MILK AUTHENTICITY AND FRAUD MITIGATION IN DAIRY SUPPLY CHAINS: A CASE STUDY AMONG DAIRY PROCESSORS AND FOOD RETAILERS

MSc Thesis

Wageningen University and Research Centre

Food Quality and Design

FQD-84036

STUDENT: LARA GAIARDONI

REGISTRATION NUMBER: 901001-249-070

SUPERVISORS: PhD YUZHENG YANG (FQD/RIKILT), prof. SASKIA VAN RUTH (FQD/RIKILT)

September 2016-March 2017

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

AKNOWLEDGEMENTS

I would like to express my gratefully acknowledge to both my thesis supervisors for all the kind help and support during these past six months. I would like to thank prof. Saskia van Ruth. I very much appreciated her valuable comments and guidance during the development of all the steps of the research and for all the precious suggestions in the process of recruitment of respondents. I want to thank PhD candidate Yuzheng Yang for her helpful advises, encouragements, for sharing new ideas and for clarifying my doubts.

A special thank also to all the Quality Assurance Managers who undertook the interviews for their participation in the research and support in getting insight in vulnerabilities in the dairy sector.

I would also like to thank dr.ir Pieternel Luning for her critical suggestions during the finalizing phase of the report.

I would like to thank my family and my friends in Italy and in the Netherlands who supported and encouraged me in these months.

Lastly, I want to thank my friend Gerke Schrijver for the suggestions and the nice time spent together to exchange feedback on our research reports.

EXECUTIVE SUMMARY

Food fraud is a significant and growing concern, driven by globalization of supply chains, economic opportunity, and in many cases by the low probability and severity of punishment. Therefore, now more than in the past, food fraud requires a clear strategy of prevention, detection and elimination. Food adulterations can be commercially devastating, can damage reputations as well as pose health risk for consumers. Although the evident importance of the problem, still limited knowledge and data are available on methods for the prevention or mitigation of this issue in food supply chains. Therefore, researches have started to be conducted among various food supply chains to assess new tools and strategies which may help companies in the evaluation and consequent prevention of food fraud vulnerabilities. The most vulnerable ingredients to fraud, which have been listed during the USP convention as olive oil, milk, honey and some few others have been taken as starting point in the assessment of strategies for prevention. Among the others, literature reveals that dairy products are in the top of most adulterated food products worldwide. Milk have become an easy target for fraudsters in recent years due to many factors such as: the importance of milk in human diets and the increased demand, the growth competition in the dairy market, the increasing complexity of the supply chains. In order to get deeper understanding in the authenticity of milk, the object of the present research is to acquire knowledge and define risk factors which may lead to fraud vulnerabilities in well-established dairy supply chains through the use of the SSAFE vulnerability tool. This self-assessment tool helps companies in their process of assessing vulnerabilities to food fraud and supports them in the development of specific interventions to mitigate the identified vulnerabilities. To fulfil the main research objective, two sub-objectives are developed. First a literature's review on risk factors which can lead to potential vulnerabilities in dairy supply chains is conducted. Secondly, the SSAFE vulnerability tool is performed on a case study among dairy processors and food retailers. For the literature analysis, scientific journals were reviewed. For the assessment of fraud vulnerabilities through the case study, a quite large number of companies was contacted, of which only nine participated to the study. Even though the case study may not be fully representative of the situation of fraud vulnerabilities in well-established supply chains, some conclusions can be drawn. The outcomes of the literature analysis and the case study highlighted that the main risk factors are linked to detection methods, which are generally not enough advanced to perform authentication tests; valuable components of milk, which play an important role as economic driver for fraudster to commit fraud; fraud monitoring systems, which are not performed systematically and not well-developed for assessing fraud vulnerabilities; and law enforcements on (inter)national level since food fraud is a relatively new issue on the European political and it has never been a key priority for legislation and enforcement at European or national level. However, some differences between literature analysis and case study as well as between the two actors involved in the study have been discovered. Further details are provided in the chapters of this research.

LIST OF ABBREVIATIONS

BRC	British Retail Consortium
CPI	Corruption Perception Index
DNA	Deoxyribonucleic acid
EMA	Economically Motivated Adulteration
EC	European Commission
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FDA	Food and Drug Administration
GFSI	Global Food Safety Initiative
GFL	General Food Law
GHP	Good Hygienic Practice
GMA	Grocery Manufacturers Association
GMP	Good manufacturing practices
HACCP	Hazard Analysis Critical Control Point
IDF	International Dairy Federation
ISO	International Standards Organisation
MCA	Multiple Correspondence Analysis
NCFPD	National Centre for Food Protection and Defense
PDO	Protected Designation of Origin
PGI	Protected Geographical Indication
RASFF	Rapid Alert System for Food and Feed
SSAFE	Safe Supply of Affordable Food Everywhere
TACCP	Threat Assessment Critical Control Point
TI	Transparency International
TSG	Traditional Specialities Guaranteed
USP	United States Pharmacopeial Convention
VACCP	Vulnerability Assessment and Critical control point system

1.1 Background

1.1.1 Impact of food fraud on economies, businesses and consumer confidence

In recent years, new and challenging risks related to food frauds have emerged and have become a major concern within the food sector (Manning & Smith, 2015; Farrell and Healy, 2000), as food supply chains have become increasingly more global and complex (Sarpong, 2014).
Food fraud has often been considered to be foremost an economic issue, but recent cases have highlighted that this detrimental practise affects indeed economies and businesses, but also consumer confidence.
Food fraud can be commercially devastating since it is usually followed by a loss of sales. Although there is no exact data about how widespread food fraud is worldwide, the Grocery Manufacturers Association (GMA) estimates that fraud may cost to the global food industry between $10 billion and $15 billion per year, affecting approximately 10% of all commercially sold food products (Johnson, 2014). However, most researchers acknowledge that the full scale of food fraud "may be unknown or even possibly unknowable" since the number of documented incidents is "most likely a fraction of the true number of incidents because the goal of adulteration for economic gain is not to be detected" (Johnson, 2014).
Moreover, food fraud can have a detrimental impact on consumer trust and it entails product recalls and damage to reputations (Lotta & Bogue, 2015). Among the others, the melamine incidents in 2007 and 2008 and the horsemeat scandal in 2013 have sparked the attention of both the media and consumers about the problem of food fraud, revealing the large impact on consumer confidence and on the reputation and finances of food businesses (Lotta & Bogue, 2015). The incidences have raised crucial questions about the security of food supply chains and a wave of criticism has prompted (Manning & Smith, 2015). What has become clear today is that reputable companies have not find yet a solution to this detrimental practise. Consequently, consumer trust has diminished and food security has become a central issue in the food chain (Grunert, 2005; Verbeke, 2005). Consumers occupy a crucial position in food chains and are active market participants, therefore it is necessary to maintain high levels of confidence (Lotta & Bogue, 2015). Consumer demands for safe and wholesome food in general provides the biggest driving force for the creation of a variety of information systems such as traceability and quality assurance schemes which can help in fighting food fraud (Gellynck and Verbeke, 2001; Leat et al., 1998).

1.1.2 Food fraud: new concern in Europe

Food fraud is a relative new concern in the European political agenda, but despite both the economic and social relevance of this phenomenon, there is still not a harmonised definition in the European Union (EU) food legislation (Lotta & Bogue, 2015). As a result, it is becoming clear that there is need of a deep analysis into the integrity and assurance of food supply networks both at the national and European level (Lotta & Bogue, 2015).

