food packaging industry, as it produces plastic kegs for consumable liquids. Food packaging has multiple functions. It provides tampering resistance and protects the food against chemical, physical, or biological threats. The kegs of Ecodraft must provide physical protection, barrier protection, containment protection, information transmission, marketing, security, convenience, and portion control. The *physical protection* includes the protection against shocks, compression, bacteria, vibration, and compression among others. The *barrier protection*

is important because liquids inside the keg are sensitive to oxygen. The containment of the plastic kegs is important for transport and for the customers handling the kegs. *Information transmission* of the packaging and labels communicate how to use, recycle and transport the products. The *marketing* aspect of the keg involves the product or its packaging looking appealing to potential customers to convince them to buy the product. The *security* of the product is important to protect the liquid against shipment security risks and theft. Distribution, display, stacking, sale, handling, use, and reusing are all aspects of the convenience of the packaging. The last-mentioned function of the packaging is *portion control.* It is important that customers can control the flow rate and amount of the liquid.

In recent years, reduced packaging solutions and sustainable packaging are getting more and more popular. This has multiple causes, such as packaging cost savings, government regulations, retailer pressure, and consumer pressure. The most known technology for information transmission, one which is known for decades and is shown in figure 6, is the barcode. These two-dimensional (2D) barcodes are increasingly used in food packaging for date coding and for ensuring correct packaging. Radio-frequency identification (RFID), as shown in figure 7, is used in food packages to ensure supply chain control and it is also used by retailers for real time visibility of the supply chain.

Figure 6: Barcode Example

Figure 7: RFID example

3. Project Definition

This chapter introduces and describes the identified problem at Ecodraft. This chapter also describes the associated main research question and the corresponding sub-questions of the identified problem.

3.1 Problem Identification

The main problem that Ecodraft is currently facing is the inability to comply with the law on traceability of its products. Recent food scares and food safety concerns have increased the interest in food traceability. An early case in which traceability was needed is the case of Bovine Spongiform Encephalopathy (BSE), also called mad cow disease, in which the origins of the diseased cow had to be traced. However, federal authorities suggested that it might take weeks or even months before the origins of the diseased cow where traced (Clementson & Simon, 2003). The cooperation between livestock dealers, herd owners and market operators, as well as detailed record searches between Canadian and United States agencies, resulted in finding the origins of the cow in just one week. This case, just like many other cases highlighted the demand for traceability to regain customer confidence in the safety of the food (packaging) industry (Pouliot & Summer, 2008). Because of this case and many others, there are strict laws concerning traceability. The EU laws are documented in the European regulations (EG) Nr. 1935/2004 (2004), a document which is updated in 2009 (Parlement, 2009). A shortened list of the relevant EU laws concerning traceability is the following (Parlement, 2009):

- Article 18: Traceability is required by law for everyone who produces, manufactures, processes, stores, transports or distributes food and feed. The traceability of materials and objects destined to get in touch with food should in all stages be guaranteed, to monitor,

recall products with defects, and facilitate consumer information and determination of liability. Operators of organizations should at least be able to trace companies to which and by which materials and items are supplied.

- Article 17: All products with the purpose to get in contact with foods, should have the symbol as illustrated in figure 8.
- Article 14, 15, 19 and 20: Organizations must withdraw products from the market, recall and report immediately, once unsafe foods or unsafe animal feed are noticed.
- Article 11 and 12: Materials with a purpose to get in contact with foods, must get a safety assessment before they are admitted to be used.

Figure 8: Food Symbol

Ecodraft belongs to the category of organizations which must follow the regulations concerning traceability, as described in Article 18. The problem Ecodraft is facing currently is that it does not comply to the traceability law because it lacks information to guarantee full traceability of its products. The reasons for this problem are a lack of financial resources, human resources, knowledge, experience, traceability technologies, and traceability systems. Further details with regard to the problem definition can be found in the cause and effect diagram in figure 9.

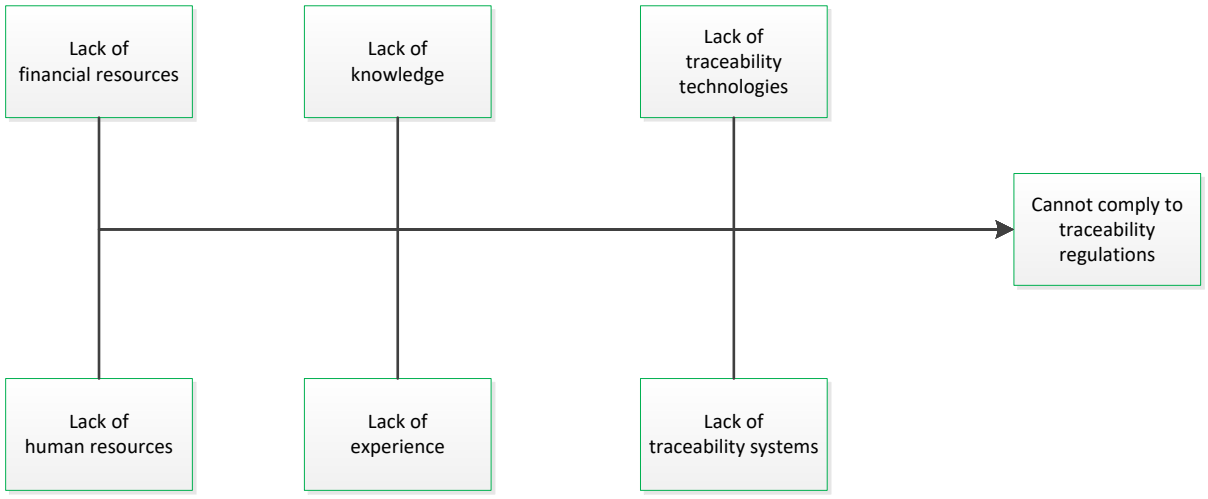


Figure 9: Cause and Effect Diagram

3.2 Research questions and sub-questions

The following research question is based on the problem of Ecodraft as described in the previous section, the research gap that technological aspects of traceability systems must improve, as indicated in Bosona and Gebresenbet (2013), and the need for further theoretical development of food traceability implementation (Karlsen, Dreyer, Olsen, & Elvevoll, 2013). Currently, Ecodraft does not have traceability of its product, even though the law requires Ecodraft to guarantee traceability. For the creation of traceability, Ecodraft wants to make the most out of the benefits of a traceability system. Ecodraft expects that traceability impacts the whole organization and that distinct departments give their preference to a traceability technology and system based on varied selection criteria. Ecodraft wants to know how traceability can best be created according to the employees of distinct departments of the organization. Therefore, the organization wants to select or develop a traceability technology and system that is beneficial for the entire organization. The research of Bosona and Gebresenbet (2013), indicates the need for improved traceability systems and state that it is hard for small companies to develop a good traceability system: “Developing

well detailed traceability systems is not easy for small food producing and processing companies as they lack financial capacity, adequate traceability information and enough knowledge to implement it" (Bosona and Gebresenbet, 2013, p. 46). The research of Karlsen et al. (2013) indicates that there is a need for developing theories of implementation of food traceability, as they state that "no common understanding of the definitions and principles of traceability exist, nor is there a common theoretical framework with respect to implementation of food traceability" (Karlsen et al., 2013, p. 415). This all together leads to the main research question.

How can a startup in the food (packaging) industry create traceability of its products, in a way that is most effective for the entire organization?

Two sub-questions need to be answered, to answer the main research question. The first research question will provide a definition of traceability. A first step to find a solution that is most effective for the organization and complies to the law concerning traceability, is to determine the definition of traceability. Academic literature on traceability will be used to answer this first sub-question.

a) How is traceability defined in this research?

In Chapter one, it is already indicated that Ecodraft must guarantee traceability for its products according to the law and therefore the organization wants to create traceability. However, the organization thinks that traceability does not only has to be created for the law, but it can also be beneficial for the organization. Therefore, Ecodraft wants to know which traceability technologies and systems can best be used. There are different traceability technologies, each has its own properties. This sub-question will answer the search for the traceability technology and system that

are preferred by the employees of distinct department of Ecodraft, as this organization is the focal point of attention in this research.

b) Which technologies and systems can best be used for traceability?

4. Literature review

In this chapter, a two-by-two matrix of the main topics of this study is presented. The topics discussed start from the point of traceability and uses a snowball effect to get to the other relevant topics.

4.1 Review Method

This literature review uses the systematic review method introduced by Galster, Weyns, Tofan, Michalik, and Avgeriou (2014). This systemic method helps to provide a clear and fair overview on the findings in current literature of traceability. This approach identifies, evaluates, and interprets relevant studies concerning a topic area.

4.1.1 Protocol Development

A review protocol is required to ensure repeatability and rigor. To start with, the protocol specifies the research question, followed by a manual search which is used as search strategy to define a search scope. Then the inclusion and exclusion criteria are created to define the search process. Finally, specific data elements are subtracted from the relevant studies found during the search.

4.1.2 Search Strategy

As search strategy for this literature review a manual search strategy is chosen, which is in general more accurate compared to an automated search strategy (Kitchenham, 2004). The automatic search strategy has a higher chance on missing relevant data which could lower the quality of this report. Another benefit of a manual search is, the possibility to find literature about traceability even if authors do not use common terms. The following three electronic databases are used for searching literature:

- Google Scholar (https://scholar.google.com)

- FOCUS (http://library.tue.nl/focus/nl/)
- Elsevier Science Direct (https://Sciencedirect.com)

The keyword Traceability is used in these databases to find relevant literature. From this starting point, other relevant keywords are found by making use of snowballing. The keywords found by snowballing are keywords such as ERP, RFID, readability, capacity to capture data. Once the main literature was found, each of these articles was manually reviewed by reading the abstract, title, and keywords. Snowballing is used to find relevant articles, related reviews and follow ups. Duplicate articles are removed from the list of articles. The results of this search strategy were around 1700 studies. A total of 53 relevant studies were found. From these studies, 10 studies are used as primary studies.

4.1.3 Data Extraction

During the data extraction, all literature studies were read, and the relevant data were extracted. The topics that appear important are collected to develop the research model of this literature review. The findings and the two-by-two matrix are described in the following sections.

4.2 Traceability

This chapter provides information about the origins of traceability, the definition of traceability, the benefits of traceability, traceability regulations, traceability technologies, traceability systems, and scientific fields of traceability.

4.2.1 Origins of traceability

In recent years, there have been multiple cases in which food or beverage deficiencies led to illness, or other negative consequences. These costly and tragic product scandals received worldwide media attention in the last decades. This led to enormous increased demands from consumers and

business partners relating traceability and documentation of food and beverage products. These demands resulted in new or strengthened legislations in multiple countries and in commercial standards for food production (Olsen & Borit, 2013). In addition, the logistic chain for food and beverages is getting more complex every day. The original location of the product is far away from its final destination; often products are transported via complex transport routes involving air transport, board handling in ships and other intermediate points in the logistic chain (Abad, et al., 2009). These factors make traceability more and more important while at the same time the traceability technologies and systems get more and more complex.

4.2.2 Definition of traceability

Traceability is used in many different industries and is referred to in many scientific articles. Dictionaries, international standards, legislations, and scientific articles often give different definitions for traceability (Olsen & Borit, 2013). These definitions will be discussed and the one that fits best to this report will be selected and used in the remainder of the report. In international standards traceability is defined as: The ability to trace the history, application or location of that which is under consideration (ISO, 2000). The definition of the EU general Food Law for traceability is: The ability to trace and follow a food, feed, food producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution (EU, 2002). In the scientific literature traceability gets defined as "with respect to a food product, traceability represents the ability to identify the farm where it was grown and sources of input materials, as well as the ability to conduct full backward tracing and forward tracking to determine the specific location and life history in the supply chain by means of records" (Opara, 2003, p. 102). These definitions combined brings us to the definition used in the rest of the report, where traceability is defined as the ability to identify sources of input materials,

applications, as well as the ability to conduct full backward tracing and forward tracking to determine the specific location and life history of a product (component) in the supply chain by means of records.

4.2.3 Benefits of traceability

Electronic systems and standards for food are improved significantly in recent years. This led to benefits associated with investing in better traceability technologies and systems. According to Pouliot and Summer (2008), many benefits arise from traceability, these will be discussed in this section.

The use of a traceability system can lead to *safer food supply*, because traceability provides information about suppliers that allows application of liability for food safety. These liabilities stimulate food suppliers to improve the quality and safety of their products. Multiple countries are investing in building systems to solve the food safety problems (Chen, Chen, Yeh, Chen & Kuo, 2008). A benefit for organizations who want to use traceability is that governments stimulate the adoption of traceability to *correct market failures* (Golan, et al., 2004). Another benefit that arises from traceability is *protectionism*. Protectionism is defined as the status adopted for improving the competitive position of local economic actors, just because they are local, vis-à-vis their foreign competitors (Regan, 1986). This protectionism is a benefit of traceability when firms in its home country have lower costs than imported firms for supplying traceability. The information about origins of materials can be used in downstream and in upstream processes (Regattieri, Gamberi, & Manzini, 2007). Another benefit of traceability, one which can reduce one of the main concerns for startups, is the improved effectiveness of *product recalls* after the discovery of a product quality or food safety problem. When a food safety outbreak occurs, there are multiple actions that should be taken to recall the contaminated products. Prior to the recall of the products, the cause (chemical

or biological) and the source of the contamination should be identified (Piramuthu, Farahani, & Grunow, 2013). Fast recall can reduce recall costs as well as the related media impact. Another benefit arising from traceability is that traceability helps to measure *batch dispersion*. A benefit for many organizations which use traceability systems is that traceability provides protection and helps regaining the general *reputation* of a country, industry, firm, or product (Pouliot & Summer, 2008). An organization's reputation can be damaged if the quality of a product is low. A traceability system helps to maintain *superior quality* by monitoring the production processes and detecting batches with defaults. The organization's reputation can also be preserved better with a traceability system because of the decreased batch recall time after safety problems. This because a traceability system can detect defect products and recall them, before disastrous consequences occur.

According to Opara (2003) traceability is necessary in modern supply chain management to keep up the quality of the products and the demands of the customers. New traceability technologies are needed to *reduce transaction costs* and facilitate the production of safe traceable products. Technological innovations are needed for the implementation of traceability in the supply chains. These innovations are necessary for process and environmental characterization, product identification, information capture, analysis, storage, transmission and system integration (Opara, 2003). Also, the traceability system can be used to improve the *monitoring* of production and processing methods in the supply chain (Quevauviller & Donard, 2001). When companies receive goods, each of these pallets of goods are often provided with a unique identification number. The applied warehouse technology and the computerized identification tracking system follows the unit from arrival in the warehouse until the delivery takes place. In this way,

computerized databases and unique identification numbers of items facilitate tracking, tracing and monitoring (Hajnal, Kollar, & Lang-Lazi, 2004).

The study of Attaran (2007) shows how supply chain management improves traceability by better tracking transportation and warehousing channels. This research indicates that RFID can help to achieve certain traceability levels at a reasonable cost. RFID technology is establishing itself as one of the best ways to reach successful and sustainable supply chain operations. It is a challenge for IT experts to determine how to integrate RFID technology with supply chain management (SCM) and enterprise resource planning (ERP) systems with the entire system (Attaran, 2007). The benefits traceability provides for the organization depend on the type of traceability technology and system, therefore the contextual factors are important in the decision which traceability technology and system to use. The selection of the best traceability technology and system depends on the main purpose of the system and the additional functions required (Hobbs, 2004). The system should fit the organization's potential growth. Another important aspect when selecting a traceability technology and system is that every country has its own type of legal system, therefore not all traceability systems are appropriate in every country (Buzby & Frenzen, 1999).

4.2.4 Traceability Regulations

In the food (packaging) industry it is often required to reach a certain quality level. The EU's General Food Law states that traceability is compulsory for all food and feed businesses since 2002 (EuropeanCommission, 2007). The guidelines of the EU states that business operators must document names and addresses of the customer and supplier, the delivery date of the product, and the nature of the product. The FDA states that if a quality deficiency is noticed, the whole batch should be recalled within an established time (FDA, 2013). Traceability is needed to be able to

recall a distributed batch in such a brief time. This is also a requirement for the packaging of the food and beverages. The perceptions of food quality and safety differ significantly between consumers from the US and those from Europe. The food labeling policies of the EU have a stronger focus on origin, production processes and traceability compared to the policies in the US (Buhr, 2003; Bureau & Valceschini, 2003). The many food scares occurred in Europe have led to the development of the EU farm-to-fork red meat traceability systems. The EU promotes the production of food products from high quality regions which led to new food labeling policies such as protected geographical indication (PGI), protected designation of origin (PDO), and country-of-origin labeling (COOL). These policies oblige organizations to provide food labels to contain geographical names and the use of various levels of traceability to document the production processes and origins. These EU traceability systems have improved the food safety and the quality of the products by labeling credence and experience attributes to the products (Buhr, 2003; Bureau and Valceschini, 2003; Dickinson and Bailey, 2002, 2005; Enneking, 2004). Most of the general food law requirements are also relevant for the packaging of food and beverages. In Europe, these requirements are developed by the European commission. The Hazard Analysis and Critical Control Points (HACCP) is a food safety plan that is required for all food processors and is covered by European legislation. The International Organization for Standardization (ISO) develops and publishes international standards such as the requirement of an identification system that allows traceability from finished product back to customer specifications and incoming material records.

4.2.5 Traceability technologies

Traceability requires the capacity to capture data such as the nature of the product, the identification of the product, the quantity of the product, the branch, and the receipt date. Most

traceability technologies are wireless sensors equipped with transmitters to convert signals from process control instruments into a radio transmission (Lotlikar, Kankapurkar, Parekar, & Mohite, 2013). A receiver interprets and converts this radio signal to a specific desired output. The two possible types of data outputs are: analog current and data analysis via computer software. The study of Lotlikar, Kankapurkar, Parekar, and Mohite (2013) indicates that the two most used wireless sensors for traceability are barcode and RFID.