European Commission (EC) has adopted an operational definition which indicates food fraud as the *"intentional violation of the rules covered by Regulation 882/2004 which are applicable to the production of food and feed, motivated by the prospect of economic or financial gain*" (Lotta & Bogue, 2015 p. 117), however the current EU legislative framework is still weak in relation to this new emerging issue. The current EU legislative framework is largely focused on food safety rather than on food fraud prevention. The only general guideline related to Food Fraud Prevention can be found in Regulation (EC) 178/2002 on General Principles and requirements of Food Law (European Commission website, 2016b). Within its principle and objectives, Regulation (EC) 178/2002, which aims at providing a high level of health protection and facilitate free movements of goods, considers consumers' interests by preventing deceptive practices in food chains

and by expanding the view of other policies related to labelling and advertising in foodstuffs placed in the internal market. Further details about European legislative framework on food fraud prevention and security are provided in Chapter 2.

1.1.3 Most common adulterated ingredients: milk is in top 7

The United States Pharmacopeial Convention (USP) which has set up a global database, added almost 800 new records, based on information published in scholarly journals and through the media in 2011 and 2012. This database has been analysed recently by Moore and others (2012) to determine the food ingredients which are most prone to fraud worldwide. According to this study, olive oil, milk, honey, saffron, orange juice and coffee seem to be the most common targets for adulteration reported in scholarly journals (Moore et al., 2012). Milk contributes with 14% of all scholarly records from 1980 to 2010 and is the second most common adulterated ingredients, after olive oil which scores 16% (Moore et al., 2012; European Commission website, 2016; Spink, 2014). By major food ingredient, oils (24%), milk (14%), and spices (11%) account for nearly 50% of all reported cases (Food Chemical Codex, 2014).

Milk fraud has vexed through history and continues to be a serious global issue (Johnson, 2014). Milk has historically been one of the most adulterated foods and one of the earliest frauds was to dilute it with water, an easy way to dilute milk simply sold on a weight or volume basis for illicit profits (Food Chemical Codex, 2014). Milk is a high risk commodity of concern for fraudulent activities and perpetrators may diminish nutritional quality through intentional adulteration and/or malpractice under poor hygiene conditions, lack of preservation, or without cooling facilities (Handford et al., 2016). The most common malpractices committed on milk are identified as:

- dilution, namely the extraction of valuable components such as milk fat and addition of cheap bulking additives i.e. low-quality flour to increase the value of total solids up to a level which goes unnoticed by consumers (Kandpal et al., 2012);
- the addition of starch, urea, rice flour, salt, glucose, vegetable oil, animal fat, melamine, whey powder, reconstituted milk in order to maintain the composition of carbohydrate and/or proteins (Azfal et al., 2011);
- the addition of variable volumes of water to artificially increase its volume for financial gain, which leads to a decrease in the nutritional value of the milk and also, if the water is contaminated, there may be risk of waterborne diseases (Kandpal et al., 2012);
- the addition of common adulterants in milk in order to increase thickness and viscosity if the milk is diluted (Azfal et al., 2011);
- the addition of ice and some chemicals such as sodium bicarbonate, sodium carbonate, calcium hydroxide, caustic soda or chemical formalin in order to increase its shelf- life (Azfal et al., 2011).

1.1.4 Initiatives to mitigate food fraud

Because modern food supply chains have been lengthened, complicated, and accelerated, the risk of food fraud has broadened (Spink et al., 2010). Food companies are nowadays operating in more complex supply chain systems and are experiencing previously unheard challenges (Ryan, 2015). Food industry has become more sophisticated and the globalization of food supply chains as well as the evolution of intensive production systems (Quested et al., 2010) have led to more concern in relation to food fraud issues. As a consequence, in order to decrease the risk of fraudulent incidents, some initiatives to detect and cope with food fraud has been developed and are continuously improved.

The Global Food Safety Initiative (GFSI) is an industry-driven initiative providing guidance on food safety management systems necessary for safety along the supply chain. The GFSI vision is that the mitigation of food fraud and its potential impact on consumer's health will become an integral part of company's food

safety management system. In late 2016, the GFSI Guidance Version 7 has been release and it requires food companies to:

- perform food fraud vulnerability assessment in which information is collected at the appropriate points along the supply chain and evaluated to identify and prioritize significant vulnerabilities for food fraud;
- have a food fraud vulnerability control plan in place that specifies the control measures that organisations need to implemented in order to minimise the risks from the identified food fraud vulnerabilities.

In addition to this and in response to food fraud issues, several schemes have been developed in order to provide guidance to companies on how to perform food fraud vulnerability assessments. The British Retail Consortium (BRC) developed the BRC Global Standards for Food Safety Issue 7, which is recognized as GFSI benchmarked food safety scheme. This standard introduces new requirements for food prevention in order to ensure transparency and minimize the risk of BCR certified sites purchasing fraudulent or adulterated raw material (BRC, 2016). The GMA (Good Manufacturers Association) released a report on "Brand Protection and Supply Chain Integrity" which provides a base from which companies can start building a Brand Protection response. Moreover, USP created the Food Fraud Mitigation Guidance providing manufacturers and retailers with an approach to help assessing food fraud vulnerabilities and develop a customized food fraud mitigation plan (USP, 2016).

1.2 SSAFE Food Fraud Vulnerability Self-Assessment Tool

Among the others, one of the initiatives which enables companies to undertake food fraud vulnerability assessment is the SSAFE Food Fraud Vulnerability Self-Assessment Tool, developed through the collaboration between SSAFE, University of Wageningen RIKILT and VU University Amsterdam (WUR-VU, 2015).
This self-assessment tool can be used by companies in their process of assessing vulnerabilities to food fraud and supports them in the development of specific interventions to mitigate the identified vulnerabilities. The SSAFE tool is not designed to detect the actual fraud or predict future food fraud incidents, but it addresses identified vulnerabilities which can lead to identification of unknown fraudulent activities and provide companies with the opportunity to stop them from occurring (WUR-VU, 2015).
The SSAFE tool can be performed by businesses across the whole supply chain, irrespective of size, location or type of food business. SSAFE vulnerability tool has already been applied on various value supply chain. Previous vulnerability assessments have been conducted among companies involved in the extra virgin olive oil supply chain (Huang, 2015), in the white fish supply chain (Krol, 2016) and in spices, but so far no previous researches have been conducted in dairy supply chains.

1.3 Demarcation and research questions

The present Master Thesis is part of a broad project about "Milk authenticity and Fraud mitigation" between the Netherlands and China, whose ultimate aim is to assess vulnerabilities in dairy supply chains in China. In order to get insight in fraud vulnerabilities in Chinese dairy supply chains, the first step in this big project is to obtain an understanding of dairy supply chains which are well-established in European countries. The study of well-established dairy supply chains may be used at later stages as benchmark for further studies in the Chinese dairy sector.

The research will primarily focus on economically motivated adulteration (EMA), since EMA is considered to be the most common and risky threat for public health (Spink, 2006, 2014) and since EMA Incidents Database indicates dairy products as one of the most susceptible category to fraud (USP, 2014).
Dutch and Irish dairy supply chains will be investigated through the use of SSAFE vulnerability tool. The research will focus the attention on dairy processors and food retailers. The Netherlands has been selected

because dairy (and agricultural sector in general) represents the engine of the country, for its economic relevance, high productivity and competition worldwide (Dutch Dairies in Figures, 2014; Tacken et al., 2009). Ireland, which is a country which has a strong and expanding milk related economy (McDonald et al., 2013), has been introduced in the research at a later stage in order to gain more insight in possible fraud vulnerabilities in another country where well-established dairy supply chains are present.
In the selection of the actors it has been taken into account that risk in food companies is crucial at any stage of the supply chain since risks faced by one actor may be part or comprise the risks faced by the other actors along the chain. Which in turn, it will affect not only the outcome of one single actor but also all the actors in the chain as a whole (Daud et al., 2015). Therefore, the analysis of dairy supply chains, from farmers to food retailers, will be performed by two master students in order to get the complete overview of fraud vulnerabilities in the dairy sector. In the present research, the focus is on dairy processors which are the core of the chain and on food retailers. Milk producers (farmers) who also play an important role in the supply chain, will be investigated by another master student, but they will not be included in the present research.

Conventional and organic drinking milk products will be the objects of the research, since their largely use and consumption worldwide (Johnson, 2014). They both will be included in the research in order to get a wider overview of the drinking milk products sold in the market.

Therefore, the main research question of the present research is:

- What would be the main food fraud vulnerability risk factors involved in well-established dairy supply chains based on the SSAFE Food Fraud Vulnerability Assessment Tool?

1.3.1 Specific research questions

In order to answer the main research question, the following specific research questions are formulated:

- Which are the potential vulnerabilities inherent the category of opportunities, motivations and control measures in well-established dairy supply chains?
- Which are the major vulnerabilities inherent opportunities, motivations and control measures based on the assessment of SSAFE vulnerability tool among dairy processors and food retailers?
- Which are similarities and differences between conventional and organic milk processors in relation to opportunities, motivations and control measures?

1.4 Overall objective

The overall objective of the present research is to study and define risk factors which may lead to fraud vulnerabilities in well-established dairy supply chains through the use of the SSAFE vulnerability tool.
In order to fulfil the main object two sub objectives are developed. The first sub-object is to explore and reveal, through in-depth literature analysis, which are the potential fraud vulnerabilities in well-established dairy supply chains. The second sub-object is to perform the SSAFE Food Fraud Vulnerability Self-Assessment Tool among dairy processors and food retailers, in order to get deeper understanding of vulnerabilities in the dairy sector.

1.5 Research approach

The research approach will be divided in 4 phases, namely the appreciation phase, the analysis phase, the assessment phase and the evaluation phase (Luning and Marcelis, 2009).

Appreciation phase: the aim of this initial phase is to get insight in food fraud concepts and gather information about frauds in dairy supply chains. As starting point, a systematic literature analysis will be performed. For this first phase, papers and researches collected from different databases, specially PubMed, Scopus, ABI/INFO will be reviewed.

Analysis phase: after the appreciation phase, in- depth literature review is performed in order to reveal the risk factors that may lead to potential vulnerabilities in dairy supply chains. The research will be based on the risk factors provided by the SSAFE vulnerability tool.

Assessment phase: the third phase of the research aims at collecting data in practice through the use of the SSAFE tool among dairy processors and food retailers. This will be done by performing a case study in which interviews will be carried out among respondents involved at processing and final distribution phases.

Evaluation phases: during the last phase, the outcomes of the case study will be analysed and vulnerabilities assessed. The aim of this phase is to perform a critical reflection about the research study. In this phase the usefulness of the research questions, selected literature, collected data will be evaluated.

CHAPTER 2: LITERATURE ANALYSIS

Milk is nutritionally important resource all over the world, it has a high food value (Handford et al., 2016), and it belongs to a group of food that is essential for certain groups of consumers, namely women, children and the elderly (de la Fuente & Juárez, 2005). Its value and importance in human diet, in addition with the increased demand, the growth competition in the dairy market and the increasing complexity of the supply chain have led to the result that milk fraud continues to be a serious global issue (Johnson, 2014; Handford et al., 2016). Therefore, it seems relevant to get insight in the dairy supply chain in order to gain information, that in combination with fraud vulnerability assessments undertaken with SSAFE vulnerability tool, may help dairy companies in the process of prevention of fraudulent incidents and in the development of mitigation strategies to combat fraud.

The present chapter aims through literature review to understand and reveal which risk factors may have an effect on potential fraud vulnerabilities in dairy supply chains. Chapter 2 is divided in sections. In order to help readers glide smoothly through the text, in the first section, general concepts about food fraud and related terminologies are introduced. In the second section European regulations on food fraud matters are described. In the third section, the SSAFE vulnerability tool is explained in more specific details. In the fourth section, the risk factors which may lead to potential vulnerabilities in dairy supply chains are defined. The fifth section describes which risk factors may not affect potential vulnerabilities in dairy supply chains. Lastly, the hypothesis and research framework are presented. This analysis aims at answer the first specific research question.

2.1 Defining food fraud

In the following paragraphs information about food fraud concepts and terminologies is presented.

2.1.1 Food fraud definition and categorization

In chapter 1, the definition of food fraud adopted by the European Union was introduced. However, when considering the concept of food fraud, it is evident that, depending on the authors, there are a number of definitions circulating. Food fraud, including the more defined subcategory of economically motivated adulteration (EMA), is defined as an intentional act with the purpose of gaining economic or financial benefit (Spink & Moyer, 2011).The first working definition of food fraud was adopted during a public meeting by the U.S. Food and Drugs Administration (FDA) in April 2009. Food fraud is stated as "*the deliberate and intentional substitution, addition, tampering or misrepresentation of food, food ingredients, or food packaging, or false or misleading statement made about a product, for economic gain"* (Spink & Moyer, 2011). Even if it differs from the one adopted by the European Commission (Lotta & Bogue, 2015), this wide definition is currently the most adopted and clarifies the key characteristics of food fraud namely 1) the non-compliance with food law and/or misrepresentation of foodstuff; 2) the intentionality of conduct; and 3) the economic gain as motivation (Lotta & Bogue, 2015). Food fraud differs in various elements, therefore the identification of different features of each type of food fraud as well as the analysis on food fraud notifications in the Rapid Alert System for Food and Feed (RASFF) and in the USP global database led to determine seven fraud categorizations (Manning, 2016). According to Spink & Moyer (2011), the different types of food fraud can be classified as follows:

- Adulteration is the change in the composition and purity of the original product by substituting, diluting of modifying it (i.e. melamine added to milk);
- Tamper occurs when product and packaging are used in fraudulent way (i.e. changes in expiry information);

- Over run occurs when legitimate product is made in excess of production agreements (i.e. fraudulent product is distributed outside of controlled supply chain);
- Theft happens when legitimate product is stolen and passed off as legitimately procedure;
- Diversion happens when the product is sold outside the intended market (i.e. shortages or delays of relief food to needy population);
- Simulation occurs when illegitimate product is designed to look like but not exactly copy the legitimate product;
- Counterfeit occurs when all the aspects of the fraudulent product and packaging are fully replicated.

2.1.2 Economically Motivated Adulteration (EMA)

EMA incidents represent a problem and a challenge to food industry because of the intentionality of the acts commit by perpetrators as well as for the frequency of these incidents, especially in various food categories such as fish, dairy products, honey and spices (Everstine, 2013). EMA is a subcategory of food fraud (FDA, 2009), which includes intentional contamination and intentional adulteration, enlarging thus the concept of food fraud (Spink & Moyer, 2011). Economically motivated adulteration has been defined, in the May 2009 FDA Open Meeting, as "*the fraudulent, intentional substitution or addition of a substance in a product for the purpose of increasing the apparent value of the product or reducing the cost of its production*" (FDA, 2009). In the National Centre for Food Protection and Defense (NCFPD) EMA Incident Database, about 300 incidents since 1980 are accessible. EMA Incidents Database indicates that, by major food ingredient category, dairy products accounted nearly for the 6 percent of the incidents, after fish and seafood (31%), oils and fats (11%), alcoholic beverages (8%), meat and meat products (7%) (USP,2014). EMA is a challenge that requires a vulnerability assessment approach since this type of food fraud is an intentional act committed by intelligent perpetrators that are stealthy and actively seek to avoid detection (Spink, 2011).
EMA incidents are classified under the categories of:

- Dilution: the process of mixing liquid ingredients with different value;
- Substitution: the process of replacing a high value ingredient or part of the product with a lower value ingredient of part of the product;
- Concealment: the process of hiding low quality food ingredients or product;
- Mislabelling: the process of placing false claims on packaging (i.e., label it as organic);
- Unapproved enhancement: the process of adding unknown or undeclared substances to food product;
- Counterfeiting: the process of copying brand name, packaging concept, recipe, etc. of food products (WUR-VU, 2015).