Barcode is an optical machine-readable representation of object related data (Lotlikar, Kankapurkar, Parekar, & Mohite, 2013). A barcode consists of a print contrast between dark and light bars, which are adequately printed with space dimensions within certain tolerances for the symbols and an all bar. For a proper use of a barcode it must be placed on a smooth surface, it must have sharp bar edges, there must be clear margins at the ends of the barcode, and it should contain no or few voids or spots. The most used barcode reading, and decoding technologies are Charge Coupled Device (CCD) readers, pen type readers, camera-based readers, and laser scanners. The main advantage of barcode is that it has relatively low costs. A disadvantage of barcode is that the capacity of capturing data is relatively low (Kärkkäinen, 2003).

Radio-frequency identification (RFID) is the use of radio-frequency electromagnetic fields as wireless non-contact systems to transfer data from a tag to an object (Lotlikar, Kankapurkar, Parekar, & Mohite, 2013). The main purposes of RFID are tracking and automatic identification. RFID works via cameras and readers that are located within the facility and connected via a network. The more cameras or RFID readers, the higher the speed of the server. The network tracks the movement of the objects which are tagged with RFID. RFID has a high capacity to capture data because of advantages such as higher flexibility and higher accuracy of data capturing compared to barcodes (Kärkkäinen, 2003). The two main disadvantages of RFID appear to be

privacy and costs (Preradovic, Balbin, Karmakar, & Swieger, 2008). The costs of RFID are getting lower and lower as technologies improve, and RFID is used more and more. Mobile phones already permit wireless physical tracking, which are practically ubiquitous and in addition, the privacy distinctions between RFID tags and mobile phones appear to erode because mobile phones exploit new channels like Wi-Fi and Bluetooth (Juels, 2005).

4.2.6 Traceability systems

The traceability technologies create lots of data, but these data are only useful if these are applied in organizations. The barcode or RFID generated data should be processed by a traceability system that can store a lot of information and process it, so it can be applied. Systems which can process this type of data in organizations are systems only for traceability such as some supply chain management (SCM) systems and systems for functions all over the organization such as enterprise resource planning (ERP) systems (Attaran, 2007).

Supply chain management system (SCM) is the integration of key business processes from end users through original supplier that provides value adding information, services, and products for customers and other stakeholders (Dehning, Richardson, & Zmud, 2007). It is also defined as the management of the flow of services and goods that involves the storage and movement of raw materials, work-in-process (WIP) inventory, and finished goods from point of origin to point of consumption. The SCM systems configure value for those that organize the networks. SCM systems have a relatively low readability of captured data (Ngai, Cheng, & Ho, 2004).

Enterprise Resources Planning (ERP) systems computerize entire businesses with software modules that cover activities in all areas of the business (Muscatello, Small, & Chen, 2003). These systems are designed to address problems of fragmentation of information in business organizations. It is also described as the link that enhances the integration between the

enterprise, the functional areas of the manufacturing enterprise and its downstream and upstream trading partners. According to Shang and Seddon (2000), ERP systems have a relatively high readability because of the considerable amounts of data it can process in a relatively brief time.

4.2.7 Scientific fields of traceability

Traceability is far reaching and impacts a variety of scientific fields. The concept traceability is studied in economics, marketing research, supply chain management, quality management, and engineering (Karlsen, Dreyer, Olsen, & Elvevoll, 2013). Multiple cost-benefit analyses are carried out for the *economic* aspect of traceability (Disney, Green, Forsythe, Wiemers, & Weber, 2001; Sparling, Henson, Dessureault, & Herath, 2006). As a *marketing research* aspect of traceability, competitive strategies and customer perceptions of traceability are studied (Van Rijswijk, Frewer, Menozzi, & Faioli, 2008; Canavari, Centonze, Hingley, & Spadoni, 2010). The *supply chain management* research field of traceability shows decision support systems, improving supply chain management, increasing the ability to regain customers, logistic management, distribution systems, product differentiation, and supply-side management (Mai, 2010). The *quality management* aspects of traceability that have been studied are quality control, quality management, quality improvement, and quality assurance systems (Frederiksen, 2002). The *engineering* aspects concerning traceability contain traceability implementation, barcodes, RFIDs, and traceability systems (Billo & Bidanda, 1998).

4.2.8 Conclusion

Traceability has become important in the last decades because of the many food scandals that occurred in places all over the world. There are many motivations to use traceability in an organization. In most parts of the world it is even included in the law to have traceability in organizations in the food (packaging) industry. Traceability data must be generated and processed

before these can be applied usefully in organizations. Therefore, both traceability technologies and traceability systems are required. The traceability technologies are divided by the level of capacity to capture data: low capacity to capture data (e.g. barcode) and high capacity to capture data (e.g. RFID). The traceability systems are divided by level of readability, low readability (e.g. SCM system) and high readability (e.g. ERP system).

4.3 Two-by-two matrix

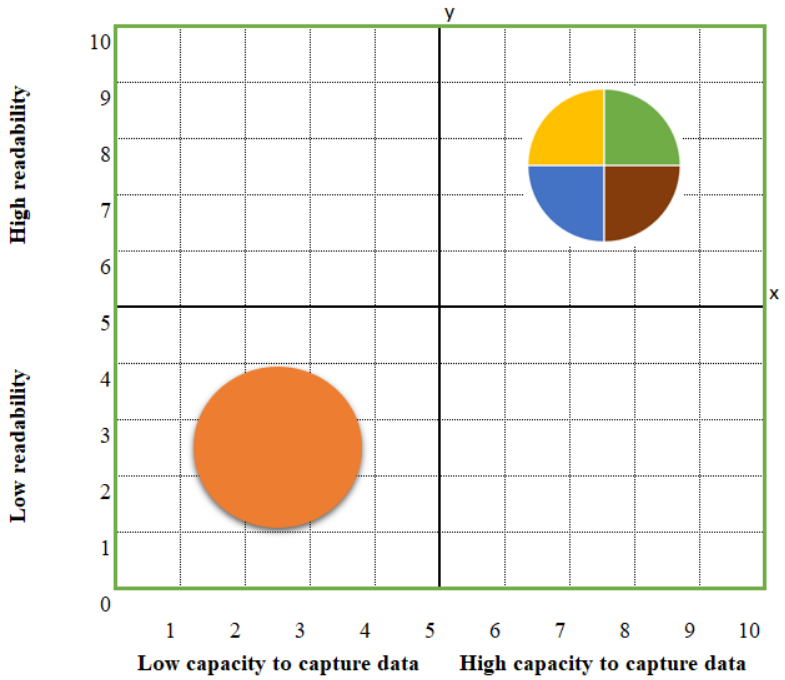
The core of this literature review is shown in the two-by-two matrix in figure 10. This matrix is based upon the literature review conducted in chapter three in context of Ecodraft. The matrix contains two trade-offs concerning traceability. The concepts of these trade-offs will be evaluated in this research. The distinct purposes of traceability are shown in the matrix.

The trade-off is between the capacity to capture data (x-axis) and the readability (y-axis). In which a low capacity to capture data represents a barcode while a high capacity to capture data represents RFID. A low readability represents a SCM system and high readability represents an ERP system. The need for these trade-offs is based upon the situation at Ecodraft and the research of Bosona and Gebresenbet (2013).

Distinct departments of an organization may select the most effective traceability solution based on different criteria. The five departments of Ecodraft which are considered in this research are economics, marketing research, supply chain management, quality management, and engineering, because these are impacted by traceability according Karlsen et al. (2013). The economic purpose contains the costs and benefits of using traceability. It is expected that the combination of low capacity to capture data (e.g. barcode) and low readability (e.g. SCM system) is most effective for economics. For economics it is expected that the cost factor is more important

than the capacity to capture data and RFID is costlier than barcode (Preradovic, Balbin, Karmakar, & Swieger, 2008). For economics it is also expected that the cost factor is more important than readability and ERP cost more than SCM systems (Muscatello, Small, & Chen, 2003). The purpose of marketing research is expected to be most effective with a high capacity to capture data (e.g. RFID) and high readability (e.g. ERP system). Considerable amounts of consumer buying behavior data is needed for marketing research, therefore high capacity to capture data is desired. RFID can capture more data than barcodes (White, Gardiner, Prabhakar, & Abt Razak, 2007). High readability (e.g. ERP system) is needed to process all the captured data for marketing research. ERP systems can process a wider range of data than SCM systems (Tarn, Yen, & Beaumont, 2002). For supply chain management it is expected that a high capacity to capture data (e.g. RFID) is needed, because excessive amounts of product information is needed to organize the supply chain of an organization (White, Gardiner, Prabhakar, & Abt Razak, 2007). For supply chain management it is also expected that high readability (e.g. ERP) is needed to process the captured data and to be able to anticipate fast enough to it (Tarn, Yen, & Beaumont, 2002). Quality management is expected to be most effective if a high capacity to capture data (e.g. RFID) and high readability (e.g. ERP) are possible. Considerable amounts of accurate data that can be linked to quality management are needed to be able to control and improve the products quality (Laframboise & Reyes, 2005). RFID can register quality data of products such as temperature and moisture (Hoffacker & Hamrita, 2005). For the engineering department, high capacity to capture data (e.g. RFID) and high readability (e.g. ERP system) are required. Using lots of data that are being processed well, gives the engineers feedback on the product and improves the efficiency of engineering (Tarn, Yen, & Beaumont, 2002). Figure 10, is a visualization of the expected two-by-

two matrix, in which the capacity to capture data and readability are given for each examined department.



= Economics
= Marketing Research
= Supply Chain Management
= Quality Management
= Engineering

Figure 10: Two-by-two matrix of Estimated Traceability

5. Method

The method section elaborates the method used for this research. The aim of this research is to build theory on traceability creation by performing a quality interview based research. Section 5.1 is an elaboration about the data sources used for this research and section 5.2 describes the qualitative analysis for this research.

5.1 Data sources

Multiple data sources are used as data collection method to ensure triangulation (Easterby-Smith, Thorpe, & Lowe, 1991). The use of triangulation reduces the impact of biases that might exist when using a single method in a single study (Denzin, 2006; Eisenhardt, 1989). Flexible and opportunistic data collection methods are used according to the theory building method of Eisenhardt (1989). The following data sources are used: systematic literature review, semi structured interviews, observations and production meetings, and document review.

Systematic literature review is one of the data sources relevant in this research to learn about traceability. A systematic literature review is used because it demonstrates scientific rigor and reproducibility (Rowe, 2014). A set of search queries concerning traceability is created based upon the primary literature review. The search engines used for these search queries are Google Scholar, FOCUS, and Elsevier Science Direct. First the number of articles found is registered. Second, a content related selection of these articles is made based on relevancy of the abstract, title and keywords of these articles. Third, a quality evaluation of the remaining articles is performed. The fourth and last step is to evaluate the complete content of the article. The snowball effect is used after this strict selection of articles. The snowball effect helps to find articles that are highly relevant for this research.

Semi structured interviews are used as second main data source for this research. Semi-structured interviews are open, this means that the interviewer can bring up ideas during the interview, based on what the interviewee says. In this way, the interviewer starts with a small framework of themes which expands during the interview (Eisenhardt, 1989). Before the interview starts, every respondent receives an overview of the topics and research details (Rubin & Rubin, 2011). The interview is based on the two-by-two matrix as shown in figure 10 and the current situation of Ecodraft. Information consent is requested before conducting the semi structured interviews, to guarantee that the information from the interviews can be used for academic purposes. Also, prior to each interview, the respondents were asked whether audio taping the interview was allowed. These audio tapes were transcribed and send back to the respondents for approval. The interviews took between 22 and 40 minutes; the average duration was 33 minutes. The core of the semi structured interviews consists of 19 open ended-questions concerning traceability. In addition, the interview contains two introduction questions, six personal questions, and one wrap up question. The interview is pretested among two employees of Ecodraft to eliminate any biases and limitations. These interviews are not added to the research data.

Each interview was introduced with a brief discussion about the relevant topics. The respondents first gave a small description about themselves and the work they perform at Ecodraft. After the introduction, the respondents were also asked how often they are dealing with traceability. Subsequently each respondent defined traceability in his own words. Next, the respondents were asked to tell what they know about barcode, RFID, SCM systems, and ERP systems. At the end of the interview, the respondents are asked to explain their preference for traceability technologies and systems based on their decision criteria. The decision criteria discussed are economics, marketing research, supply chain management, quality management, and

engineering. The complete examination of the interview protocol can be found in Appendix VIII. An example of an interview can be found in Appendix IX.

Respondents are carefully selected to conduct these semi structured interviews. All respondents are employees from different departments of Ecodraft. All respondents work together to make the same products to a success, but each respondent has another function in reaching this goal. An overview of the functions can be found in table 1. The average age of the respondents is 42 years; the youngest respondent is 22 years and the oldest respondent is 69 years. Among the respondents, there are 5 males and 3 females. No more interviews are given because theoretical saturation occurred. Theoretical saturations occur when almost no additional information received from conducting interviews, this concept helps to determine the number of respondents (Glaser & Strauss, 1967).

Function Title
• Chief Executive Officer (CEO)
• Director Technology & Engineering
• Operations Director
• Quality Engineer
• Business Development Manager
• Senior Advisor
• Marketing & Sales Coordinator
• Logistics

Table 1: Respondents' Functions

Observations and production meetings are used in this research to gather information concerning traceability. Ecodraft plans a production meeting every Monday. In these meetings distinct aspects of traceability are discussed. These meetings help to keep everyone up to date and provide the opportunity to ask questions concerning traceability.

There are also webinars concerning traceability that employees can follow. Business review webinar hosted a webinar concerning intelligent packaging in which the modern technologies were discussed in depth October 10th, 2017. In this webinar, distinct solutions were explained and how they can practically be utilized in sales and marketing, supply chain, quality, and engineering.

Document review is a data source that contains historical information of Ecodraft. The documents contain among others information about traceability processes, ERP systems, SCM systems, barcode, and RFID. This information can be used to verify data retrieved from the semi-structured interviews.

5.2 Qualitative analysis

The qualitative analysis contains the coding of the transcribed interviews, a within-respondent analysis, a cross-respondent analysis, and the results placed in a two-by-two matrix.

5.2.1 Coding

Audio recordings of semi-structured interviews are used to make transcripts of the interviews, which are sent to the respondents for approval and correction. The coding of the interviews starts after approval of the respondents. The first step of coding is to review and analyze the transcripts independently to get to know the themes and to create an initial set of codes based on these themes.

The second step is to uncover new and unforeseen codes that can be incorporated in the codebook (Harris and Sutton, 1986). The purpose of this research is to break though standard ways of thinking to discover new insights, therefore open coding is used (Corbin and Strauss, 1990). "Open coding is the interpretive process by which data are broken down analytically" (Corbin and Strauss, 1990, p. 423). In the open coding process, events, actions, and interventions, are compared to discover similarities and differences. In the third step, these events, actions, and interventions are labeled and grouped together based on these similarities and differences. In this way, categories and subcategories are formed by grouping the conceptually similar ones. The fourth step is to consolidate the sub-codes into higher level codes, a step that can be repeated when needed. The complete table of themes, codes, and definitions can be found in appendix I.

An example of the coding process is shown in table 2 and table 3. The results of these tables are elaborated in the results section. Table 2, is the codebook of the initial set of codes of the theme 'General purpose' and the corresponding definitions of each code. The theme 'General purpose' stands for the reasons why traceability can be used in organizations.

Themes	Codes	Definitions
General purpose	Claim handling	Traceability information helps in handling customer claims.
	Recalls	Traceability provides necessary information for recalls.
	Quality improvement	Traceability helps in quality improvement.
	Quality control	Traceability enhances product quality control.
	Unique selling point (USP)	Traceability of a product can be used as an USP.
	Competitor comparison	Traceability enhances the ability to compare products with competitors.
	Risk management	Traceability information enhances risk predictions.
	Inventory management	Traceability enhances inventory management.
	Logistic management	Traceability enhances logistic management.

Table 2: Codebook General Purpose

Table 3, also provides the codebook of the theme 'General purpose', but with consolidated codes. This means that certain codes that have many similarities are grouped together to prevent

ambiguity. The consolidated codes are given in the same color in both tables. For example, the codes ‘Claim handling’ and ‘Recalls’ which are colored green in table 2, are consolidated to ‘Defect product handling’ with the same color, in table 3.

Themes	Codes	Definitions
General purpose	Defect product handling	Traceability enhances handling cases with defect products.
	Quality improvement	Traceability helps in quality improvement.
	Quality control	Traceability enhances product quality control.
	Product differentiation	Traceability can differentiate a product from other products.
	Risk management	Traceability information enhances risk predictions.
	Inventory management	Traceability enhances inventory management.
	Logistic management	Traceability enhances logistic management.

Table 3: Consolidated Codebook General Purpose

5.2.2 Within-respondent analysis

The within-respondent analysis, is performed to get an overview of the coded information of the interviews for each respondent. Microsoft Excel is used to summarize the data of the coded interviews into a matrix. Table 4, is used as an example of the within-respondent analysis of this research. The complete within-respondent analysis matrix can be found in Appendix II. In table 4, all codes that are grouped in categories, are placed on the horizonal axis. The first vertical column is an overview of the themes of this research. In the second column, the corresponding sub codes are shown. In all the other columns, the frequency of the specific codes given by each respondent is shown. This matrix is a summary of the within-respondent analysis and it helps to perform a cross-respondent analysis. The results of this matrix will be elaborated in the results section.

Themes	Subcodes	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5	Respondent 6	Respondent 7	Respondent 8	Total
First usage	< 1 Year	0	1	0	0	0	0	1	0	**2**
	Between 1 and 3 Years	0	0	0	1	0	0	0	1	**2**
	Between 3 and 10 Years	0	0	1	0	1	0	0	0	**2**
	> 10 Years	1	0	0	0	0	1	0	0	**2**
Frequency of use	Daily	0	0	0	1	0	0	0	1	**2**
	Weekly	1	0	1	0	1	0	0	0	**3**
	Monthly	0	0	0	0	0	1	1	0	**2**
	Less than monthly	0	1	0	0	0	0	0	0	**1**
General purpose	Defect product handling	2	1	3	3	1	2	3	1	**16**
	Quality improvement	3	2	3	2	4	1	0	0	**15**
	Quality control	3	3	1	2	0	1	0	0	**10**
	Product differentiation	4	1	1	0	2	0	3	0	**11**
	Risk management	2	0	0	2	1	0	0	0	**5**
	Inventory management	4	2	3	1	0	1	0	3	**14**
	Logistic management	2	1	2	1	1	1	2	2	**12**
Technology	Date stamp	1	2	0	0	0	3	0	0	**6**
	Paper based	1	1	1	1	1	2	0	1	**8**
	QR-code	1	1	1	3	2	2	3	1	**14**
	Barcode	1	1	3	1	2	2	1	3	**14**
	RFID	3	4	1	3	2	2	2	2	**19**
System	Paper based	1	2	0	1	1	0	1	2	**8**
	Microsoft Excel	1	2	2	1	1	1	2	1	**11**
	SCM system	2	1	2	1	1	1	1	3	**12**
	ERP system	5	3	2	3	1	2	2	4	**22**

Table 4: Matrix of Within-Respondents' Analysis (Summary)

5.2.3 Cross-respondent analysis

A cross-respondent analysis is performed, once the within-respondent analysis is finalized. The cross-respondent analysis is created by using conditional formatting in Microsoft Excel, as data visualization technique. Conditional formatting enables to color cells that contain a number based on the value of the number, the highest number in a group of cells is colored green, while the lowest number is colored red, and the other values are scaled in between the range of red and green.

Table 5 is an example of conditional formatting in which it is easy to see which codes are used often and which are used rarely. The complete matrix with conditional formatting and averages per category can be found in appendix III.

Themes	Subcodes	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5	Respondent 6	Respondent 7	Respondent 8	Total	Average per category
General purpose	Defect product handling	2	1	3	3	1	2	3	1	**16**	1,3
	Quality improvement	3	2	3	2	4	1	0	0	**15**	1,3
	Quality control	3	3	1	2	0	1	0	0	**10**	0,8
	Product differentiation	4	1	1	0	2	0	3	0	**11**	0,9
	Risk management	2	0	0	2	1	0	0	0	**5**	0,4
	Inventory management	4	2	3	1	0	1	0	3	**14**	1,2
	Logistic management	2	1	2	1	1	1	2	2	**12**	1,0

Table 5: Cross-Respondent Analysis (Conditional Formatting)

Another possibility of conditional formatting is to group respondents based on their response. This enables the researcher to compare responses and discover patterns of codes. For each code, the average group value is calculated to get an even clearer overview. Table 6 is an example of cross respondent analysis in which four groups are compared. The first group contains respondents that are faced with traceability on daily basis, while the second group contains respondents that deal with traceability on weekly basis, the third group on monthly basis, and the fourth group on less than monthly basis. The complete table of conditional formatting grouped by frequency of use can be found in appendix V.

		Daily			Weekly				Monthly			Less than monthly	
Themes	**Subcodes**	**Respondent 4**	**Respondent 8**	**Group average**	**Respondent 1**	**Respondent 3**	**Respondent 5**	**Group average**	**Respondent 6**	**Respondent 7**	**Group average**	**Respondent 2**	**Group average**
General purpose	Defect product handling	3	1	1,6	2	3	1	1,0	2	3	2,5	1	0,7
	Quality improvement	2	0	0,8	3	3	4	1,7	1	0	0,5	2	1,4
	Quality control	2	0	0,8	3	1	0	0,7	1	0	0,5	3	2,1
	Product differentiation	0	0	0,0	4	1	2	1,2	0	3	1,5	1	0,7
	Risk management	2	0	0,8	2	0	1	0,5	0	0	0	0	0
	Inventory management	1	3	1,6	4	3	0	1,2	1	0	0,5	2	1,4
	Logistic management	1	2	1,2	2	2	1	0,8	1	2	1,5	1	0,7

Table 6: Cross-Respondent Analysis (Grouping Respondents)

Not all the respondents mentioned the same number of codes during the interview, therefore the numerical data is scaled between zero and hundred. Scaled data is not used for theory building because scaled data is biased and asymmetrical. Though, scaled data is useful for verifying data. An example of scaled numerical data is shown in table 7, here you can clearly see that some respondents provide more information than others. The complete table with scaled data can be found in appendix VII.

		Respondent 1	**Scaled to 100**	**Respondent 2**	**Scaled to 100**	**Respondent 3**	**Scaled to 100**	**Respondent 4**	**Scaled to 100**	**Respondent 5**	**Scaled to 100**	**Respondent 6**	**Scaled to 100**	**Respondent 7**	**Scaled to 100**	**Respondent 8**	**Scaled to 100**	**Average per subcode**
Themes	**Subcodes**																	
General purpose	Defect product handling	2	10,00	1	10,00	3	23,08	3	27,27	1	11,11	2	33,33	3	37,50	1	16,67	21,49
	Quality improvement	3	15,00	2	20,00	3	23,08	2	18,18	4	44,44	1	16,67	0	0,00	0	0,00	19,46
	Quality control	3	15,00	3	30,00	1	7,69	2	18,18	0	0,00	1	16,67	0	0,00	0	0,00	12,46
	Product differentiation	4	20,00	1	10,00	1	7,69	0	0,00	2	22,22	0	0,00	3	37,50	0	0,00	13,85
	Risk management	2	10,00	0	0,00	0	0,00	2	18,18	1	11,11	0	0,00	0	0,00	0	0,00	5,66
	Inventory management	4	20,00	2	20,00	3	23,08	1	9,09	0	0,00	1	16,67	0	0,00	3	50,00	13,13
	Logistic management	2	10,00	1	10,00	2	15,38	1	9,09	1	11,11	1	16,67	2	25,00	2	33,33	13,95

Table 7: Cross-Respondent Analysis (Scaled Data)

5.2.4 Placing results in a two-by-two matrix

The results of the cross-respondent analysis are used to determine the coordinates of the (sub) codes in the two-by-two matrix. The starting point of the coordinates of the (sub) codes in the matrix is in the center. The (sub) code moves stepwise outwards in the matrix, based on the number of times a specific (sub) code is mentioned. In figure 11, it is shown that the coordinate (5,5) is the

center of the matrix. If for example respondent 8 mentions low capacity to capture data (e.g. barcode) zero times, high capacity to capture data (e.g. RFID) two times, low readability (e.g. SCM system) zero times, and high readability (e.g. ERP system) once, then this will result in coordinate (7,6). The two-by-two matrix including coordinates is given in the results section.

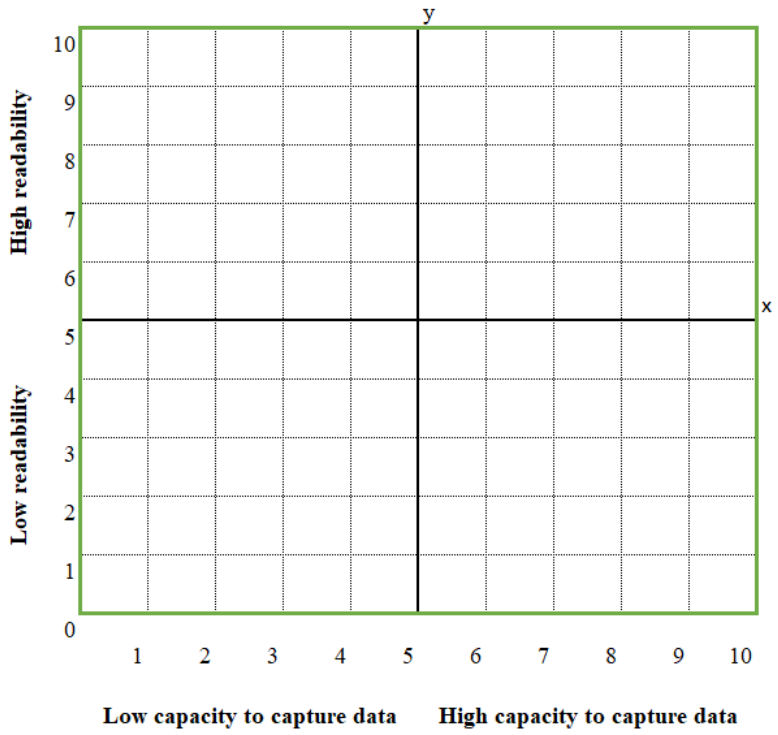


Figure 11: Empty two-by-two matrix regarding traceability

Table 8 is an example of how the coordinates of the (sub) codes are determined for each respondent. Not all respondents have the same number of coordinates. This depends on the information provided by the interviews. Respondents that could not answer certain questions have less coordinates because the information for those coordinates is missing. It is also possible that for respondents there are more coordinates, because the concepts of the interview are not mutually exclusive. For example, one could provide the information that in some situations a low capacity

to capture data (e.g. barcodes) is needed while in other situations a high capacity to capture data (e.g. RFID) is needed for traceability.

Subcodes	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5	Respondent 6	Respondent 7	Respondent 8
Low capacity to capture data (e.g. barcode)	0	1	1	0	1	0	0	0
High capacity to capture data (e.g. RFID)	5	4	0	3	2	2	4	2
Low readability (e.g. SCM system)	0	0	1	0	0	0	0	0
High readability (e.g. ERP system)	5	2	0	3	2	2	4	1
Coordinate 1	(10,10)	(4,7)	(4,4)	(8,8)	(4,7)	(7,7)	(9,9)	(7,6)
Coordinate 2		(9,7)			(7,7)			

Table 8: Determination of Coordinates (Sub) Codes

5.3 Theory generation

Theory is generated by using the information from the interviews, following the grounded theory building methods of Strauss and Corbin (1990), as well as the within- and cross-respondent analysis methods of Eisenhardt (1989). Multiple confirming and contradicting scientific literature is used for theory building, while according to Corbin and Strauss (1990) and Eisenhardt (1989) theory building is comparing existing literature, concepts, and theories. The wide collection of literature increases construct validity, builds internal validity, and raises the theoretical level of the research (Eisenhardt, 1989). Well executed generalizations sharpen the validity of constructs (Eisenhardt, 1989). The literature with similarities is useful for enhancing the internal validity of the research, while the literature with contradictions shows which concepts could be interesting for further research. Data from the semi-structured interviews, the systematic literature review, document review as well as data from the observations and production meetings are used for comparisons between theory and data, as explained by the comparative method for developing grounded theories (Strauss and Corbin, 1990). Evidence accumulation is approached

incrementally, because this helps to reveal adjustments in data collection. The link between existing literature and the findings of this research is discussed in the following chapter.

6. Results

The results section elaborates the findings from this study. Section 6.1 elaborates the descriptive results from this study and section 6.2 explains how the major findings are placed in a two-by-two matrix.

6.1 Descriptive statistics

Conditional formatting is used to discover patterns in the descriptive statistics. A matrix that contains all themes and associated codes from open coding, is created to be able to use conditional formatting in Microsoft Excel. The 22 themes are: 1. First Usage, 2. Frequency of use, 3. Impact on work, 4. General purpose, 5. Technology, 6. System, 7. Most effective solution, 8. Economic purpose, 9. Economic technology, 10. Economic system, 11. Marketing research purpose, 12. Marketing research technology, 13. Marketing research system, 14. SCM purpose, 15. SCM technology, 16. SCM system, 17. Quality Management purpose, 18. Quality Management technology, 19. Quality Management system, 20. Engineering purpose, 21. Engineering technology, and 22. Engineering system. Each theme contains between two and seven codes, depending on the results of open coding. Originally there were twenty-eight codes but the ones that had many similarities were consolidated. The consolidation process also took place for the sub codes, in which for example the sub codes of the theme purpose went from nine to seven sub codes. Some themes of the study are mutually exclusive, while others are not. Questions such as ‘How often do you engage in traceability?’ can just have one answer, therefore this theme is mutually exclusive. On the other hand, questions such as ‘Which traceability technologies do you know?’, can have more answers and are therefore not mutually exclusive.

An example that makes use of descriptive statistics is given in table 9. This table shows anonymously the respondents behavior towards traceability. It shows when the respondents used traceability for the first time, the frequency of use, and the impact on work.

Respondent	First usage	Frequency of use	Impact on work
Respondent 1	More than 10 years	Weekly	Medium
Respondent 2	Less than 1 year	Less than monthly	Low
Respondent 3	Between 3 and 10 years	Weekly	High
Respondent 4	Between 1 and 3 years	Daily	High
Respondent 5	Between 3 and 10 years	Weekly	Medium
Respondent 6	More than 10 years	Monthly	Medium
Respondent 7	Less than 1 year	Monthly	Medium
Respondent 8	Between 1 and 3 years	Daily	High

Table 9: Descriptive Statistics

6.2 Capacity to capture data

Traceability data are captured in organizations by using traceability technologies. According to Lotlikar et al., (2013), there are two traceability technologies that are most effective, these are RFID and barcode. This research strives to identify whether low capacity to capture data (e.g. barcodes) or high capacity to capture data (e.g. RFID) is perceived to be most effective for traceability. The matrices in appendices IV, V, and VI provide overviews of conditional formatting for grouped respondents. These matrices are used to develop histograms from which it is easily seen how distinct groups perceive capacity to capture data.

Five out of eight respondents indicate that a high capacity to capture data is needed for traceability. One respondent elaborated that a low capacity to capture data is enough for traceability. Two out of eight respondents mentioned low as well as high capacity to capture data. Seven respondents mentioned a high capacity to capture data more often than a low capacity to capture data during the interviews. Some examples of why a high capacity to capture data (e.g. RFID) is most effective for traceability are given below:

- R1: RFID is the most accurate traceability technology that currently exists.
- R2: For reading RFID there is no need for line-of-sight, which is a huge advantage compared to barcode.
- R4: The quality of products can be controlled very well by using RFID whereas, no other traceability technology equals this level.
- R6: The reading speed of RFID is much higher compared to other technologies, this makes RFID the most effective traceability technology.

The respondents, who indicated both low and high capacity (e.g. barcode and RFID) to capture data as most effective for traceability, provided the following arguments:

- R2: RFID has many benefits, but it is also expensive, using a combination of RFID and barcode enables the possibility to maintain the benefits and keeping the costs relatively low.
- R5: For customers it is in many situations useful to be able to read the traceability technology, because almost anyone has a smartphone which can read barcodes nowadays. RFID is more accurate but cannot be read without a RFID reader.

Histograms are developed to find trends between distinct factors. Figure 12, shows a histogram of capacity to capture data, in which respondents are grouped, based on the first-time they used traceability. The histogram shows that the group with respondents that used traceability for the first time between three and five years ago, mentioned low and high capacity to capture data just as often. The other three groups indicated that a high capacity of data is needed.

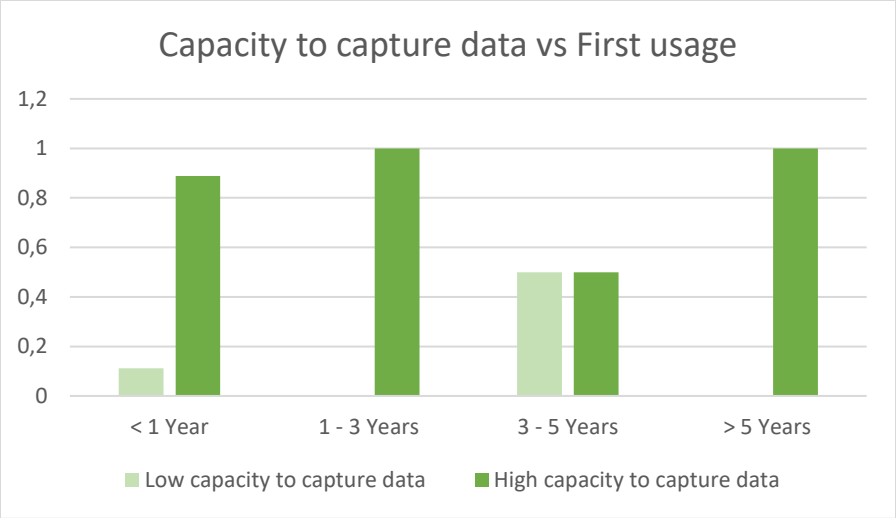


Figure 12: Histogram Capacity to capture data vs First usage

Figure 13, is a histogram that shows the capacity to capture data of the respondents grouped based on frequency of use of traceability. The histogram shows that all groups perceived the high capacity to capture data as most effective.

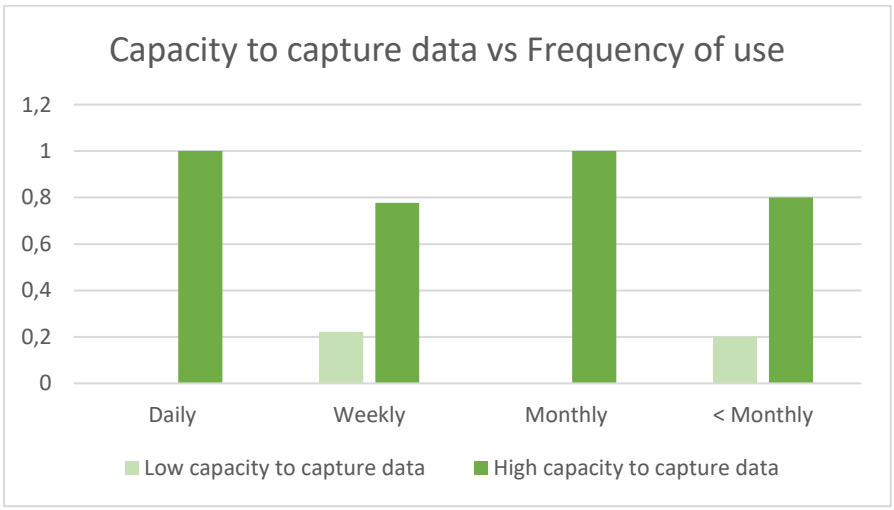


Figure 13: Histogram Capacity to capture data vs Frequency of use

Figure 14, is a histogram of the capacity to capture data based on impact traceability has on the respondents. The histogram shows that all groups perceive a technology with a high capacity

to capture data as the most effective traceability technology. The histogram also shows that there is a larger difference in preference for a high capacity to capture data for respondents that are medium impacted by traceability in their work.