2.1.3 Food Fraud Vulnerability

In 2014, GFSI has presented its direction for including Food Fraud in Food Safety Management Systems, with the shift in focus from risk analysis towards vulnerability analysis. It is believed that risk is something that is occurred in the past and will occur again, but not enough data are present to conduct a statistical analysis. Vulnerability is more a state of being that could lead to an incident. Therefore, GFSI has come up with the definition that Food fraud vulnerability refers to "susceptibility or exposure to a gap or deficiency that could place consumer health at risk and/or have an economic or reputational impact on a food company's operations if not addressed" (Spink, 2014). The Food Safety Management Umbrella has been implemented in order to incorporate HACCP (hazard/ Food Safety), TACCP (threat/ Food Defense) and VACCP (vulnerability/ Food Fraud).

2.1.4 Food Fraud Vulnerability Assessment

Food Fraud Vulnerability Assessment refers to the process of collection and evaluation of information on

potential food fraud risk factors as well as mitigation measures which, when combined, determine the actual fraud vulnerability. According to GFSI, The Food Fraud Vulnerability Assessment should be in place in companies to identify and address food fraud vulnerabilities (Spink, 2014).

2.1.5 Food Fraud Mitigation Measures

Food Fraud Mitigation Measures are defined as the hard and soft actions that are taken to combat against identified food fraud vulnerabilities (WUR-VU, 2015).

2.2 European legislation on food fraud

In Europe, specific regulations to counter food fraud are still not present. As briefly explained in Chapter 1, the current EU legislative framework is largely focused on food safety rather than on food fraud prevention (FDA,2014). However, a number of initiatives have been taken to improve the capability of Member States' competent authorities in the process of identifying as early as possible violations of food law which are motivated by the intention to obtain an undue benefit. This category broadly overlaps with the "fraudulent and deceptive practices" referred to in Article 8 of Regulation (EC) No 178/2002 (the "General Food Law") (European Commission, 2017).
Despite the lack of specific regulations, the European Parliament's Committee on the Environment, Public Health and Food Safety (ENVI) adopted an own initiative report (2013/2091 (INI)) "*on food crisis, fraud in the food chain and the control thereof*" which aims at making prevention and combating of food fraud, an integral part of EU policy. The report indicates the principal guidelines and action measures that need to be adopted to combat food fraud. In March 2013 the European Commission launched a five-point plan, which provided a list of actions to be carried out over the short, medium and long term, for restoring consumer confidence in the food supply by strengthening several controls against fraudulent practices.
The action plan has been set out to prioritise the fight against food fraud and strengthen coordination among Member States. Action proposed included the creation of dedicated IT tool, similar to the RASSF system, and a food fraud team.
Moreover, in the last five years, food fraud has also drawn the attention of the International Standards Organisation (ISO) and the Global Food Safety Initiative. The first, in 2009, established the Technical Committee Fraud Countermeasures and Controls, which has the defined scope to support other current standards, such as ISO 22000 Food Safety and ISO 28000 Supply Chain Security, in the food fraud struggle. In addition, in 2014, GFSI released a position paper on food fraud mitigation, developed by the GFSI Guidance Document Working Group in conjunction with the GFSI Food Fraud Think Thank. It includes new requirements, such as performing a food fraud vulnerabilities assessment and having food fraud vulnerability control plans in place, which need to be met by companies when look to combat food frauds.
In addition, the database created by the European Commission and called Rapid Alert System for Food and Feed Safety provides "a round-the-clock service to ensure that urgent notifications are sent, received and responded collectively and efficiently". It enables information to be shared efficiently between EU member, and at the same time, it also prevents that many food safety risks may reach and been harmful to European consumers (European Commission website, 2016).

2.2.1 European Regulations for organic products

In the European Union (EU), organic market is regulated by Regulation (EC) No. 834/2007 and by the corresponding implementing regulation (Regulation (EC) No 889/2008) which lay down the principles of organic production, certification and labelling (European Commission, 2016a). With the increase in global demand for organic food products in the last 20 years (Jensen et al., 2011), in July 2012, a new development in the regulatory environment has been the introduction of a mandatory logo for organic food (Janssen & Hamm, 2014) in order to harmonise and replace a large of different organic labels and in the meantime enhance and protect consumer's trust (Albersmeier et al., 2010; Jensen et al., 2011). The label assigned by

Stichting Skal is 'EKO-Quality mark'. This label 'organic' is protected by law and is restricted to organic companies, like farmers and producers, that are licensees of Stichting EKO-Keurmerk and certified by Skal (EKO-Keurmerk, n.d.). However, it needs to be mentioned that despite the new regulatory system, organic food markets still feature a high degree of information asymmetry and consumers are not often able to verify whether or not a product is produced in accordance to the promised characteristics (Janssen & Hamm, 2012). Thus, due to the irregular distribution of information between enterprises in the supply chain, credence good markets are prone to fraud and opportunistic behaviour (Janssen & Hamm, 2012). Among the others, mislabelling is the type of EMA incidents most likely to happen within the category of organic products. Organic products are credence food and frequently cases of detected mislabelling are reported by the European Press. Mislabelling of conventional food as organic is profitable: suppliers of conventional food can misrepresent the nature of their product (i.e., label it as organic) and take advantage of the price premium paid for organic food, while enjoying the cost savings associated with the production of its conventional counterpart (Giannakas, 2002).

2.3 SSAFE Food Fraud Vulnerability Assessment Tool

This section explains in more details the SSAFE Food Fraud Vulnerability Self-Assessment Tool, which will be performed in the caste study among dairy processors and food retailers. Moreover, an insight in the criminological theory behind the tool is given.

2.3.1 Criminology applied to food fraud

Food fraud is opportunistic in nature and represents a great challenge to food industry. Furthermore, this phenomenon is further complicated by unpredictable variables linked to fraudster's personal characteristics, such as intelligence or resilience (Spink and Moyer, 2011). Therefore, criminology and behavioural sciences are often used to obtain knowledge and understanding of the problem. Criminology is the science which studies criminal behaviours, such as fraud, which is an economically motivated crime (WUR-VU, 2015).
One of the theories which can provide insight and helps to understand the nature of food fraud is the Crime Triangle (Spink and Moyer, 2011). This is the framework of the Routine Activities Theory, which has been used as reference during the development of the SSAFE Food Fraud Vulnerability Assessment Tool (WUR-VU, 2015).
The Crime Triangle is composed of three legs: victim who is the person(s) cheated, fraudster (or referenced in criminology research as "criminal") and guardian including hurdle gaps (Cohen and Felson, 1979; Wheatley, 2013). In order to adapt the concept, as the legs increase in length so the area of the triangle increases, which represents an increase in the crime opportunity. The Routine Activities Theory suggests that when motivated offenders (fraudsters) and suitable targets (victims) meet in the absence of capable guardians (guardians and hurdle gasps), crime is likely to happen (Cohen and Felson,1979). At its heart there is the idea that in absence of effective control, offender will prey upon attractive targets (Spink and Moyer, 2011b).
The Routine Activity Theory behind the tool is shown in the figure 1.