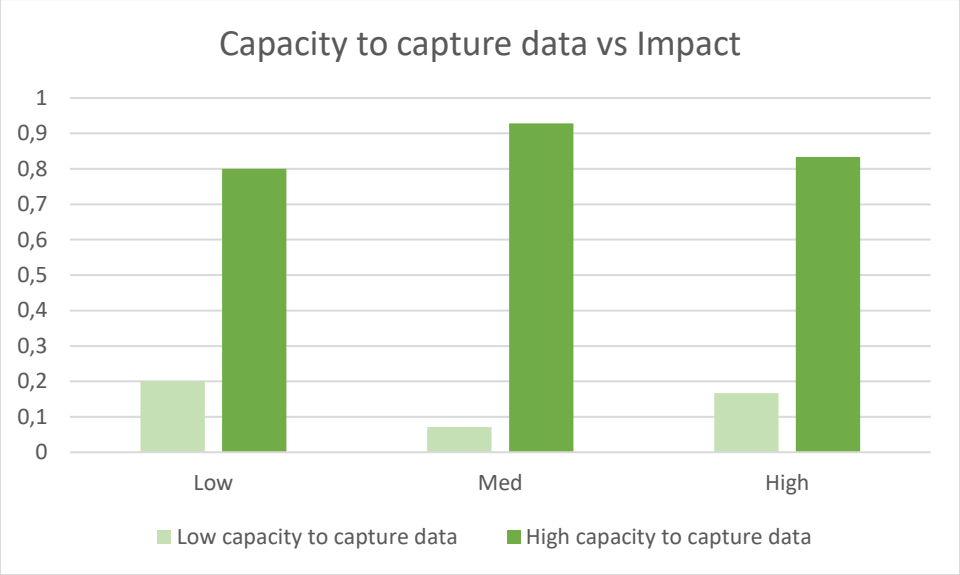


Figure 14: Histogram Capacity to capture data vs Impact

6.3 Readability

The captured data from the traceability technologies must be read before it can be helpfully used. Systems which can process this type of data in organizations are systems only for traceability such as some supply chain management (SCM) systems and systems for functions all over the organization such as enterprise resource planning (ERP) systems (Attaran, 2007). This research strives to identify if a low readability (e.g. SCM system) or high readability (e.g. ERP system) is required for traceability. The matrices in appendices III, IV, and V provide overviews of conditional formatting for grouped respondents. These matrices are used to develop histograms from which it is easily seen how distinct groups perceive readability.

Seven out of eight respondents perceive a high readability as the most effective for traceability. One respondent perceives that low readability is required for traceability. Amongst others, the following reasons are given why high readability perceived as most effective for traceability.

- R1: ERP systems can combine information from all functional areas of the organization's production.
- R6: ERP enhances the communication between the organization and the customer as well as the communication between the organization and the supplier.

There was also one respondent who explained why low readability is sufficient for traceability, the reason this person gave is the following:

- R2: SCM systems are relatively low-cost systems that are well able to process traceability data, especially in smaller organizations this is the most effective solution.

Histograms are developed to find trends between distinct factors. Figure 15, is a histogram of the readability based on the first-time respondents used traceability. The histogram shows that all groups perceived high readability as most effective for traceability. The group with respondents that used traceability for the first time between three and five years ago also mentioned high readability most often but also mentioned low readability a few times as most effective for traceability.

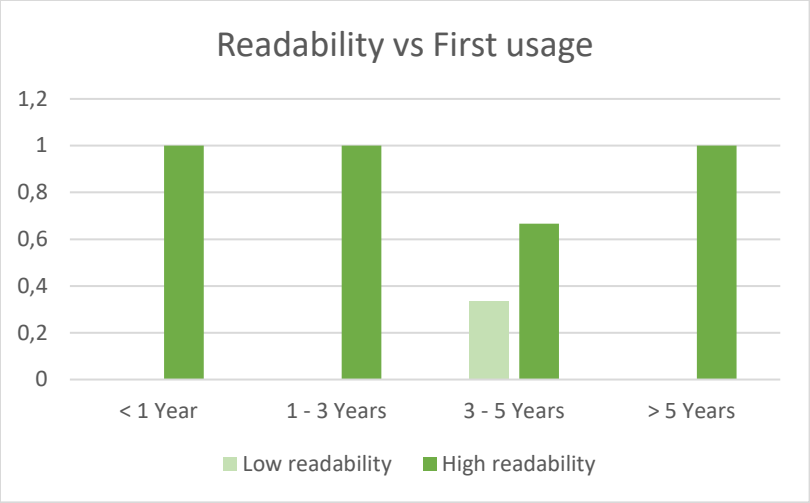


Figure 15: Histogram Readability vs First usage

Figure 16, is a histogram that shows the readability of the traceability system with respondents grouped on frequency of use of traceability. The histogram shows that for the groups of respondents that use traceability on daily, monthly, and less than monthly perceive high readability as the most effective for traceability 100 percent. The group that uses traceability on weekly basis also perceives high readability as most effective system for traceability, but low readability is also mentioned.

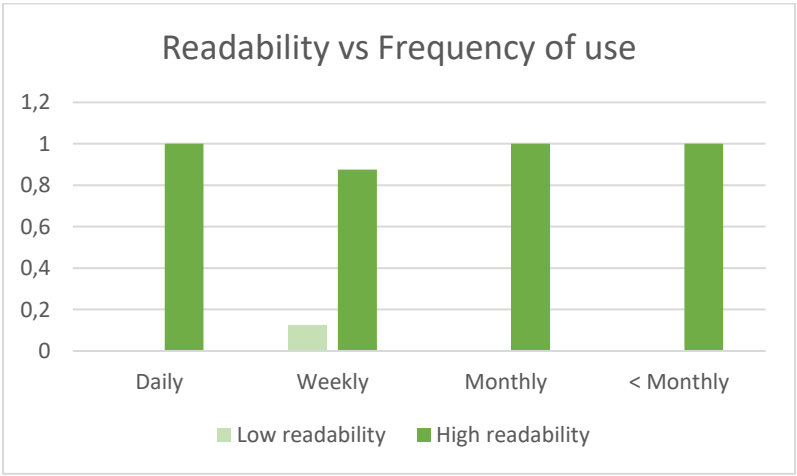


Figure 16: Histogram Readability vs Frequency of use

Figure 17, is a histogram readability of traceability systems in which respondents are grouped by impact of traceability on the respondents. The histogram shows that all three groups perceive high readability as the most effective for traceability. The histogram also shows that the groups that are less and medium impacted by traceability perceive only high readability as the most effective traceability system, while the groups that are more impacted also mentioned low readability a few times.

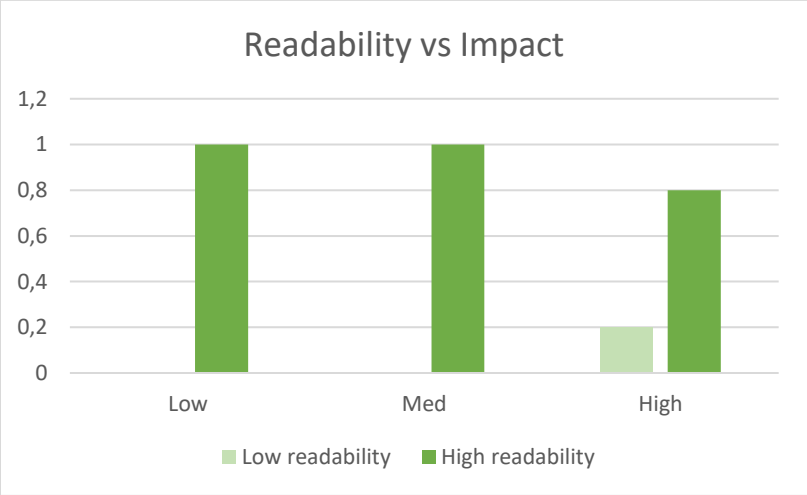


Figure 17: Histogram Readability vs Impact

6.4 Results placed in the two-by-two matrix

In this section, the results of the study are placed in the two-by-two matrix. First this is done for the general purpose of traceability. Then, this is done for the different departments that are impacted by traceability.

In figure 18 the results of the general purpose of traceability are placed in the two-by-two matrix. The framework shows that the combination of a high capacity to capture data (e.g. RFID) with high readability (e.g. ERP) is most effective for traceability in an organization. Two

respondents mentioned the combination of low capacity to capture data (e.g. barcode) with high readability (e.g. ERP). It further shows that one respondent perceives a combination of a low capacity to capture data (e.g. barcode) and low readability (e.g. SCM) as most effective. An argument why a high capacity to capture data in combination with high readability is most effective is given below:

- R3: RFID can capture lots of traceability data because of the high reading speed, while ERP can process this data and make it useful by combining it with other data.

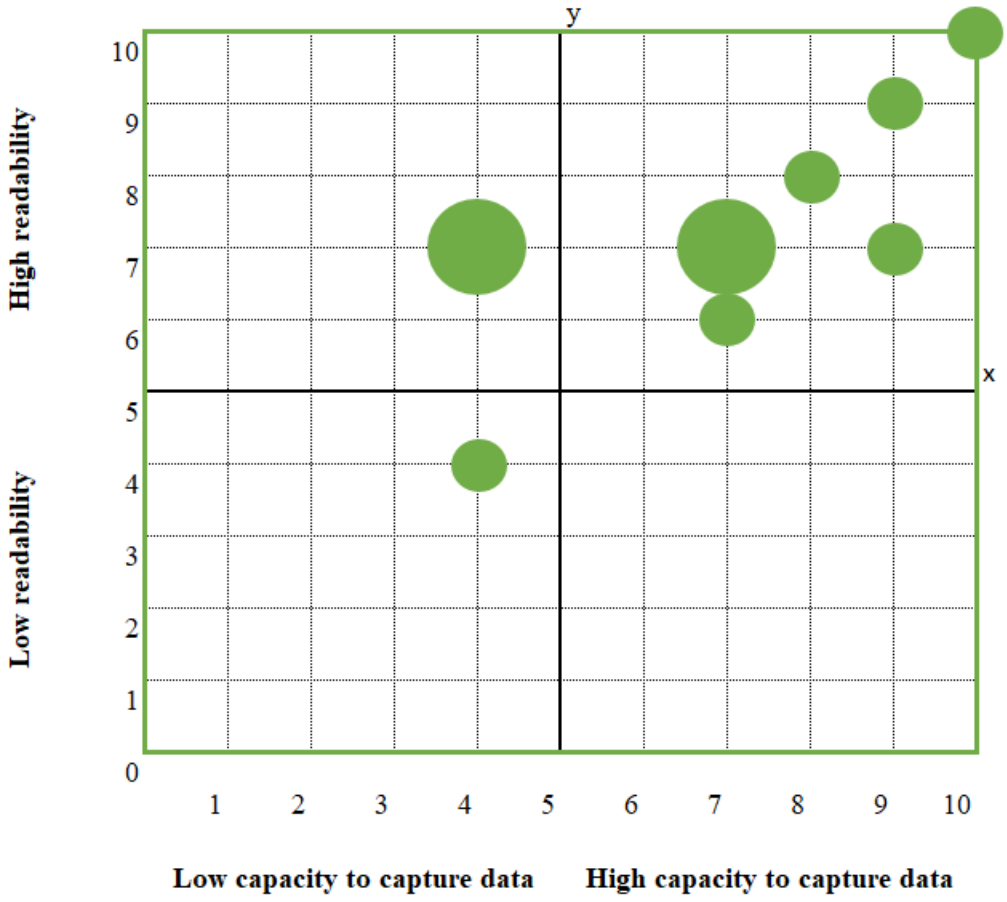
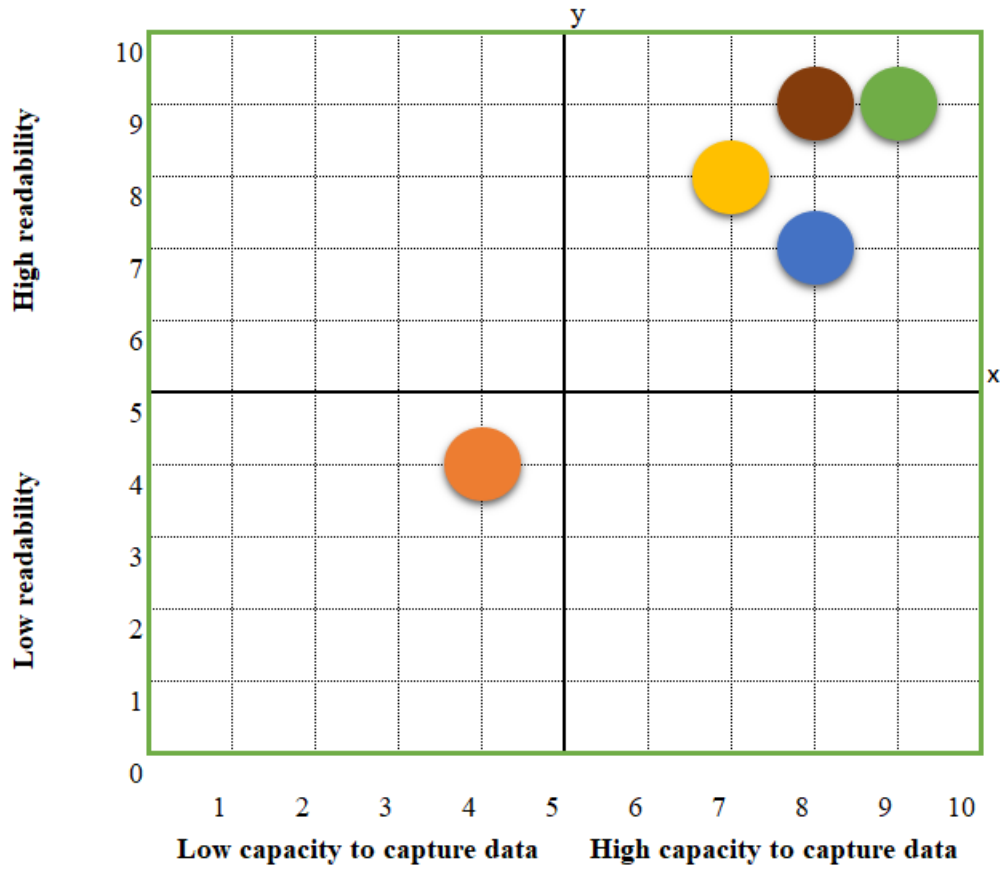


Figure 18: Two-by-two matrix General Purpose

In figure 19, the results of the preference for traceability by each department of the organization are shown in the two-by-two matrix. For economic purposes, it is most effective to use low capacity to capture data (e.g. barcode) in combination with low readability (e.g. SCM system). For supply chain management, quality management, engineering, and marketing research purposes, it is most effective to combine high capacity to capture data (e.g. RFID) and high readability (e.g. ERP system).



= Economics
= Marketing Research
= Supply Chain Management
= Quality Management
= Engineering

Figure 19: Two-by-two matrix Distinct departments

The main reason respondents gave for not perceiving high capacity to capture data and high readability as the most effective traceability solution is the following:

- R3: RFID and ERP are both very costly compared to their alternatives.

The main reason for high readability as already indicated by respondent three, is the ability to combine data from multiple departments. Reasons why respondents do perceive a high capacity to capture data as most effective for traceability, are the following:

- Marketing research: R7: RFID can capture data that can be used to determine customer buying behavior.
- Supply chain management: R2: The fast and without line-of-sight reading ability of RFID can enhance inventory management significantly.
- Quality management: R4: Quality of products can be measured with high accuracy when using RFID.
- Engineering: R1: RFID can be processed well in products and it gives useful feedback for further engineering.

6.5 Linking concepts with literature

This section explains how underlying patterns and concepts are used to place the findings in the academic scope. First, each concept found in the literature that can be linked is elaborated on. Then a table is given to provide an overview of the linked concepts.

This study shows that RFID is a traceability technology with many benefits and a high capacity to capture traceability data. This is in accord with Preradovic et al., 2008: RFID has many advantages such as high accuracy and speed of capturing traceability data. The main disadvantage of RFID appears to be the costs.

ERP systems are perceived as systems with high readability that are appropriate for processing traceability data. This confirms the findings by Attaran (2007): ERP systems can process data from functions all over the organization, including traceability.

Further, it is shown that distinct departments of an organization evaluate traceability by using different criteria. The departments discussed are economics, marketing research, supply chain management, quality management, and engineering. This matches the findings by Karlsen et al. (2013).

The economic department of an organization focuses on costs and benefits of traceability as selection criteria for a traceability solution. This confirms the findings by Disney et al. (2001): Cost-benefit analyses must be developed to determine the possibilities concerning traceability, as traceability impacts the economics of an organization significantly.

The marketing research department values the criterion of customer buying behavior as the most important criterion for selecting a traceability solution. This can be linked to Van Rijswijk et al. (2008): Traceability data can be used to detect trends in consumer and industrial buying behavior.

For the supply chain management, the selection criteria logistic management and inventory management matter the most for the selection of a traceability solution. This is in accord with Mai et al. (2010): A benefit of traceability is that it improves the supply chain management by improving the logistics.

This study shows that the most important selection criteria for a traceability solution according to quality management are quality control and quality improvement. This corresponds

to the findings by Galvao et al. (2010): Traceability can identify the origin of a lack in a product's quality.

The engineering department mostly bases its evaluation on the following selection criterium; implementation of traceability in products and design. This matches the findings by Billo and Bidanda (1998): Traceability impacts engineering in the way products are being designed and implemented.

Table 10 gives an overview of the links between the found concepts and literature.

Concepts found in study	Definitions	Literature
RFID for traceability	RFID is perceived as a traceability technology that is well able to capture traceability data.	(Preradovic, Balbin, Karmakar, & Swieger, 2008).
ERP for traceability	ERP is perceived as a traceability system that is well able to process traceability data.	(Attaran, 2007)
Traceability departments	Traceability influences distinct departments in organizations.	(Karlsen et al., 2013)
Traceability and economics	Traceability influences the economics of organizations.	(Disney et al., 2001)
Traceability and marketing research	Traceability influences the marketing research of organizations	(Van Rijswijk et al., 2008)
Traceability and supply chain management	Traceability influences the supply chain management of organizations	(Mai et al., 2010)
Traceability and quality management	Traceability influences the quality management of organizations	(Galvao et al., 2010)
Traceability and engineering	Traceability influences the engineering of organizations	(Billo and Bidanda, 1998)

Table 10: Linking Concepts with Literature

7. Discussion & Conclusion

This chapter starts with a section (7.1) in which the managerial implications and theory implementation plan are elaborated on. Section 7.2 discusses the theoretical implications, meaning that the developed theory is added to the existing literature on traceability. Section 7.3 elaborates on the potential future research directions and the limitations of this study. Section 7.4 provides the overall conclusion of this study.

7.1 Managerial implications

Multiple recommendations are developed based on the information retrieved from this study. One of these recommendations towards management is that the traceability technologies with higher capacities to capture data are generally preferred. Therefore, it is recommended that RFID is used as a traceability technology for data capturing. It is found that systems with high readability are preferred. Therefore, it is recommended that ERP systems are used for processing traceability data. Also, a combination of RFID as a traceability technology and ERP as a traceability system is recommended. A combination of both RFID and barcode with ERP is also perceived as effective for traceability, but to a lesser extent. This confirms the findings of Preradovic et al. (2008) and Attaran (2007).

In accordance with the study by Karlsen et al. (2013) it is recommended for management to consider all departments of an organization when deciding on how to create traceability. It is found that distinct departments evaluate traceability solutions on various selection criteria. The departments that have diverse selection criteria are economics, marketing research, supply chain management, quality management, and engineering.

When only looking at the economic factors of traceability, it is found that barcode is perceived as the most effective technology for traceability. The most effective system for traceability concerning economics is the SCM system. The costs of this traceability technology and system are relatively low and are therefore recommended for traceability only when looking at the economic factors (Vipul and Dong, 2007; Gargeya and Brady, 2005).

For the development of traceability with management focusing on marketing research factors, a combination of RFID as the traceability technology and ERP as the traceability system is perceived as most effective and therefore a combination of these is recommended as the traceability solution.

Similarly, it is recommended to use a combination of RFID as traceability technology and ERP as traceability system to develop a complete solution for the supply chain management aspects of an organization.

The same applies to traceability creation regarding quality management aspects of organizations. It is recommended to use a combination of RFID as the technology and ERP as the system for traceability.

The engineering aspects of traceability are also perceived to be most effective when a combination of RFID and ERP is used for traceability, therefore a combination of this technology and system is recommended when creating traceability.

7.2 Theoretical implications

In this section, the theoretical findings are compared to the existing literature on traceability. Both contradicting and confirming literature on traceability is discussed to raise the theoretical level,

increase the construct validity, and build internal validity (Eisenhardt, 1989). The main finding of this research is that the traceability technology with a high capacity to capture data in combination with the traceability system that has a high readability is preferred. Therefore, the solution with RFID as the traceability technology and ERP as the traceability system is perceived as the most effective for traceability creation in organizations in general. This finding is in accordance with the study of Preradovic et al. (2008) and Attaran (2007).

The main benefits of RFID compared to alternatives is that RFID has a high reading accuracy, line of sight is not necessary, it can detect quality levels of products, multiple products can be read at the same time with high speed, it can be rewritten, it is sustainable, and is not influenced by light. According to respondent 1, RFID is the most accurate traceability technology that currently exists. Respondent 2 emphasized that for reading RFID there is no need for line-of-sight, which is a huge advantage compared to barcode. Respondent 4 observed that the quality of products can be controlled very well by using RFID, no other traceability technology equals this level. Respondent 6 explained that the reading speed of RFID is much higher compared to other technologies, which makes RFID the most effective traceability technology. According to respondent 6, RFID tags are more sustainable than barcodes. This confirms the RFID benefits as described by Preradovic et al. (2008). It contrasts with the study of White, Gardiner, and Razak (2007), which found that the percentage of equipment failures of RFID technology is higher than that of barcodes.

The main benefits of ERP compared to its alternatives is that ERP systems can combine data from all over the organization, and it enhances the communication between the organization and other organizations in the supply chain. Respondent 1 emphasized that ERP systems can combine information from all functional areas of the organization's production. Respondent 6

stated that ERP enhances the communication between the organization and the customer as well as the communication between the organization and the supplier. This is in line with the benefits of ERP as described by Attaran (2007).

Further, it is found that distinct departments of an organization use different criteria for selecting a traceability solution. Respondent 1 observed that traceability does not just impact one department, but it is important for the whole organization. This study confirms the findings by Karlsen et al. (2013), as traceability impacts economics, marketing research, supply chain management, quality management, and engineering in distinct ways.

The decision criteria of the economic department correspond to the study of Karlsen et al. (2013): the two main decision criteria are costs and benefits. For economics it is also found that low capacity to capture data (e.g. barcode) and low readability (e.g. SCM) are sufficient. This contrasts with the findings for the organization in general, since for the organization in general a high capacity to capture data (e.g. RFID) and high readability (e.g. ERP) are needed. The main reason for the solution with low capacity to capture data and low readability is that the alternatives with high capacity to capture data and high readability cost more.

This study confirms the findings of Karlsen et al. (2013) and Van Rijswijk et al. (2008) concerning the marketing research aspect of traceability, while both studies indicate that customer buying behavior is important for marketing. This study shows that customer buying behavior is an important criterion for decision making concerning traceability. It adds the concept of unique selling point (USP), as decision criterion for traceability. Respondent 7 mentioned that being able to guarantee traceability to customers is an underestimated unique selling point.

Further, this study confirms the findings of Karlsen et al. (2013) and Mai et al. (2010) on supply chain management aspects of traceability. Logistic management, inventory management, risk management, product differentiation, and decision support system are all seen as decision criteria for traceability. This study also adds the finding that communication system for supply chain management is a crucial decision criterion. Respondent 2 said that the decision for a traceability solution depends on the how well the solution performs on inventory management.

For the quality management, the most crucial decision criteria for traceability are quality control, quality improvement, quality assurance, and defect product handling. These findings correspond with the research directions of Karlsen et al. (2013). Respondent 4 indicates the importance of detecting quality problems by using traceability because it helps the respondent in problem handling and improving product's quality.

It is found that implementation, design, and design feedback are the most important decision criteria for the engineering department. This finding also confirms the study of Billo and Bidanda (1998), based on the value of traceability on design. Respondent 6 observed that traceability provides feedback on design and in that way, supports developing a successful design.

7.3 Further research and limitations

Traceability is a research topic already investigated in multiple studies in the past decades. However, the way traceability is created differs as time progresses. Recently there have been some significant changes in traceability systems and technologies and it is expected that these systems and technologies will change even more in the coming years. Therefore, it would be interesting to do further research on traceability systems and technologies as they improve by time (Tao, Fan, Lay, & Li, 2016).

Because this research is performed in one organization, it could give biased results. Further research on traceability will be strengthened if distinct organizations are used.

The number of respondents that are interviewed is not high. However, the number of respondents is determined based on the concept called data saturation (Glaser and Strauss, 1967; Guest, Bunce, and Johnson, 2006). Data saturation is described as the point when no additional data is found whereby the researcher can develop properties of the category (Glaser and Strauss, 1967). In interview-based qualitative research, explaining the usage of small sample sizes is an example of scientific conformity (Crouch and McKenzie, 2006).

Traceability impacts multiple departments of an organization (Karlsen et al., 2013). This research confirmed that distinct departments of an organization base their selection for a traceability solution on different criteria. For further research it could be interesting to discover other areas which are impacted by traceability and how these areas decide on traceability solutions.

This research is only conducted in the food (packaging) industry, because in this industry, traceability is of high importance. Therefore, the generalization of the results is not substantiated for further research in other industries. For further research it would be interesting to discover how traceability should be created in industries where traceability currently seems to be less important.

This research has some limitations; however, these should be regarded as opportunities for future research in this area.

7.4 Conclusion

In conclusion, this study serves to answer the main and sub-research questions as described in section 3.2 of this report. The results indicate that in general the most effective technology for traceability is a technology that has a high capacity to capture data (e.g. RFID) Further, I showed

that for traceability a high readability system (e.g. ERP) is most effective. These findings also confirm the studies of Preradovic et al. (2008); Attaran (2007). This study shows that distinct departments have different criteria for selecting a traceability solution. For the economic department the decision criteria are costs and savings. For the marketing research department, USP and customer buying behavior are the decision criteria. Logistic management, inventory management, risk management, product differentiation, decision support system, and communication system are the criteria for the supply chain management. Quality management mentioned the decision criteria: Quality control, quality improvement, quality assurance, and defect product handling. The engineering department pointed out that implementation, design, and design feedback, are decision criteria. Furthermore, the study shows that a combination of a low capacity to capture data (e.g. barcode) and a low readability (e.g. SCM system) is the most effective solution in terms of economic aspects. For marketing research, supply chain management, quality management, and engineering purposes, the combination of a technology with a high capacity to capture data (e.g. RFID) and a high readability system (e.g. ERP system) appears to be most effective. It can be concluded that these findings can highly impact organizations; it is shown that traceability has a high impact on distinct departments of organizations. This study fills the scientifically knowledge gap concerning traceability technologies and systems (Bosona and Gebresenbet, 2013; Karlsen et al., 2013). These findings can be of major help to the management of organizations, in deciding how to create product traceability in practice.

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Appendix

I. Themes, codes, and associated definitions

Themes	Codes	Definitions
First usage	Several Months 1 Year 3 Years 10 Years	The moment, a respondent first used traceability.
Frequency of use	Daily Weekly Monthly Less than monthly	How often respondents are faced with traceability.
Impact on work	No Little Medium High	The impact traceability has on the respondent's job.
General Purpose	Defect product handling Quality improvement Quality control Product differentiation Risk management Inventory management Logistic management	Traceability enhances handling cases with defect products. Traceability helps in quality improvement. Traceability enhances product quality control. Traceability can differentiate a product from other products. Traceability information enhances risk predictions. Traceability enhances inventory management. Traceability enhances logistic management.
Technology	Date clock Paper based Barcode QR-code RFID	The traceability technologies that respondents prefer to use.
System	Paper based Microsoft Excel SCM system ERP system	The traceability systems that respondents prefer to use.
Most Effective Solution	Barcode RFID SCM ERP	The traceability solution that is perceived as most effective for the organization by the respondents.
Economic Purpose	Costs Savings	The purpose traceability has on economic aspects of the organization.
Economic Technology	Barcode RFID	The traceability technology that is perceived as most effective for the economic aspects of an organization by the respondent.
Economic System	SCM ERP	The traceability system that is perceived as most effective for the economic aspects of an organization by the respondent.
Marketing Research Purpose	USP Buying behavior	The purpose traceability has on marketing aspects of organizations.
Marketing Research Technology	Barcode RFID	The traceability technology that is perceived as most effective for the marketing research aspects of an organization by the respondent.
Marketing Research System	SCM ERP	The traceability system that is perceived as most effective for the marketing research aspects of an organization by the respondent.
SCM Purpose	Logistic management Inventory management Risk management Product differentiation Distribution systems	The purpose traceability has on SCM aspects of organizations.
SCM Technology	Barcode RFID	The traceability technology that is perceived as most effective for the supply chain management aspects of an organization by the respondent.

SCM System	SCM ERP	The traceability system that is perceived as most effective for the supply chain management aspects of an organization by the respondent.
Quality Management Purpose	Quality control Quality improvement Quality assurance system Quality management system	The purpose traceability has on quality management aspects of organizations.
Quality Management Technology	Barcode RFID	The traceability technology that is perceived as most effective for the quality management aspects of an organization by the respondent.
Quality Management System	SCM ERP	The traceability system that is perceived as most effective for the quality management aspects of an organization by the respondent.
Engineering Purpose	Implementation of traceability Traceability systems Information technology Electronic identification and data recording Barcodes and RFID tag technology	The purpose traceability has on engineering aspects of organizations.
Engineering Technology	Barcode RFID	The traceability technology that is perceived as most effective for the engineering aspects of an organization by the respondent.
Engineering System	SCM ERP	The traceability system that is perceived as most effective for the engineering aspects of an organization by the respondent.
Age	20-29 30-39 40-49 50-59 60-69	The age of the respondent.
Nationality	Belgium Czech	The nationality of the respondent.
Highest Educational Degree	Master degree Bachelor degree Associate degree	The highest level of education of the respondent.
Function	Chief Executive Officer (CEO) Operations Director Director Technology & Engineering Marketing & Sales Coordinator Business Development Manager Senior Advisor Quality Engineer Logistics	The function in the organization of the respondent.
Employment in Company	Less than 6 months Between 6 and 12 months Between 12 and 36 months More than 36 months	The time the respondent is employed by the current organization.
Employment in Industry	Less than 6 months Between 6 and 12 months Between 12 and 36 months More than 36 months	The time the respondent is employed in the food (packaging) industry.

II. Original codebook

Themes	Subcodes	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5	Respondent 6	Respondent 7	Respondent 8	Total
1. First usage	< 1 Year	0	1	0	0	0	0	1	0	**2**
	Between 1 and 3 Years	0	0	0	1	0	0	0	1	**2**
	Between 3 and 10 Years	0	0	1	0	1	0	0	0	**2**
	> 10 Years	1	0	0	0	0	1	0	0	**2**
2. Frequency of use	Daily	0	0	0	1	0	0	0	1	**2**
	Weekly	1	0	1	0	1	0	0	0	**3**
	Monthly	0	0	0	0	0	1	1	0	**2**
	Less than monthly	0	1	0	0	0	0	0	0	**1**
3. Impact on work	Low	0	1	0	0	0	0	0	0	**1**
	Med	1	0	0	0	1	1	1	0	**4**
	High	0	0	1	1	0	0	0	1	**3**
4. General purpose	Defect product handling	2	1	3	3	1	2	3	1	**16**
	Quality improvement	3	2	3	2	4	1	0	0	**15**
	Quality control	3	3	1	2	0	1	0	0	**10**
	Product differentiation	4	1	1	0	2	0	3	0	**11**
	Risk management	2	0	0	2	1	0	0	0	**5**
	Inventory management	4	2	3	1	0	1	0	3	**14**
	Logistic management	2	1	2	1	1	1	2	2	**12**
5. Technology	Date stamp	1	2	0	0	0	3	0	0	**6**
	Paper based	1	1	1	1	1	2	0	1	**8**
	QR-code	1	1	1	3	2	2	3	1	**14**
	Barcode	1	1	3	1	2	2	1	3	**14**
	RFID	3	4	1	3	2	2	2	2	**19**
6. System	Paper based	1	2	0	1	1	0	1	2	**8**
	Microsoft Excel	1	2	2	1	1	1	2	1	**11**
	SCM system	2	1	2	1	1	1	1	3	**12**
	ERP system	5	3	2	3	1	2	2	4	**22**
7. Most effective solution	Barcode	0	1	1	0	1	0	0	0	**3**
	RFID	5	4	0	3	2	2	4	2	**22**
	SCM	0	0	1	0	0	0	0	0	**1**
	ERP	5	2	0	3	2	2	4	1	**19**
8. Economic purpose	Costs	2	3	2	2	1	1	1	3	**15**
	Savings	3	1	2	0	3	0	1	1	**11**
9. Economic technology	Barcode	1	2	3	1	2	1	0	1	**11**
	RFID	1	0	0	1	0	0	1	0	**3**
10. Economic system	SCM	1	3	3	2	1	2	1	1	**14**
	ERP	1	0	0	2	0	0	2	1	**6**
11. Marketing research purpose	USP	3	1	1	1	0	0	3	1	**10**
	Customer buying behavior	1	1	1	0	1	0	3	0	**7**