Figure 1. Routine Activity Theory

2.3.2 Scope of the SSAFE tool

SSAFE can be used by companies in their systematic process of assessing vulnerabilities to food fraud. The core concept is helping in providing a profile of a company's potential food fraud vulnerability, which it might give the basis for the development of specific interventions to mitigate the identified vulnerabilities. Since the tool is not designed for detecting fraud neither for predicting the future fraud incidents, it can be seen as good mean for companies to stop vulnerabilities from occurring (WUR-VU, 2015).

2.3.3 Components of the SSAFE tool

The Food Fraud Vulnerability Assessment Tool consists of seven parts (WUR-VU, 2015):

I. A general information sheet regarding company information and the team that completed the information in the tool
II. A decision tree to help the user decide where to apply the tool
III. Fifty assessment questions
IV. Main spider webs providing a general overview of the findings
V. Detailed spider webs providing further insight into the findings
VI. Outputs enabling the user to prepare potential mitigation strategies and techniques for identified vulnerabilities
VII. A final report summarizing the outcome of the assessment.

2.3.4 Assessment questions of SSAFE vulnerability tool

The tool is constituted of 50 questions for food fraud vulnerability assessments. Each question aims to assess the level of risk of the indicator to which it is linked. The indicators, also called risk factors, of the SSAFE vulnerability tool are structured in two dimensions, which are displayed in Figure 2.

Figure 2. First and second dimension of SSAFE vulnerability tool

From the picture, it can be seen that the first dimension involves three key elements namely opportunities, motivations and fraud control measures, which have been topic of extensive studies and theory testing. Criminologists have reason to believe these three categories determine a company's vulnerability to food fraud since in contemporary criminology, economically motivated crimes are seen as the outcome of the aggregation of 1) opportunities, 2) motivations, and 3) the absence of control measures (WUR-VU, 2015).

Opportunities (suitable target) refer to gaps and holes in the system that lead fraudsters to commit frauds. This category can be evaluated by indicators which aim at understanding product and process characteristics. For instance, ingredients represent - by the nature of their composition, qualities, and geographical or production origin - an attractive way (field) for adulteration, substitution, mislabelling or counterfeiting (WUR-VU, 2015).

Motivations (motivated offender) for frauds may differ, depends on the circumstances. Frauds can be committed by individual offenders working in a company or organized networks, as well as by corporate offenders such as companies operating across the supply chain. The motivation behind this malpractice is usually economic since it assumes the pursuit of individual material gain or some kind of business advancement. In other words, greed versus need: the drive for more material gain versus the perception that law breaking is unavoidable for economic survival. The main factors which belong to this category and that may have an impact on the motivations to commit food frauds are: organizational strategy, business culture, level of competition and relationships with suppliers (WUR-VU, 2015).

Control measures (lack of guardianship) are defined as "hard and soft actions that are adopted to combat against identified food fraud vulnerabilities". This category takes into account the indicators related to mitigation and contingency control measures (such as tracking and tracing system, information system and so on) in place in the company's Food Safety Management System and/or in the supply chain, industry segment, and/or legal framework (WUR-VU, 2015).

Opportunities and motivations are determined by the company's internal and external environment and are defined as potential risk factors. The potential risk resulting from these two elements can be mitigate by the third element, namely fraud control measures, which companies implement to detect or prevent fraud (WUR-VU, 2015).

The second dimension, as show in figure 2 is divided into different layers of context. From small to large order, contexts are company, company's supply chains, industry segment, country/regional environment and global environment.

2.4 Potential risk factors affecting fraud vulnerabilities in dairy supply chains

SSAFE vulnerability tool comprises a large variety of risk factors that may affect fraud vulnerabilities in various food supply chains. The overview of the risk factors is displayed in table 1. Within each category of the SSAFE vulnerability tool, the risk factors have been classified and grouped according to their intrinsic characteristics and similarities. This sub-division of risk factors has been made by the researcher and it differs a bit from the division in dimensions provides in the SSAFE vulnerability tool's paper. In the category of opportunities, the risk factors are classified in technical and in time and space; within the category of motivations, the risk factors are classified in economic drivers and cultural and behavioural issues; lastly, within the category of control measures, risk factors are classified in technical and managerial.

Table 1. Overview of risk factors of SSAFE vulnerability tool divided by category of opportunities, motivations and control measures.

	Opportunities-related fraud risk factors	*Motivations-related fraud risk factors*	*Control-measures related fraud risk factors*
Technical / *Economic drivers* / *Technical measures*	Complexity of adulteration; knowledge to adulterate and technology's availability; adulteration detectability.	Supply and pricing of materials; special attributes or value determining components of materials; price asymmetries in countries; level of competition in sector; economic health business.	Specificity and accuracy of fraud monitoring system; systematics and autonomy of verification of fraud monitoring system; accuracy information for mass balance control; extensiveness tracking and tracing system; fraud contingency plan
In time and space / *Cultural and behaviour issues* / *Managerial measures*	Accessibility to materials in production/processing lines; transparency supply chain network; relationships within the supply chain.	Business strategy; ethical business culture; previous criminal offences; national corruption level; victimisation.	Strictness ethical code of conduct; application integrity screening; support whistle blowing system; contractual requirements suppliers; social control and transparency across supply chain; established guidance for fraud prevention and law enforcement.

For the present research, risk factors inherent the category of opportunities, motivations and control measures which may have an effect on potential vulnerabilities to fraud in dairy supply chains are analysed in the following sections. Afterwards, the hypothesis is formulated and the research framework is created to display what found in the literature.

2.4.1 Opportunities-related fraud risk factors

This section related to opportunities of the SSAFE Vulnerability Assessment Tool is divided in "technical" risk factors and "in time and space" risk factors, as explain in table 1. The opportunities-related risk factors which may have an effect on potential fraud vulnerabilities in dairy supply chains are described below.

TECHNICAL RISK FACTORS

2.4.1.1 Complexity of adulteration

Milk is a biologically complex fluid, constituted mainly of water, proteins, lactose, fat and inorganic compounds (Nollet and Toldrá, 2016), its composition is dynamic in nature and varies continuously due to different factors such as breed, feed, age of the animal, season and stage of lactation (Verma & Ambatipudi, 2016; Molkentin, 2013). It has been seen that simplicity of adulteration is strictly related to ingredient's complexity and variability. **Typically, the more complex and variable an ingredient is, the more susceptible it is to fraud because of difficulties in characterizing it analytically** (Food Chemical Codex, 2014).
Therefore, it can be assumed that complexity of adulteration represents a potential vulnerability to fraud in dairy supply chains.

2.4.1.2 Knowledge to adulterate and technology's availability

By browsing on internet, it is quite simple to find papers, reports and instructions related to adulterants and relative techniques for adding them to milk and milk products. There are many techniques to alter milk composition and therefore reduces its nutritional quality (Finete et al., 2013). Milk composition can be modified through the use of different substances that have been classified into two categories, namely adulterants and preservatives.

The different methods to adulterate milk depend on what the fraudsters are aiming at: if the purpose is to **adjust milk's composition illegally**, it can be adulterated by the addition of starch, sugar, gelatine, maltodextrin, saccharin, colouring agents, melamine, sodium hydroxide and flour (Singh & Gandhi, 2015); **for increasing the volume**, a common practice is the addition of milk extenders, especially whey or water (Kasemsumran et al. 2007). The latter can sometimes pose a health risk if polluted with feces, microorganisms, harmful chemicals, and poisonous substances (Singh & Gandhi, 2015). Addition of urea, detergents, and pond water in sour and spoiled milk is also in practice to **make it fit for the processing and consumption** (Upadhyay et al., 2014). Another practice is also the addition of chemical preservatives to milk samples so that the **composition does not change** until the analysis. For instance, hydrogen peroxide is widely used as a preservative in milk and milk products because of its potential to **inhibit microbial proliferation** and milk spoilage (Singh & Gandhi, 2015). All these practise are usually done for economic purposes, but rather than that some unethical activities are usually adapted to prevent financial losses due to the spoilage of milk during its transportation and sale (Singh & Gandhi, 2015).