12. Marketing research technology	Barcode	0	1	1	0	0	0	0	0	**2**
	RFID	5	3	2	2	2	2	5	4	**25**
13. Marketing research system	SCM	0	0	0	0	0	0	0	0	**0**
	ERP	6	4	5	2	3	2	5	3	**30**
14. SCM purpose	Logistic management	2	1	3	2	1	1	1	3	**14**
	Inventory management	3	1	2	2	2	1	1	3	**15**
	Risk management	1	1	0	2	1	1	0	0	**6**
	Product differentiation	2	0	1	0	0	0	2	0	**5**
	Decision support system	0	0	0	1	0	0	0	0	**1**
	Communication system	2	0	1	0	0	0	2	0	**5**
15. SCM technology	Barcode	0	2	1	0	2	0	0	0	**5**
	RFID	4	2	3	3	3	2	1	2	**20**
16. SCM system	SCM	0	1	2	0	0	0	0	0	**3**
	ERP	3	2	2	4	2	1	3	2	**19**
17. Quality Management purpose	Quality control	2	3	1	2	1	1	1	0	**11**
	Quality improvement	1	1	2	2	1	2	0	0	**9**
	Quality assurance	1	0	1	3	0	0	0	1	**6**
	Defect product handling	2	1	1	4	2	0	2	1	**13**
18. Quality Management technology	Barcode	0	0	1	0	0	1	1	1	**4**
	RFID	3	1	2	3	2	1	2	2	**16**
19. Quality Management system	SCM	0	0	0	0	1	0	0	0	**1**
	ERP	3	4	2	4	3	3	3	2	**24**
20. Engineering purpose	Implementation	2	2	1	1	0	2	0	1	**9**
	Design	1	0	1	0	2	3	2	0	**9**
	Design feedback	0	0	0	0	1	2	0	0	**3**
21. Engineering technology	Barcode	1	0	2	0	0	1	0	0	**4**
	RFID	2	2	2	3	1	4	2	1	**17**
22. Engineering system	SCM	0	0	1	0	0	0	0	0	**1**
	ERP	3	2	2	1	2	3	1	1	**15**

III. Conditional formatting of codes' averages

Themes	Subcodes	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5	Respondent 6	Respondent 7	Respondent 8	Total	Average per theme
1. First usage	< 1 Year	0	1	0	0	0	0	1	0	**2**	0,25
	Between 1 and 3 Years	0	0	0	1	0	0	0	1	**2**	0,25
	Between 3 and 10 Years	0	0	1	0	1	0	0	0	**2**	0,25
	> 10 Years	1	0	0	0	0	1	0	0	**2**	0,25
2. Frequency of use	Daily	0	0	0	1	0	0	0	1	**2**	0,25
	Weekly	1	0	1	0	1	0	0	0	**3**	0,38
	Monthly	0	0	0	0	0	1	1	0	**2**	0,25
	Less than monthly	0	1	0	0	0	0	0	0	**1**	0,13
3. Impact on work	Low	0	1	0	0	0	0	0	0	**1**	0,13
	Med	1	0	0	0	1	1	1	0	**4**	0,50
	High	0	0	1	1	0	0	0	1	**3**	0,38
4. General purpose	Defect product handling	2	1	3	3	1	2	3	1	**16**	0,19
	Quality improvement	3	2	3	2	4	1	0	0	**15**	0,18
	Quality control	3	3	1	2	0	1	0	0	**10**	0,12
	Product differentiation	4	1	1	0	2	0	3	0	**11**	0,13
	Risk management	2	0	0	2	1	0	0	0	**5**	0,06
	Inventory management	4	2	3	1	0	1	0	3	**14**	0,17
	Logistic management	2	1	2	1	1	1	2	2	**12**	0,14
5. Technology	Date stamp	1	2	0	0	0	3	0	0	**6**	0,10
	Paper based	1	1	1	1	1	2	0	1	**8**	0,13
	QR-code	1	1	1	3	2	2	3	1	**14**	0,23
	Barcode	1	1	3	1	2	2	1	3	**14**	0,23
	RFID	3	4	1	3	2	2	2	2	**19**	0,31
6. System	Paper based	1	2	0	1	1	0	1	2	**8**	0,15
	Microsoft Excel	1	2	2	1	1	1	2	1	**11**	0,21
	SCM system	2	1	2	1	1	1	1	3	**12**	0,23
	ERP system	5	3	2	3	1	2	2	4	**22**	0,42
7. Most effective solution	Barcode	0	1	1	0	1	0	0	0	**3**	0,07
	RFID	5	4	0	3	2	2	4	2	**22**	0,49
	SCM	0	0	1	0	0	0	0	0	**1**	0,02
	ERP	5	2	0	3	2	2	4	1	**19**	0,42
8. Economic purpose	Costs	2	3	2	2	1	1	1	3	**15**	0,58
	Savings	3	1	2	0	3	0	1	1	**11**	0,42
9. Economic technology	Barcode	1	2	3	1	2	1	0	1	**11**	0,79
	RFID	1	0	0	1	0	0	1	0	**3**	0,21
10. Economic system	SCM	1	3	3	2	1	2	1	1	**14**	0,70

	ERP	1	0	0	2	0	0	2	1	**6**	0,30
11. Marketing research purpose	USP	3	1	1	1	0	0	3	1	**10**	0,59
	Customer buying behavior	1	1	1	0	1	0	3	0	**7**	0,41
12. Marketing research technology	Barcode	0	1	1	0	0	0	0	0	**2**	0,08
	RFID	5	3	2	2	2	2	5	4	**25**	0,93
13. Marketing research system	SCM	0	0	0	0	0	0	0	0	**0**	0,00
	ERP	6	4	5	2	3	2	5	3	**30**	1,00
14. SCM purpose	Logistic management	2	1	3	2	1	1	1	3	**14**	0,30
	Inventory management	3	1	2	2	2	1	1	3	**15**	0,33
	Risk management	1	1	0	2	1	1	0	0	**6**	0,13
	Product differentiation	2	0	1	0	0	0	2	0	**5**	0,11
	Decision support system	0	0	0	1	0	0	0	0	**1**	0,02
	Communication system	2	0	1	0	0	0	2	0	**5**	0,11
15. SCM technology	Barcode	0	2	1	0	2	0	0	0	**5**	0,20
	RFID	4	2	3	3	3	2	1	2	**20**	0,80
16. SCM system	SCM	0	1	2	0	0	0	0	0	**3**	0,14
	ERP	3	2	2	4	2	1	3	2	**19**	0,86
17. Quality Management purpose	Quality control	2	3	1	2	1	1	1	0	**11**	0,28
	Quality improvement	1	1	2	2	1	2	0	0	**9**	0,23
	Quality assurance	1	0	1	3	0	0	0	1	**6**	0,15
	Defect product handling	2	1	1	4	2	0	2	1	**13**	0,33
18. Quality Management technology	Barcode	0	0	1	0	0	1	1	1	**4**	0,20
	RFID	3	1	2	3	2	1	2	2	**16**	0,80
19. Quality Management system	SCM	0	0	0	0	1	0	0	0	**1**	0,04
	ERP	3	4	2	4	3	3	3	2	**24**	0,96
20. Engineering purpose	Implementation	2	2	1	1	0	2	0	1	**9**	0,43
	Design	1	0	1	0	2	3	2	0	**9**	0,43
	Design feedback	0	0	0	0	1	2	0	0	**3**	0,14
21. Engineering technology	Barcode	1	0	2	0	0	1	0	0	**4**	0,19
	RFID	2	2	2	3	1	4	2	1	**17**	0,81
22. Engineering system	SCM	0	0	1	0	0	0	0	0	**1**	0,06
	ERP	3	2	2	1	2	3	1	1	**15**	0,94

IV. Conditional formatting grouped by first usage.

		< 1 Year			Between 1 and 3 Years			Between 3 and 10 years			> 10 Years		
		Respondent 2	Respondent 7	Group average	Respondent 4	Respondent 8	Group average	Respondent 3	Respondent 5	Group average	Respondent 1	Respondent 6	Group average
Themes	**Subcodes**												
1. First usage	< 1 Year	1	1	1,0	0	0	0,0	0	0	0,0	0	0	0,0
	Between 1 and 3 Years	0	0	0,0	1	1	1,0	0	0	0,0	0	0	0,0
	Between 3 and 10 Years	0	0	0,0	0	0	0,0	1	1	1,0	0	0	0,0
	> 10 Years	0	0	0,0	0	0	0,0	0	0	0,0	1	1	1,0
2. Frequency of use	Daily	0	0	0,0	1	1	1,0	0	0	0,0	0	0	0,0
	Weekly	0	0	0,0	0	0	0,0	1	1	1,0	1	0	0,5
	Monthly	0	1	0,5	0	0	0,0	0	0	0,0	0	1	0,5
	Less than monthly	1	0	0,5	0	0	0,0	0	0	0,0	0	0	0,0
3. Impact on work	Low	1	0	0,5	0	0	0,0	0	0	0,0	0	0	0,0
	Med	0	1	0,5	0	0	0,0	0	1	0,5	1	1	1,0
	High	0	0	0,0	1	1	1,0	1	0	0,5	0	0	0,0
4. General purpose	Defect product handling	1	3	2,0	3	1	2,0	3	1	2,0	2	2	2,0
	Quality improvement	2	0	1,0	2	0	1,0	3	4	3,5	3	1	2,0
	Quality control	3	0	1,5	2	0	1,0	1	0	0,5	3	1	2,0
	Product differentiation	1	3	2,0	0	0	0,0	1	2	1,5	4	0	2,0
	Risk management	0	0	0,0	2	0	1,0	0	1	0,5	2	0	1,0
	Inventory management	2	0	1,0	1	3	2,0	3	0	1,5	4	1	2,5
	Logistic management	1	2	1,5	1	2	1,5	2	1	1,5	2	1	1,5
5. Technology	Date stamp	2	0	1,0	0	0	0,0	0	0	0,0	1	3	2,0
	Paper based	1	0	0,5	1	1	1,0	1	1	1,0	1	2	1,5
	QR-code	1	3	2,0	3	1	2,0	1	2	1,5	1	2	1,5
	Barcode	1	1	1,0	1	3	2,0	3	2	2,5	1	2	1,5
	RFID	4	2	3,0	3	2	2,5	1	2	1,5	3	2	2,5
6. System	Paper based	2	1	1,5	1	2	1,5	0	1	0,5	1	0	0,5
	Microsoft Excel	2	2	2,0	1	1	1,0	2	1	1,5	1	1	1,0
	SCM system	1	1	1,0	1	3	2,0	2	1	1,5	2	1	1,5
	ERP system	3	2	2,5	3	4	3,5	2	1	1,5	5	2	3,5
7. Most effective solution	Barcode	1	0	0,5	0	0	0,0	1	1	1,0	0	0	0,0
	RFID	4	4	4,0	3	2	2,5	0	2	1,0	5	2	3,5
	SCM	0	0	0,0	0	0	0,0	1	0	0,5	0	0	0,0
	ERP	2	4	3,0	3	1	2,0	0	2	1,0	5	2	3,5
8. Economic purpose	Costs	3	1	2,0	2	3	2,5	2	1	1,5	2	1	1,5
	Savings	1	1	1,0	0	1	0,5	2	3	2,5	3	0	1,5
9. Economic technology	Barcode	2	0	1,0	1	1	1,0	3	2	2,5	1	1	1,0
	RFID	0	1	0,5	1	0	0,5	0	0	0,0	1	0	0,5
10. Economic system	SCM	3	1	2,0	2	1	1,5	3	1	2,0	1	2	1,5
	ERP	0	2	1,0	2	1	1,5	0	0	0,0	1	0	0,5
11. Marketing research purpose	USP	1	3	2,0	1	1	1,0	1	0	0,5	3	0	1,5
	Customer buying behavior	1	3	2,0	0	0	0,0	1	1	1,0	1	0	0,5
12. Marketing research technology	Barcode	1	0	0,5	0	0	0,0	1	0	0,5	0	0	0,0
	RFID	3	5	4,0	2	4	3,0	2	2	2,0	5	2	3,5
13. Marketing research system	SCM	0	0	0,0	0	0	0,0	0	0	0,0	0	0	0,0
	ERP	4	5	4,5	2	3	2,5	5	3	4,0	6	2	4,0
14. SCM purpose	Logistic management	1	1	1,0	2	3	2,5	3	1	2,0	2	1	1,5
	Inventory management	1	1	1,0	2	3	2,5	2	2	2,0	3	1	2,0
	Risk management	1	0	0,5	2	0	1,0	0	1	0,5	1	1	1,0
	Product differentiation	0	2	1,0	0	0	0,0	1	0	0,5	2	0	1,0
	Decision support system	0	0	0,0	1	0	0,5	0	0	0,0	0	0	0,0
	Communication system	0	2	1,0	0	0	0,0	1	0	0,5	2	0	1,0
15. SCM technology	Barcode	2	0	1,0	0	0	0,0	1	2	1,5	0	0	0,0
	RFID	2	1	1,5	3	2	2,5	3	3	3,0	4	2	3,0
16. SCM system	SCM	1	0	0,5	0	0	0,0	2	0	1,0	0	0	0,0
	ERP	2	3	2,5	4	2	3,0	2	2	2,0	3	1	2,0
17. Quality Management purpose	Quality control	3	1	2,0	2	0	1,0	1	1	1,0	2	1	1,5
	Quality improvement	1	0	0,5	2	0	1,0	2	1	1,5	1	2	1,5
	Quality assurance	0	0	0,0	3	1	2,0	1	0	0,5	1	0	0,5
	Defect product handling	1	2	1,5	4	1	2,5	1	2	1,5	2	0	1,0
18. Quality Management technology	Barcode	0	1	0,5	0	1	0,5	1	0	0,5	0	1	0,5
	RFID	1	2	1,5	3	2	2,5	2	2	2,0	3	1	2,0
19. Quality Management system	SCM	0	0	0,0	0	0	0,0	0	1	0,5	0	0	0,0
	ERP	4	3	3,5	4	2	3,0	2	3	2,5	3	3	3,0
20. Engineering purpose	Implementation	2	0	1,0	1	1	1,0	1	0	0,5	2	2	2,0
	Design	0	2	1,0	0	0	0,0	1	2	1,5	1	3	2,0
	Design feedback	0	0	0,0	0	0	0,0	0	1	0,5	0	2	1,0
21. Engineering technology	Barcode	0	0	0,0	0	0	0,0	2	0	1,0	1	1	1,0
	RFID	2	2	2,0	3	1	2,0	2	1	1,5	2	4	3,0
22. Engineering system	SCM	0	0	0,0	0	0	0,0	1	0	0,5	0	0	0,0
	ERP	2	1	1,5	1	1	1,0	2	2	2,0	3	3	3,0
	Total	82	77	79,5	84	64	74,0	84	68	76,0	111	65	88,0

V. Conditional formatting grouped by frequency of use

		Daily			Weekly				Monthly			Less than monthly	
		Respondent 4	Respondent 8	Group average	Respondent 1	Respondent 3	Respondent 5	Group average	Respondent 6	Respondent 7	Group average	Respondent 2	Group average
Themes	**Subcodes**												
1. First usage	< 1 Year	0	0	0,0	0	0	0	0,0	0	1	0,5	1	1,0
	Between 1 and 3 Years	1	1	1,0	0	0	0	0,0	0	0	0,0	0	0,0
	Between 3 and 10 Years	0	0	0,0	0	1	1	0,7	0	0	0,0	0	0,0
	> 10 Years	0	0	0,0	1	0	0	0,3	1	0	0,5	0	0,0
2. Frequency of use	Daily	1	1	1,0	0	0	0	0,0	0	0	0,0	0	0,0
	Weekly	0	0	0,0	1	1	1	1,0	0	0	0,0	0	0,0
	Monthly	0	0	0,0	0	0	0	0,0	1	1	1,0	0	0,0
	Less than monthly	0	0	0,0	0	0	0	0,0	0	0	0,0	1	1,0
3. Impact on work	Low	0	0	0,0	0	0	0	0,0	0	0	0,0	1	1,0
	Med	0	0	0,0	1	0	1	0,7	1	1	1,0	0	0,0
	High	1	1	1,0	0	1	0	0,3	0	0	0,0	0	0,0
4. General purpose	Defect product handling	3	1	2,0	2	3	1	2,0	2	3	2,5	1	1,0
	Quality improvement	2	0	1,0	3	3	4	3,3	1	0	0,5	2	2,0
	Quality control	2	0	1,0	3	1	0	1,3	1	0	0,5	3	3,0
	Product differentiation	0	0	0,0	4	1	2	2,3	0	3	1,5	1	1,0
	Risk management	2	0	1,0	2	0	1	1,0	0	0	0,0	0	0,0
	Inventory management	1	3	2,0	4	3	0	2,3	1	0	0,5	2	2,0
	Logistic management	1	2	1,5	2	2	1	1,7	1	2	1,5	1	1,0
5. Technology	Date stamp	0	0	0,0	1	0	0	0,3	3	0	1,5	2	2,0
	Paper based	1	1	1,0	1	1	1	1,0	2	0	1,0	1	1,0
	QR-code	3	1	2,0	1	1	2	1,3	2	3	2,5	1	1,0
	Barcode	1	3	2,0	1	3	2	2,0	2	1	1,5	1	1,0
	RFID	3	2	2,5	3	1	2	2,0	2	2	2,0	4	4,0
6. System	Paper based	1	2	1,5	1	0	1	0,7	0	1	0,5	2	2,0
	Microsoft Excel	1	1	1,0	1	2	1	1,3	1	2	1,5	2	2,0
	SCM system	1	3	2,0	2	2	1	1,7	1	1	1,0	1	1,0
	ERP system	3	4	3,5	5	2	1	2,7	2	2	2,0	3	3,0
7. Most effective solution	Barcode	0	0	0,0	0	1	1	0,7	0	0	0,0	1	1,0
	RFID	3	2	2,5	5	0	2	2,3	2	4	3,0	4	4,0
	SCM	0	0	0,0	0	1	0	0,3	0	0	0,0	0	0,0
	ERP	3	1	2,0	5	0	2	2,3	2	4	3,0	2	2,0
8. Economic purpose	Costs	2	3	2,5	2	2	1	1,7	1	1	1,0	3	3,0
	Savings	0	1	0,5	3	2	3	2,7	0	1	0,5	1	1,0
9. Economic technology	Barcode	1	1	1,0	1	3	2	2,0	1	0	0,5	2	2,0
	RFID	1	0	0,5	1	0	0	0,3	0	1	0,5	0	0,0
10. Economic system	SCM	2	1	1,5	1	3	1	1,7	2	1	1,5	3	3,0
	ERP	2	1	1,5	1	0	0	0,3	0	2	1,0	0	0,0
11. Marketing research purpose	USP	1	1	1,0	3	1	0	1,3	0	3	1,5	1	1,0
	Customer buying behavior	0	0	0,0	1	1	1	1,0	0	3	1,5	1	1,0
12. Marketing research technology	Barcode	0	0	0,0	0	1	0	0,3	0	0	0,0	1	1,0
	RFID	2	4	3,0	5	2	2	3,0	2	5	3,5	3	3,0
13. Marketing research system	SCM	0	0	0,0	0	0	0	0,0	0	0	0,0	0	0,0
	ERP	2	3	2,5	6	5	3	4,7	2	5	3,5	4	4,0
14. SCM purpose	Logistic management	2	3	2,5	2	3	1	2,0	1	1	1,0	1	1,0
	Inventory management	2	3	2,5	3	2	2	2,3	1	1	1,0	1	1,0
	Risk management	2	0	1,0	1	0	1	0,7	1	0	0,5	1	1,0
	Product differentiation	0	0	0,0	2	1	0	1,0	0	2	1,0	0	0,0
	Decision support system	1	0	0,5	0	0	0	0,0	0	0	0,0	0	0,0
	Communication system	0	0	0,0	2	1	0	1,0	0	2	1,0	0	0,0
15. SCM technology	Barcode	0	0	0,0	0	1	2	1,0	0	0	0,0	2	2,0
	RFID	3	2	2,5	4	3	3	3,3	2	1	1,5	2	2,0
16. SCM system	SCM	0	0	0,0	0	2	0	0,7	0	0	0,0	1	1,0
	ERP	4	2	3,0	3	2	2	2,3	1	3	2,0	2	2,0
17. Quality Management purpose	Quality control	2	0	1,0	2	1	1	1,3	1	1	1,0	3	3,0
	Quality improvement	2	0	1,0	1	2	1	1,3	2	0	1,0	1	1,0
	Quality assurance	3	1	2,0	1	1	0	0,7	0	0	0,0	0	0,0
	Defect product handling	4	1	2,5	2	1	2	1,7	0	2	1,0	1	1,0
18. Quality Management technology	Barcode	0	1	0,5	0	1	0	0,3	1	1	1,0	0	0,0
	RFID	3	2	2,5	3	2	2	2,3	1	2	1,5	1	1,0
19. Quality Management system	SCM	0	0	0,0	0	0	1	0,3	0	0	0,0	0	0,0
	ERP	4	2	3,0	3	2	3	2,7	3	3	3,0	4	4,0
20. Engineering purpose	Implementation	1	1	1,0	2	1	0	1,0	2	0	1,0	2	2,0
	Design	0	0	0,0	1	1	2	1,3	3	2	2,5	0	0,0
	Design feedback	0	0	0,0	0	0	1	0,3	2	0	1,0	0	0,0
21. Engineering technology	Barcode	0	0	0,0	1	2	0	1,0	1	0	0,5	0	0,0
	RFID	3	1	2,0	2	2	1	1,7	4	2	3,0	2	2,0
22. Engineering system	SCM	0	0	0,0	0	1	0	0,3	0	0	0,0	0	0,0
	ERP	1	1	1,0	3	2	2	2,3	3	1	2,0	2	2,0
	Total	84	64	74,0	111	84	68	87,7	65	77	71,0	82	82,0

VI. Conditional formatting grouped by impact

		Low		Med					High			
		Respondent 2	Group average	Respondent 1	Respondent 5	Respondent 6	Respondent 7	Group average	Respondent 3	Respondent 4	Respondent 8	Group avergae
Themes	**Subcodes**											
1. First usage	< 1 Year	1	1,0	0	0	0	1	0,3	0	0	0	0,0
	Between 1 and 3 Years	0	0,0	0	0	0	0	0,0	0	1	1	1,0
	Between 3 and 10 Years	0	0,0	0	1	0	0	0,3	1	0	0	0,0
	> 10 Years	0	0,0	1	0	1	0	0,3	0	0	0	0,0
2. Frequency of use	Daily	0	0,0	0	0	0	0	0,0	0	1	1	1,0
	Weekly	0	0,0	1	1	0	0	0,3	1	0	0	0,0
	Monthly	0	0,0	0	0	1	1	0,7	0	0	0	0,0
	Less than monthly	1	1,0	0	0	0	0	0,0	0	0	0	0,0
3. Impact on work	Low	1	1,0	0	0	0	0	0,0	0	0	0	0,0
	Med	0	0,0	1	1	1	1	1,0	0	0	0	0,0
	High	0	0,0	0	0	0	0	0,0	1	1	1	1,0
4. General purpose	Defect product handling	1	1,0	2	1	2	3	2,0	3	3	1	2,0
	Quality improvement	2	2,0	3	4	1	0	1,7	3	2	0	1,0
	Quality control	3	3,0	3	0	1	0	0,3	1	2	0	1,0
	Product differentiation	1	1,0	4	2	0	3	1,7	1	0	0	0,0
	Risk management	0	0,0	2	1	0	0	0,3	0	2	0	1,0
	Inventory management	2	2,0	4	0	1	0	0,3	3	1	3	2,0
	Logistic management	1	1,0	2	1	1	2	1,3	2	1	2	1,5
5. Technology	Date stamp	2	2,0	1	0	3	0	1,0	0	0	0	0,0
	Paper based	1	1,0	1	1	2	0	1,0	1	1	1	1,0
	QR-code	1	1,0	1	2	2	3	2,3	1	3	1	2,0
	Barcode	1	1,0	1	2	2	1	1,7	3	1	3	2,0
	RFID	4	4,0	3	2	2	2	2,0	1	3	2	2,5
6. System	Paper based	2	2,0	1	1	0	1	0,7	0	1	2	1,5
	Microsoft Excel	2	2,0	1	1	1	2	1,3	2	1	1	1,0
	SCM system	1	1,0	2	1	1	1	1,0	2	1	3	2,0
	ERP system	3	3,0	5	1	2	2	1,7	2	3	4	3,5
7. Most effective solution	Barcode	1	1,0	0	1	0	0	0,3	1	0	0	0,0
	RFID	4	4,0	5	2	2	4	2,7	0	3	2	2,5
	SCM	0	0,0	0	0	0	0	0,0	1	0	0	0,0
	ERP	2	2,0	5	2	2	4	2,7	0	3	1	2,0
8. Economic purpose	Costs	3	3,0	2	1	1	1	1,0	2	2	3	2,5
	Savings	1	1,0	3	3	0	1	1,3	2	0	1	0,5
9. Economic technology	Barcode	2	2,0	1	2	1	0	1,0	3	1	1	1,0
	RFID	0	0,0	1	0	0	1	0,3	0	1	0	0,5
10. Economic system	SCM	3	3,0	1	1	2	1	1,3	3	2	1	1,5
	ERP	0	0,0	1	0	0	2	0,7	0	2	1	1,5
11. Marketing research purpose	USP	1	1,0	3	0	0	3	1,0	1	1	1	1,0
	Customer buying behavior	1	1,0	1	1	0	3	1,3	1	0	0	0,0
12. Marketing research technology	Barcode	1	1,0	0	0	0	0	0,0	1	0	0	0,0
	RFID	3	3,0	5	2	2	5	3,0	2	2	4	3,0
13. Marketing research system	SCM	0	0,0	0	0	0	0	0,0	0	0	0	0,0
	ERP	4	4,0	6	3	2	5	3,3	5	2	3	2,5
14. SCM purpose	Logistic management	1	1,0	2	1	1	1	1,0	3	2	3	2,5
	Inventory management	1	1,0	3	2	1	1	1,3	2	2	3	2,5
	Risk management	1	1,0	1	1	1	0	0,7	0	2	0	1,0
	Product differentiation	0	0,0	2	0	0	2	0,7	1	0	0	0,0
	Decision support system	0	0,0	0	0	0	0	0,0	0	1	0	0,5
	Communication system	0	0,0	2	0	0	2	0,7	1	0	0	0,0
15. SCM technology	Barcode	2	2,0	0	2	0	0	0,7	1	0	0	0,0
	RFID	2	2,0	4	3	2	1	2,0	3	3	2	2,5
16. SCM system	SCM	1	1,0	0	0	0	0	0,0	2	0	0	0,0
	ERP	2	2,0	3	2	1	3	2,0	2	4	2	3,0
17. Quality Management purpose	Quality control	3	3,0	2	1	1	1	1,0	1	2	0	1,0
	Quality improvement	1	1,0	1	1	2	0	1,0	2	2	0	1,0
	Quality assurance	0	0,0	1	0	0	0	0,0	1	3	1	2,0
	Defect product handling	1	1,0	2	2	0	2	1,3	1	4	1	2,5
18. Quality Management technology	Barcode	0	0,0	0	0	1	1	0,7	1	0	1	0,5
	RFID	1	1,0	3	2	1	2	1,7	2	3	2	2,5
19. Quality Management system	SCM	0	0,0	0	1	0	0	0,3	0	0	0	0,0
	ERP	4	4,0	3	3	3	3	3,0	2	4	2	3,0
20. Engineering purpose	Implementation	2	2,0	2	0	2	0	0,7	1	1	1	1,0
	Design	0	0,0	1	2	3	2	2,3	1	0	0	0,0
	Design feedback	0	0,0	0	1	2	0	1,0	0	0	0	0,0
21. Engineering technology	Barcode	0	0,0	1	0	1	0	0,3	2	0	0	0,0
	RFID	2	2,0	2	1	4	2	2,3	2	3	1	2,0
22. Engineering system	SCM	0	0,0	0	0	0	0	0,0	1	0	0	0,0
	ERP	2	2,0	3	2	3	1	2,0	2	1	1	1,0
	Total	82	82	111	68	65	77	70,0	84	84	64	74,0

VII. Conditional formatting of scaled data

Themes	Subcodes	Respondent 1	Scaled to 100	Respondent 2	Scaled to 100	Respondent 3	Scaled to 100	Respondent 4	Scaled to 100	Respondent 5	Scaled to 100	Respondent 6	Scaled to 100	Respondent 7	Scaled to 100	Respondent 8	Scaled to 100	Average per theme
1. First usage	< 1 Year	0	0,00	1	100,00	0	0,00	0	0,00	0	0,00	0	0,00	1	100,00	0	0,00	25,00
	Between 1 and 3 Years	0	0,00	0	0,00	0	0,00	1	100,00	0	0,00	0	0,00	0	0,00	1	100,00	25,00
	Between 3 and 10 Years	0	0,00	0	0,00	1	100,00	0	0,00	1	100,00	0	0,00	0	0,00	0	0,00	25,00
	> 10 Years	1	100,00	0	0,00	0	0,00	0	0,00	0	0,00	1	100,00	0	0,00	0	0,00	25,00
2. Frequency of use	Daily	0	0,00	0	0,00	0	0,00	1	100,00	0	0,00	0	0,00	0	0,00	1	100,00	25,00
	Weekly	1	100,00	0	0,00	1	100,00	0	0,00	1	100,00	0	0,00	0	0,00	0	0,00	37,50
	Monthly	0	0,00	0	100,00	0	0,00	0	0,00	0	0,00	1	100,00	1	100,00	0	0,00	37,50
	Less than monthly	0	0,00	1	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0,00
3. Impact on work	Low	0	0,00	1	100,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	12,50
	Med	1	100,00	0	0,00	0	0,00	0	0,00	1	100,00	1	100,00	1	100,00	0	0,00	50,00
	High	0	0,00	0	0,00	1	100,00	1	100,00	0	0,00	0	0,00	0	0,00	1	100,00	37,50
4. General purpose	Defect product handling	2	10,00	1	10,00	3	23,08	3	27,27	1	11,11	2	33,33	3	37,50	1	16,67	21,12
	Quality improvement	3	15,00	2	20,00	3	23,08	2	18,18	4	44,44	1	16,67	0	0,00	0	0,00	17,17
	Quality control	3	15,00	3	30,00	1	7,69	2	18,18	0	0,00	1	16,67	0	0,00	0	0,00	10,94
	Product differentiation	4	20,00	1	10,00	1	7,69	0	0,00	2	22,22	0	0,00	3	37,50	0	0,00	12,18
	Risk management	2	10,00	0	0,00	0	0,00	2	18,18	1	11,11	0	0,00	0	0,00	0	0,00	4,91
	Inventory management	4	20,00	2	20,00	3	23,08	1	9,09	0	0,00	1	16,67	0	0,00	3	50,00	17,35
	Logistic management	2	10,00	1	10,00	2	15,38	1	9,09	1	11,11	1	16,67	2	25,00	2	33,33	16,32
5. Technology	Date stamp	1	14,29	2	22,22	0	0,00	0	0,00	0	0,00	3	27,27	0	0,00	0	0,00	7,97
	Paper based	1	14,29	1	11,11	1	16,67	1	12,50	1	14,29	2	18,18	0	0,00	1	14,29	12,66
	QR-code	1	14,29	1	11,11	1	16,67	3	37,50	2	28,57	2	18,18	3	50,00	1	14,29	23,83
	Barcode	1	14,29	1	11,11	3	50,00	1	12,50	2	28,57	2	18,18	1	16,67	3	42,86	24,27
	RFID	3	42,86	4	44,44	1	16,67	3	37,50	2	28,57	2	18,18	2	33,33	2	28,57	31,27
6. System	Paper based	1	11,11	2	25,00	0	0,00	1	16,67	1	25,00	0	0,00	1	16,67	2	20,00	14,31
	Microsoft Excel	1	11,11	2	25,00	2	33,33	1	16,67	1	25,00	1	25,00	2	33,33	1	10,00	22,43
	SCM system	2	22,22	1	12,50	2	33,33	1	16,67	1	25,00	1	25,00	1	16,67	3	30,00	22,67
	ERP system	5	55,56	3	37,50	2	33,33	3	50,00	1	25,00	2	50,00	2	33,33	4	40,00	40,59
7. Most effective solution	Barcode	0	0,00	1	14,29	1	50,00	0	0,00	1	20,00	0	0,00	0	0,00	0	0,00	10,54
	RFID	5	50,00	4	57,14	0	0,00	3	50,00	2	40,00	2	50,00	4	50,00	2	66,67	45,48
	SCM	0	0,00	0	0,00	1	50,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	6,25
	ERP	5	50,00	2	28,57	0	0,00	3	50,00	2	40,00	2	50,00	4	50,00	1	33,33	37,74
8. Economic purpose	Costs	2	40,00	3	75,00	2	50,00	2	100,00	1	25,00	1	100,00	1	50,00	3	75,00	64,38
	Savings	3	60,00	1	25,00	2	50,00	0	0,00	3	75,00	0	0,00	1	50,00	1	25,00	35,63
9. Economic technology	Barcode	1	50,00	2	100,00	3	100,00	1	50,00	2	100,00	1	100,00	0	0,00	1	100,00	75,00
	RFID	1	50,00	0	0,00	0	0,00	1	50,00	0	0,00	0	0,00	1	100,00	0	0,00	25,00
10. Economic system	SCM	1	50,00	3	100,00	3	100,00	2	50,00	1	100,00	2	100,00	1	33,33	1	50,00	72,92
	ERP	1	50,00	0	0,00	0	0,00	2	50,00	0	0,00	0	0,00	2	66,67	1	50,00	27,08
11. Marketing research purpose	USP	3	75,00	1	50,00	1	50,00	1	100,00	0	0,00	0	0,00	3	50,00	1	100,00	53,13
	Customer buying behavior	1	25,00	1	50,00	1	50,00	0	0,00	1	100,00	0	0,00	3	50,00	0	0,00	34,38

12. Marketing research technology	Barcode	0	0,00	1	25,00	1	33,33	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	7,29
	RFID	5	100,00	3	75,00	2	66,67	2	100,00	2	100,00	2	100,00	5	100,00	4	100,00	92,71
13. Marketing research system	SCM	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0,00
	ERP	6	100,00	4	100,00	5	100,00	2	100,00	3	100,00	2	100,00	5	100,00	3	100,00	100,00
14. SCM purpose	Logistic management	2	20,00	1	33,33	3	42,86	2	28,57	1	25,00	1	33,33	1	16,67	3	50,00	31,22
	Inventory management	3	30,00	1	33,33	2	28,57	2	28,57	2	50,00	1	33,33	1	16,67	3	50,00	33,81
	Risk management	1	10,00	1	33,33	0	0,00	2	28,57	1	25,00	1	33,33	0	0,00	0	0,00	16,28
	Product differentiation	2	20,00	0	0,00	1	14,29	0	0,00	0	0,00	0	0,00	2	33,33	0	0,00	8,45
	Decision support system	0	0,00	0	0,00	0	0,00	1	14,29	0	0,00	0	0,00	0	0,00	0	0,00	1,79
	Communication system	2	20,00	0	0,00	1	14,29	0	0,00	0	0,00	0	0,00	2	33,33	0	0,00	8,45
15. SCM technology	Barcode	0	0,00	2	50,00	1	25,00	0	0,00	2	40,00	0	0,00	0	0,00	0	0,00	14,38
	RFID	4	100,00	2	50,00	3	75,00	3	100,00	3	60,00	2	100,00	1	100,00	2	100,00	85,63
16. SCM system	SCM	0	0,00	1	33,33	2	50,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	10,42
	ERP	3	100,00	2	66,67	2	50,00	4	100,00	2	100,00	1	100,00	3	100,00	2	100,00	89,58
17. Quality Management purpose	Quality control	2	33,33	3	60,00	1	20,00	2	18,18	1	25,00	1	33,33	1	33,33	0	0,00	27,90
	Quality improvement	1	16,67	1	20,00	2	40,00	2	18,18	1	25,00	2	66,67	0	0,00	0	0,00	23,31
	Quality assurance	1	16,67	0	0,00	1	20,00	3	27,27	0	0,00	0	0,00	0	0,00	1	50,00	14,24
	Defect product handling	2	33,33	1	20,00	1	20,00	4	36,36	2	50,00	0	0,00	2	66,67	1	50,00	34,55
18. Quality Management technology	Barcode	0	0,00	0	0,00	1	33,33	0	0,00	0	0,00	1	50,00	1	33,33	1	33,33	18,75
	RFID	3	100,00	1	100,00	2	66,67	3	100,00	2	100,00	1	50,00	2	66,67	2	66,67	81,25
19. Quality Management system	SCM	0	0,00	0	0,00	0	0,00	0	0,00	1	25,00	0	0,00	0	0,00	0	0,00	3,13
	ERP	3	100,00	4	100,00	2	100,00	4	100,00	3	75,00	3	100,00	3	100,00	2	100,00	96,88
20. Engineering purpose	Implementation	2	66,67	2	100,00	1	50,00	1	100,00	0	0,00	2	28,57	0	0,00	1	100,00	55,65
	Design	1	33,33	0	0,00	1	50,00	0	0,00	2	66,67	3	42,86	2	100,00	0	0,00	36,61
	Design feedback	0	0,00	0	0,00	0	0,00	0	0,00	1	33,33	2	28,57	0	0,00	0	0,00	7,74
21. Engineering technology	Barcode	1	33,33	0	0,00	2	50,00	0	0,00	0	0,00	1	20,00	0	0,00	0	0,00	12,92
	RFID	2	66,67	2	100,00	2	50,00	3	100,00	1	100,00	4	80,00	2	100,00	1	100,00	87,08
22. Engineering system	SCM	0	0,00	0	0,00	1	33,33	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	4,17
	ERP	3	100,00	2	100,00	2	50,00	1	33,33	2	100,00	3	60,00	1	50,00	1	100,00	74,17
	Total	111		82		84		84		68		65		77		64		

VIII. Interview protocol

Introduction

Introduce the research and yourself and ask for consent.