Among the others, a common malpractice is **the dilution of milk with water** (Singh & Gandhi, 2015). One of the most significant side effects is the reduction of protein concentration, which lead to an alteration of the composition and it reduces the nutritional value quality (Finete et al., 2013). As a consequence, fraudster add nitrogen-rich compounds to correct the apparent milk protein content. Since a number of water-soluble nitrogen compounds such as melamine, ammonium sulphate and urea produce the same analytical characteristics as proteins using the Kjeldahl method, they are frequently used for modifications in milk composition (Finete et al., 2013).
Another way is the substitution of milk with fat and proteins **with cheaper foreign fats such as vegetable oil/fats** (Kumar et al.,2010). This is performed for economic reasons due to increases in demands and milk production costs (Kumar et al.,2010). Milk fat is an important constituent that plays a significant role in the physico-chemical properties of milk and milk products. In addition to being a valuable source of fat-soluble vitamins and essential fatty acids and apart of having rich and pleasant attributes, milk fat represents an expensive raw material fraction (De La Fuente et al. 2005).

Moreover, milk is frequently adulterated by **mixing milk from random sources and different animal species** (Azad & Ahmed, 2016) since some types of milk can have more valuable components due to genetic, physiological, nutritional, and environmental factors (Gantner et al., 2015).
Therefore, it can be assumed that technology's availability and knowledge for adulteration represent potential vulnerability to fraud in dairy supply chains.

2.4.1.3 Adulteration's detectability in milk

Analytical detection methods play also a crucial role in the identification of vulnerabilities to food frauds because as scientist are developing and improving detection methods for substances in milk (Singh & Gandhi, 2015; Food Chemical Codex, 2014), unscrupulous producers introduce new alternatives that cannot be detected by established techniques (Finete et al., 2013; Singh & Gandhi, 2015).
In order to avoid all the unethical practices related to adulteration from happening, safeguard the interest of consumers, check milk adulterants, different methods for the determination of milk profile have been developed by scientists (Verma & Ambatipudi, 2016).
Detection of adulteration by substitution of one type of milk for another has been achieved principally by protein analysis (Borkova and Snaselova', 2005). HPLC analysis has been employed mainly to determine individual milk proteins due to the fact that different chromatographic profile can be obtained for milk from different species (Downey, 2016).
To identify adulteration within an individual type of milk, more complex techniques are used, such as immunological techniques and techniques based on DNA analysis. These methods are extremely precise, they enable detecting as little as 0,5 and 0,1 % of adulterants respectively (Borkova et al., 2005). To examine and quantify adulterants like whey, urea, caustic soda and hydrogen peroxide in milk, infrared spectroscopy has provided a non-destructive fingerprinting approach (Verma & Ambatipudi, 2016).
Analytical methods for assessing the authenticity of milk fat based on fatty acid composition were adopted by the International Dairy Federation (IDF) as the basis for the quantification of milk fat in fat mixtures. Nowadays, the best way to reveal foreign fats in milk includes the study of the fatty acid composition, the triglyceride profile, and the different fractions of the minor lipid constituents, mainly form the unsaponifiable fraction (De La Fuente et al., 2005). Traditionally, sterol analysis has been used for the detection of admixtures of animal fats and vegetable oils by determination of cholesterol and phytosterols (Kumar et al.,2010). This is the most sensitive method to determine and differentiate vegetable and animal fat. Animals fats, such as milk fat, primarily contain cholesterol; phytosterols are not detectable or only present at trace levels. Among the different sterols present in vegetable oils, B-sitosterol is usually the main constituent, therefore, a suitable marker for the detection of the addition of vegetable oil to milk fat (Kumar et al.,2010).
It follows that analysis of minor components, mainly constituents of the unsaponifiable matter, can be an indispensable tool for authentication purposes in milk (Kumar et al.,2010).

Moreover, as the literature explains, milk samples form **organic** and **conventional** raised cows differ in the content of specific fatty acids due to the different feed used (Schröder et al., 2011). Consequently, a starting point for potential procedures is by checking the milk composition, which can vary greatly depending on differences in the diets of the cows (Schröder et al., 2011). In order to distinguish both types of dairy agriculture, analysis need to be conducted on several marker fatty acids, such as phytanic acid a-linolenic acid (18:3n-3), eicosapentaenoic acid (20:5n-3), because it has been proved that due to higher amount of grass in the feed of organic, the concentration of these fatty acids are usually higher than in conventional milk (twofold higher in organic milk fat than in conventional milk) (Schröder et al., 2011).

However, despite the wide availability of detection methods, **the ability to actively detect fraud (i.e. authenticate products) represents the most technically challenge aspect of food fraud prevention**. Food ingredient's composition is sometimes so complex that can have thousands of different molecules which all react and interact differently under various conditions even when tested by different methods (Moyer et al., 2017). Analytical testing to confirm that a food product is authentic is very challenging, often nearly

impossible and is not fool proof. For instance, adulteration would remain undetected if there is a misleading assumption behind the adoption of a test, with the outcome that the test is inadequate for detecting the adulteration actually taking place (Moyer et al., 2017).

Therefore, it can be concluded that even though the wide availability of detection methods, adulteration's detectability may represent a potential vulnerability to fraud in dairy supply chains, and especially for organic milk.

IN TIME AND SPACE RISK FACTORS

2.4.1.4 Transparency of Supply Chain Network

"Transparency of a supply chain network is the extent to which all the network's stakeholders have a shared understanding of, and access to, product and process related information that they request, without loss, noise, delay and distortion" (pag 482, Beulens et al., 2005). **Transparency represents a crucial factor in establishing food security** (Beulens et al., 2005), since food ingredient's vulnerability to fraud increases with complexity of the supply chain. In dairy supply chains, data recording, intensified information exchange and integrated information systems are needed to achieve and ensure transparency of dairy products (Trienekens at al., 2011). Since it is not allowed to place unsafe food (art. 14, General Food Law (GFL – 178/2002/EC) on the market, this imposes demands for transparency, in particular through traceability, to all actors along supply chains (Wognum at al., 2011). Hence, it is necessary to interconnect all information systems belonging to all food business operators that are involved in food supply chains as well as to build-up an inter-organizational information system (IOIS) in order to have a full traceability from the top stream to the downstream (Anica-Popa, 2012).

Therefore, it can be assumed that transparency may represent a potential vulnerability to fraud in dairy supply chains.

2.4.1.5 Relationships within the supply chain

Collaborative relationships based on trust and commitment, in turn lead to improved satisfaction, secure valued resources and technologies, and improve firms' performances (Nyaga et al., 2010). However, even though the best relationship occurs when it is built on a 'win- win' model (Spekman, 1988), sometimes the parties may enter into relationship for which they do not desire long term mutual benefits (Cox, 2004). Vertical relationships as well as horizontal relationships within food supply chains have long been recognized as influencing factors in the business performance and critical for supply chain management strategies (Tan, 2001; Nyaga et al., 2010), especially within the agri-food sector (Fischer et al., 2010). Since power is not an absolute concept and emerges from the specific context of the relationship, it has been assumed that power depends on the relative position held by each actor (Gorton et al., 2015). This implies that actors behave and interact with others differently, depending on their relative power sources. For instance, dairy processing companies are directly dependent on the performance of their suppliers (Benton & Maloni, 2005) and at the same time, do indeed feel the pressure exerted by their buyers, especially since they supply one of the supermarket's most important fresh products: milk (Mauser, 2001). Relationships within supply chains are crucial at any stage since it has been seen that the quality and quantity of manufacturer's output depend highly on the capabilities and performance of its suppliers (Benton & Maloni, 2005). Since opportunities for fraudsters are more likely to appear in networks which rely on unfounded trusting relationships (Levine, 2014), it is important to continuously communicate and cooperate in an environment where parties in the relationship benefit equivalently.

Therefore, relationships may represent a potential vulnerability to fraud in dairy supply chains.

2.4.2 Motivations-related fraud risk factors

This section related to motivations of the SSAFE Vulnerability Assessment Tool is divided in "economic drivers" risk factors and "cultural and behavioural" risk factors, as explained in table 1. The motivations-related fraud risk factors which may have an effect on potential fraud vulnerabilities in dairy supply chains are described below.

ECONOMIC DRIVERS

2.4.2.1 Supply and price of milk

The year 2007 can be considered as an important turn-over year. Before this period, milk and dairy prices were mostly regulated at European level, therefore, the prices were more stable. Since the dairy sector has shifted from a more European regulation oriented to more internationally regulated, dairy prices in Europe are today largely determined by international demand and supply and by milk prices in other international markets (Dutch Dairies in Figures, 2014; McDonald et al., 2013). The integration of additional deregulations in the EU after 2007 led to fluctuations in EU milk prices which were 85% higher than in the previous period. This price volatility is mainly determined by a complex array of factors which lie outside the influence of dairy sector and which cannot simply be eliminated. The causes behind price volatility are related to emerging, mostly volatile economies and are also dependent on the weather patterns, which are becoming more extreme and less predictable and have bigger influence especially in those areas where cows are primarily outside and feed on grass (Dutch Dairies in Figures, 2014). Moreover, it is important to take into account that **when price volatility become larger and unexpected, it can have a negative impact on food security** (FAO,2016).
Therefore, supply and price of milk may represent a potential vulnerability to fraud in dairy supply chains.

2.4.2.2 Special attributes or value determining components of milk

Milk composition and its attributes are economically important to milk producers and processors and nutritionally important to consumers (Linn, 1988). The **introduction of milk pricing on a component basis** have created new interest in how milk components can be modified through diet, environment management practises, diets, breeds to accommodate these new emerging markets (Linn, 1988). Therefore, companies have started to place on the market, products with superior attributes. These special attributes are enhanced through the use of labels: for instance, eco-labels since environmentally friendly goods are often defined as credence goods and also producers are able to benefit more (Limnios et al.,2016); food quality labels, such as PDO (protected designation of origin), PGI (protected geographical indication) and TSG (traditional specialities guaranteed) has been introduced in order to protect producers of food with special qualities (Grunert & Aachmann, 2016). In the Netherlands, "Weidemelk", which is the Dutch term for "pasture milk", is a quality label recently introduced for milk and dairy products, that are produced from cows on pasture at least 4 months per year, six hours per day (Elgersma, 2012). The European regulation for organic farming requires that the animals are given an adequate access to an outdoors area and that at least 60% of the dry matter in the daily ration of herbivores should consist of roughage (Commission regulation (EC) No 889/2008).

Moreover, organic products are also generally perceived with higher quality compared to the conventional counterpart. Consumers have positive attitudes towards organic products because they are perceived as healthier, environment and animal friendly, with a superior taste (Marian et al., 2014). Furthermore, they are also usually premium priced, which leads to higher prices when are purchased (Marian et al., 2014) and benefits for the actors involved in the supply chain. Therefore, **quality labels may be attractive for unscrupulous people who want to enhance their profits**. Specifically, for milk and dairy products, it has been seen that, since consumers are nowadays increasingly interested in information about the origin of foods

including information on dairy cow's diet, housing and herd management, organic products are gaining an added value compared to conventional counterparts, but the side effect is that these products might therefore be fraudulently mislabelled (Capuano et al., 2014).
Therefore, special attributes may represent a potential vulnerability to fraud in dairy supply chains.

2.4.2.3 Market competitiveness

The European dairy industry is confronted with losing market share in the global competition as a result of changes in agricultural trade policy that have led to a major liberalisation of the dairy market and high fluctuations in milk prices (Tacken et al., 2009). Among the others, raw material prices and productivity at farm level have been identified as the most influent factors in dairy market competitiveness, since they also affect the other actors among the supply chain counterparts (Tacken et al., 2009). European countries are highly competitive between each other's. Moreover, in addition to this, prices per litre of milk in European countries (at farm level) are higher than in other part of the world, due mainly to the cost of milk quotas, animal welfare regulations and the relatively high cost of land and labour. Being the milk a highly standardized product, the competition on the (inter)national market is therefore fierce. As a consequence, non-European countries such as Australia, New Zealand and USA are increasingly gaining market share and are becoming competitively stronger on this product than the European counterparts (Tacken et al., 2009).
Therefore, market competitiveness may represent a potential vulnerability to fraud in dairy supply chains.

2.4.2.4 Economic business health

European dairy supply chains are facing a quite large number of challenges related to policy changes, new European regulation and new global trends, which add pressure and have financial implication on the economic performance of dairy companies (Soboh et al., 2011). The introduction of milk quota imposed restrictions on the productivity improvements and the falling of milk prices also put more pressure on dairy farms, with the consequence of partially influence as well the other following actors involved in the chain (Dutch Dairies in Figures, 2014). The economic business health is very diversified within dairy supply chains and it is therefore hard to established it. It is determined by factors such as strategic relationships between companies and critical suppliers (Ambrose et al., 2010) or firms' size which can have positive or negative influence on economic performances (Tacken et al., 2009). However, it can be deducted that farmers are constantly facing more financial problems compared to dairy processors and food retailers, which are operating in more dynamic markets.
Therefore, it can be assumed that economic business health may represent a potential vulnerability to fraud in dairy supply chains.

CULTURAL AND BEHAVIOURAL RISK FACTORS

2.4.2.5 National Corruption Level

Corruption is defined by the Transparency International (TI) as "*the abuse of entrusted power for private gain*" which is closely related with to the concept of food fraud. TI is a global civil organization leading the fight against corruption. It annually publishes the Corruption Perception Index (CPI), which indicates the perceived level of public corruption on a scale of 0 (highly level of perceived corruption) to 100 (low level of perceived corruption) among countries worldwide. The country's rate indicates its position relative to the other countries in the index. Overall, European countries scores very differently. In year 2016, among 168 countries, the Netherlands scored 83 and was 8° in the chart and Ireland scored 73 and was 19° in the chart. However, other European countries, such as Italy, Spain, Greece scored low in the chart. At national level, it can be seen that the corruption level between EU Member States differ significantly (Transparency International website, 2017).
Therefore, it can be concluded that National corruption level may represent a potential vulnerability to fraud in

dairy supply chains, depending on which countries dairy supply chains are involved.

2.4.2.6 Ethical business culture

The capability to behave ethically refers to the extent to which employees believe that they have the sufficient means (time, budgets, equipment, information and authority at their disposal) to fulfil their ethical responsibility (Kaptein, 2011). Ethical business culture can have a significant effect in the prevention of fraudulent incidents. It has been seen that many factors may play a role in influencing (un)ethical behaviour (Kaptein, 2011). An ethical business culture which is not characterized by: clarity of ethical standards (Bird and Waters, 1989; Jackson, 2000; Tyler and Blader, 2005), ethical role modelling of management and supervisors (Kaptein, 2011), commitment to behave ethically, transparency of behaviour (Greenberg, 1997; Skarlicki et al., 1999), openness to discuss ethical issues (Kaptein, 2011), reinforcement of ethical behaviour which refers to the likelihood of managers and employees being punished for behaving unethically and rewarded for behaving ethically (Kaptein, 2011), can lead to demotivation, mistrust and dissatisfaction and can be a breeding ground for unethical behaviour (Greenberg, 1997; Skarlicki et al., 1999).
When unethical behaviour is not punished, the message is that it can be acceptable (Ball et al., 1994). Usually, organisations which have taken the time to consider where they stand on ethical issues, have come to realise that high ethical standards bring long term benefits (CIMA, 2008).
No specific papers or articles are found on ethical business culture in dairy supply chains, therefore it depends on the kind of culture expected in the dairy sector whether it may present an addition to potential vulnerability.
However, it can be assumed that ethical business culture may represent a potential vulnerability to fraud in dairy supply chains.