- I am Pieter Swerts, Master student Innovation Management at the Eindhoven University of Technology and performing my Master thesis research at Ecodraft. The purpose of this project is to research traceability creation in the food packaging industry, in organizational context.
- The content of this research is traceability with the focus on the traceability technologies and traceability systems.
    - Do you know what traceability is?
        - Yes ➡ Could you give me a brief description of traceability?
        - No ➡ Brief description of traceability[1]
    - There are two traceability technologies particularly associated with traceability:
        - Barcodes[2]
        - Radio-Frequency Identification (RFID)[3]
    - There are two traceability systems particularly associated with traceability:
        - Supply Chain Management systems (SCM)[4]
        - Enterprise Resources Planning systems (ERP)[5]
- This research will remain confidential, meaning that I will be the only person who knows your answers. The interview will be audio recorded of which you will receive a transcript for revision and confirmation. I hope you will feel confident during this interview because no answers are right or wrong and there are no answers desirable nor undesirable. If you allow me to conduct this interview and allow me to use the information of this interview for further research then you may give verbally consent, so we can start with the introduction questions.

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[1] *Traceability* is the ability to identify sources of input materials, applications, as well as the ability to conduct full backward tracing and forward tracking to determine the specific location and life history of a product (component) in the supply chain by means of records.

[2] *Barcode* is an optical machine-readable representation of object related data. A barcode consists of a print contrast between dark and light bars, which are adequately printed with space dimensions within certain tolerances for the symbols and an all bar.

[3] *Radio-frequency identification (RFID)* is the use of radio-frequency electromagnetic fields as wireless non-contact systems to transfer data from a tag to an object.

[4] *Supply chain management system (SCM)* is the integration of key business processes from end users through original supplier that provides value adding information, services, and products for customers and other stakeholders.

[5] *Enterprise Resources Planning (ERP)* systems computerize entire businesses with software modules that cover activities in all areas of the business.

Introduction questions

1. Could you tell me about your experiences with traceability?
2. Why is traceability used in general?

Core research questions

1. How are you introduced and when was the first time you used traceability?
2. How often do you engage in traceability?
3. How does traceability impact you in your work?
4. What is the general purpose of traceability?
5. Which traceability technologies do you know?
    a. Could you tell me about the experiences with these technologies?
    b. Which traceability technologies do you prefer to use?
    c. Why do you prefer these technologies?
6. Which traceability systems do you know?
    a. Could you tell me about the experiences with these systems?
    b. Which traceability systems do you prefer to use?
    c. Why do you prefer these systems?
7. How would you create traceability in your organization?
8. How does traceability impacts economics?
    a. Which traceability technique is most effective on economic aspects?
    b. Which traceability system is most effective on economic aspects?
9. How does traceability impacts marketing research?
    a. Which traceability technique is most effective on marketing research aspects?
    b. Which traceability system is most effective on marketing research aspects?
10. How does traceability impacts supply chain management?
    a. Which traceability technique is most effective on SCM aspects?
    b. Which traceability system is most effective on SCM aspects?
11. How does traceability impacts quality management?
    a. Which traceability technique is most effective on quality management aspects?
    b. Which traceability system is most effective on quality management aspects?
12. How does traceability impacts engineering?
    a. Which traceability technique is most effective on engineering aspects?
    b. Which traceability system is most effective on engineering aspects?

Personal questions

13. What is your age?
14. What is your nationality?
15. What is your highest completed educational degree?
16. What is your function in this organization?
17. How long have you already been working for this organization?
18. How long have you been working in the food (packaging) industry?

Wrap up

1. Do you have anything to add when it comes to traceability creation in the food packaging industry?

Thank you for your time, effort and valuable information. Feel free to contact me in case of any further questions concerning this research. Please inform me if you are interested in the results of the research, these will be available in about two months from now.

IX. Interview example

Respondent 4

Date: 10-10-2017

Audio length: 33 minutes

Interviewer: Introductie interview

Interviewer: Mag de informatie uit dit interview worden gebruikt voor verder onderzoek?

Respondent: Dat is prima.

Interviewer: Kun je iets vertellen over de ervaring die je met traceerbaarheid hebt?

Respondent: Traceerbaarheid van producten is heel belangrijk in de voedingsindustrie. Er gaat veel werk in zitten om een goede traceerbaarheid op te stellen en vaak is het nog niet 100% waterdicht, het gaat altijd wel een keer mis.

Interviewer: Kan je kort uitleggen waarom traceerbaarheid in het algemeen gebruikt wordt?

Respondent: De hoofdzakelijke reden voor traceerbaarheid is om klachten te kunnen verwerken met betrekking tot defecte producten. Als een klant een defect product heeft, moet achterhaald kunnen worden uit welke materialen dit product precies bestaat. Met deze informatie kan worden beslist welke eventuele vervolgacties moeten worden genomen.

Interviewer: Hoe ben je geintroduceerd met traceerbaarheid en wanneer was de eerste keer dat je traceerbaarheid gebruikte?

Respondent: Via de cursus voedselveiligheid, die via de universeit was geregeld toen ik mijn opleiding biotechnologie deed, dit was twee jaar geleden.

Interviewer: Hoe vaak krijg je te maken met traceerbaarheid? En hoeveel tijd besteed je er dan aan.

Respondent: Dagelijks, ik kom veel met traceerbaarheid in aanraking. Gemiddeld besteed ik ongeveer een half uur per dag aan traceerbaarheid.

Interviewer: Hoe beïnvloedt traceerbaarheid jouw werk?

Respondent: Ik werk mee om traceerbaarheidsystemen op te zetten, dus traceerbaarheid heeft een grote invloed op mijn werk. Nog veel problemen, met name doordat wij nog geen traceerbaarheid technieken hebben en alles op papier moeten doen.

Interviewer: Waarvoor wordt traceerbaarheid gebruikt?

Respondent: Met name bij om klachten te kunnen behandelen. Als er een klacht is moet je kunnen aantonen met welke batch er iets mis is en waar dus de klacht over is. Als het bedrijf een klacht heeft over de leverancier en ook als een klacht van de klant afkomt, is het belangrijk om traceerbaarheid te hebben. Voor terugroepingen (recalls) van voedingsmiddelen heb je in de communicatie traceerbaarheid gegevens nodig. Als iets wordt terug geroepen via de media dan moeten klanten op hun verpakking kunnen zien of het om hun product gaat. Met name in de voedings industrie is dit belangrijk, maar niet enkel in deze industry. Daarnaast is traceerbaarheid belangrijk om kwaliteit te kunnen verbeteren en te controleren. Traceerbaarheid van producten helpt te onderzoeken welke risicos er zijn en waar de defecten van een product kunnen optreden. Dit is een soort van kwaliteitscontrole die kan worden gebruikt om de kwaliteit te verbeteren. Naast

de risicos verminderen, kan traceerbaarheid ook worden gebruikt voor het managen van de inventaris en de logistieke processen.

Interviewer: Welke traceerbaarheid technieken ken je?

Respondent: De technieken die ik ken zijn RFID, QR-code, barcode en ook het traceren op papier. Waarvan ik de meeste ervaring heb met RFID en QR-code. QR-codes zijn heel klant vriendelijk en gemakkelijk in gebruik, terwijl RFIDs naar mijn mening de beste traceerbaarheids techniek is voor industrieel gebruik.

Interviewer: Welke techniek heeft de voorkeur en waarom heeft deze de voorkeur?

Interviewer: Welke traceerbaarheidsystemen ken je? Kan je me iets vertellen over de ervaringen die je hebt met deze systemen.

Respondent: ERP systemen zijn het bekenst voor mij. Traceerbaarheid systemen op papier, in excel of SCM ken ik ook, maar ERP is wel het bekenst. In mijn vorige bedrijf heb ik met een ERP systeem gewerkt, hier heb ik beste ervaringen mee.

Interviewer: Hoe zou jij traceerbaarheid in jouw organisatie creeren, zodat deze het meest effectief is voor de organisatie?

Respondent: Ik zou zeker gebruik maken van RFID en ERP. RFID is zoals ik net al benoemde de techniek naar mijn mening voor industrieel gebruik. RFID is accuraat en zeer handig in gebruik. ERP systemen kunnen gebruikt worden om informatie van de hele organisatie aan elkaar te koppelen. Verder kan een ERP systeem de traceerbaarheid data goed omzetten in bruikbare informatie.

Interviewer: Hoe beïnvloedt traceerbaarheid de economische factoren van een bedrijf?

Respondent: Traceerbaarheid heeft middelmatig tot grote invloed op de kosten die in een bedrijf gemaakt worden. De kosten van technieken en systemen zijn vaak hoog maar deze moeten wel gemaakt worden om traceerbaarheid te kunnen garanderen.

Interviewer: Welke traceerbaarheid techniek is het meest effectief als wordt gekeken naar de economische aspecten van een organisatie?

Respondent: Dan zijn er twee technieken die beide even goed zijn voor mijn gevoel. Barcode is goed omdat de kosten relatief laag zijn en RFID heeft hogere kosten maar ook veel arbeidskosten kunnen worden bespaard.

Interviewer: Welke traceerbaarheid systeem is het meest effectief als wordt gekeken naar de economische aspecten van een organisatie?

Respondent: Dan zijn zowel SCM en ERP goede opties. SCM systemen zijn vaak relatief goedkoop terwijl ERP systemen duurder zijn, maar ook kosten kunnen besparen.

Interviewer: Hoe beïnvloedt traceerbaarheid de marketing onderzoek van een bedrijf?

Respondent: Traceerbaarheid heeft een middelmatige impact op marketing onderzoek van een bedrijf. Als je als bedrijf een goede traceerbaarheid kan garanderen dan kan dit wel gelden als een unique selling point naar de klanten.

Interviewer: Welke traceerbaarheid techniek is het meest effectief als wordt gekeken naar de marketing onderzoeks aspecten van een organisatie?

Respondent: Dan ga ik voor RFID. RFID is namelijk een techniek waar veel consumenten van onder de indruk zijn. Het geeft ze een vertrouwen in het product.

Interviewer: Welke traceerbaarheid systeem is het meest effectief als wordt gekeken naar de marketing onderzoeks aspecten van een organisatie?

Respondent: Een ERP is wel duidelijk het beste traceerbaarheidsysteem dat ook gebruikt kan worden voor marketing onderzoek. Ook naar de klanten toe, wekt het vertrouwen als een bedrijf een goed ERP systeem heeft.

Interviewer: Hoe beïnvloedt traceerbaarheid de supply chain management van een bedrijf?

Respondent: Traceerbaarheid heeft een hele grote invloed op de supply chain management van een bedrijf. Traceerbaarheid wordt in de supply chain management vooral gebruikt op het gebied van logistiek, inventaris en risico management. Logistieke processen kunnen verbeterd worden als traceerbaarheidsdata op een correcte manier wordt gebruikt. Traceerbaarheid is cruciaal om de inventaris te kunnen bij houden. De data kan ook gebruikt worden om risicos beter in te schatten en aan de hand daarvan een weloverwogen keuze te kunnen maken.

Interviewer: Welke traceerbaarheid techniek is het meest effectief als wordt gekeken naar de supply chain management aspecten van een organisatie?

Respondent: Dit is zeker RFID. RFID vergemakkelijkt de supply chain in vele manieren. RFIDs zorgen ervoor dat alle data van de supply chain veel nauwkeuriger wordt gemeten en ook nog eens relatief een stuk sneller dan de alternatieve technologiën.

Interviewer: Welke traceerbaarheid systeem is het meest effectief als wordt gekeken naar de supply chain management aspecten van een organisatie?

Respondent: Dit is het ERP systeem. Met name omdat ERP systemen een goede communicatie hebben met andere bedrijven. De meeste leveranciers gebruiken ERP systemen en de koppeling

van deze ERP systemen kan de supply chain management processen sterk verbeteren en efficiënter maken.

Interviewer: Hoe beïnvloedt traceerbaarheid de kwaliteits management van een bedrijf?

Respondent: Traceerbaarheid heeft veel invloed op hoe met klachten kan worden omgegaan. Bij klachten moet je via lotcodes alle producten die betrokken zijn kunnen terug vinden. Niet alleen de grondstoffen maar ook bij welke klant zit welk product. Kwaliteit moet worden gegarandeerd naar de klanten toe door middel van traceerbaarheid. Zeker als er toch een defect in een product blijkt te zitten en de klanten dienen een klacht in dan moet verzekerd worden dat de kwaliteit van de toekomstige producten beter is. Traceerbaarheid is een must voor kwaliteitsmanagement. Voor inspecties is het belangrijk, zodat je weet welke controles er zijn geweest en wat de resultaten hiervan waren en zodoende de kwaliteit kan verbeteren. Dus voor kwaliteits controles, kwaliteits verbeteringen en kwaliteitsgarantie is traceerbaarheid heel belangrijk.

Interviewer: Welke traceerbaarheid techniek is het meest effectief als wordt gekeken naar de kwaliteits management aspecten van een organisatie?

Respondent: Op het gebied van kwaliteits management is RFID de meest geschikte techniek. RFIDs kunnen veel data meten, wat onmogelijk is voor andere technieken. Daarnaast zijn RFID een stuk accurater dan de alternatieve technieken.

Interviewer: Welke traceerbaarheid systeem is het meest effectief als wordt gekeken naar de kwaliteits management aspecten van een organisatie?

Respondent: ERP systemen zijn het beste voor kwaliteitsmanagement. De koppeling, die een ERP systeem kan maken, tussen de product data en andere bedrijfsdata is heel belangrijk. ERP systemen

kunnen ook communiceren met andere bedrijven of klanten en zo de kwaliteitsproblemen tijdig opsporen en verbeteren. Dit is een heel groot voordeel van ERP systemen.

Interviewer: Hoe beïnvloedt traceerbaarheid het ingenieurswerk van een bedrijf?

Respondent: De techniek en het systeem hebben beide wel veel invloed op de engineering in een bedrijf. Met name bij de implementatie van traceerbaarheid technieken en systemen is het belangrijk dat de ingenieurs betrokken worden bij het ontwikkelen van traceerbaarheid in een bedrijf.

Interviewer: Welke traceerbaarheid techniek is het meest effectief als wordt gekeken naar de ingenieurs aspecten van een organisatie?

Respondent: RFID is de techniek die iets kan betekenen voor ingenieurs. RFID tags moeten op de juiste manieren worden verwerkt in de producten en ook moeten RFID readers zo worden ingesteld dat dit allemaal goed functioneerd. Zonder een goede combinatie zal de techniek nooit optimaal gebruikt kunnen worden.

Interviewer: Welke traceerbaarheid systeem is het meest effectief als wordt gekeken naar de ingenieurs management aspecten van een organisatie?

Respondent: Als ingenieurs is ERP het systeem dat de traceerbaarheid data kan omzetten in bruikbare informatie. Product informatie kan worden gekoppeld aan design informatie waardoor deze verbeterd kan worden.

Interviewer: Verder nog een aantal persoonlijke vragen: hoe oud ben je?

Respondent: 22 jaar.

Interviewer: Wat is jouw nationaliteit?

Respondent: Belg

Interviewer: Wat is jouw hoogst behaalde opleidingsniveau?

Respondent: Bachelor, biotechnologie met een specialisatie in voedingsmiddelentechnologie.

Interviewer: Wat is jouw functie in dit bedrijf?

Respondent: Quality Assurance Engineer

Interviewer: Hoe lang werk je hier al?

Respondent: Vanaf maart 2017, dus dat is 8 maanden.

Interviewer: Hoe lang werk je al in de voedings (verpakkings) industrie?

Respondent: 1 jaar en 3 maanden.

Interviewer: Is er verder nog iets wat je zou willen toevoegen met betrekking tot het creeren van traceerbaarheid in de voedsel (verpakkings) industrie?

Respondent: Traceerbaarheid is belangrijk in deze sector en iets waar veel mensen te licht over denken, terwijl het veel inspanning en tijd kost om traceerbaarheid van producten te kunnen garanderen.