2.4.2.7 Business strategies

Manufacturers seek long-term relationships with fewer suppliers to secure valued resources and technologies, harness supplier skills and strengths, and gain from quality and process improvements. However, in spite of the demonstrable benefits, many firms are struggling to achieve the desired level of collaboration and/or the expected benefit of such collaborations (Nyaga et al., 2010). It may be sometimes difficult to find the balance between parties. This is because critical details, such as selecting the right partner, matching inter-organizational needs and capabilities, and clearly defining standards and goals, are often overlooked (Nyaga et al., 2010).
Therefore, it can be assumed that business strategies may represent a potential vulnerability to fraud in dairy supply chains.

2.4.3 Control measures-related fraud risk factors

This section related to control measures of the SSAFE Vulnerability Assessment Tool is divided in "technical" risk factors and "managerial" risk factors, as shown in table 1. The control measures-related fraud risk factors which may have an effect in the mitigation of potential fraud vulnerabilities in dairy supply chains are described below.

TECHNICAL CONTROL MEASURES

2.4.3.1 Specificity and accuracy of fraud monitoring system

Fraud monitoring systems are essential tools for organizations and should be in place in order to evaluate, remedy and improve organization's fraud prevention and detections techniques (Crain et al., 2016). As the level of complexity of food supply chain is increasing, fraud monitoring systems need to be implemented in order to develop a more strategic approach in response to the new threats. The establishment and

promotion of clear fraud monitoring system is an element of prevention, as well as detection of fraudulent incidents. As for food safety analysis systems, at the core of the fraud monitoring system there is Hazard Analysis Critical Control Point (HACCP), but some adjustments have been made to make the system applicable against food frauds. By using the same core principle of HACCP, GFSI Board of Directors came up with the new concept of Vulnerability Assessment and Critical control point system (VACCP), which has been included in the Food Safety Management System (Bogadi et al.,2016). The shift in focus from risk based analysis (HACCP) towards vulnerability analysis (VACCP) is due to the nature of food fraud. In practice, since HACCP principles cannot be directly used to detect or mitigate fraudulent actions (Bogadi et al.,2016), VACCP applies the HACCP-type system specifically to the unique attributes of a food fraud incident. This implementation had begun in 2012, when GFSI Board of Directors has started to analyse how food fraud could be incorporate into the GFSI Guidance Document, as a consequence of the weak level of food defence among companies, which is directly dependent on the extent of fraud monitoring systems. The idea is that, like the introduction of food defence into the Guidance document a few years ago, the mitigation of food fraud and the potential impact on consumers' health become an integral part of a company's food safety management system.

Therefore, it can be assumed that fraud monitoring system is a crucial control measure in the process of mitigation of fraudulent incidents. Low adequacy of this system may represent a potential vulnerability to fraud in dairy supply chains.

2.4.3.2 Extensiveness tracking and tracing system and accuracy of systems for mass balance controls

One of the main characteristics in foods is that their safety cannot be completely guaranteed through an analysis of the final products, but need to be built on appropriate control of processes along the food supply chain (Fritz & Schiefer, 2009).

For this reason, the realization of tracking and tracing schemes is essential and involves the need for agreements and coordination between suppliers and customers. The balance of activities between enterprises might be difficult to reach because of lack in transparency, differences in perception, differences in decision behaviour, differences in tracking and tracing requirements as well as difficulties in system's implementation, different interests and complexity of the decision scenario (Fritz & Schiefer, 2009).

Since the importance of tracking and tracing system is considered crucial for enterprises and essential for managing logistics supply networks efficiently (Shamsuzzoha & Helo, 2011), tracking and tracing concepts are at the core of any managerial improvements in the food value chain (Fritz & Schiefer, 2009). Information shared between the companies in the supply chain can decrease potential food fraud as the food units are monitored and traced for suspicious transaction (Manning & Soon, 2014). However, most of the existing tracking and tracing systems are not really comprehensive since they focus only on the enterprise internal activities and therefore there is a lack of tracking and tracing for multi-organization environments (Shamsuzzoha & Helo, 2011).

Next to traceability system, in more recent years, mass balance traceability checks have been introduced. Mass balance checks are considered critical (for instance in cases of product withdrawal, recalls or in determining volumes of product sold between enterprises as they were originally being made available) because they determine the extent and ability of a company to identify and locate the resource units along the supply chain (Manning & Soon, 2014). Moreover, it has been highlighted the importance of routine mass balance checks in food adulteration controls (Manning & Soon, 2014).

Therefore, it can be assumed that degree of tracking and tracing system and mass balance control are crucial control measures in the process of mitigation fraudulent incidents. Low adequacy of these systems may represent a potential vulnerability to fraud in dairy supply chains.

2.4.3.3 Contingency plan

Contingency plan, which is plan devised for dealing with an emergency, may also play an important role in reducing fraud and protect businesses from threats. Contingency plans should focus on developing effective policies and procedures as well as implementing fraud education among employees to avoid fraudulent activities. Risk is unavoidable, but contingency plans are formulated to ensure that incidents are escalated and investigated in a consistent and uniform manner across an organisation (Iyer & Samociuk, 2006).
Therefore, it can be assumed that contingency plan is a crucial control measure in the process of mitigation fraudulent incidents. Otherwise, low adequacy of this system may represent a potential vulnerability to fraud in dairy supply chains.

MANAGERIAL CONTROL MEASURES

2.4.3.4 Support whistle blowing process

One possible method that is used to limit illegal, immoral or illegitimate practises is to encourage employees to monitor and report malpractices through for instance whistle blowing process (Reckers-Sauciuc & Lowe, 2010). Whistle blowing process is crucial in reporting unlawful activities within a company and helps to examine the occurrence of fraudulent phenomena (Caillier, 2016). The system can be very helpful in the process of preventing fraudulent activities within an organization since it will therefore be very tricky to know and estimate the number of illegal activities (Reckers-Sauciuc & Lowe, 2010). However even if the positive influence of whistle blowing process, it has been seen that the system is not fully adopted and applied since many, if not most, employees are reticent when it is time to report unethical conduct due to fear, improper tone at the top, affective disposition (Reckers-Sauciuc & Lowe, 2010). There are many other factors which play a role in the adoption and use by employees of whistle blowing process such as employees' education, severity of wrongdoing, frequency of occurrence, supportive culture (Miceli et al., 2008), which can influence the likelihood that employees report wrongdoing (Caillier, 2016). Therefore, encourage employees to serve as monitor in reporting unethical conduct can have positive influence on the companies' welfare and also in the process of avoiding possible ongoing corporate scandals (Reckers-Sauciuc & Lowe, 2010; Mayer et al., 2013).
Therefore, it can be assumed that whistle blowing process is a crucial control measures in the process of mitigation fraudulent incidents. Low adequacy of this process may represent a potential vulnerability to fraud in dairy supply chains.

2.4.3.5 Strictness ethical code of conduct

Ethical code of conduct is also a key control measure both in deterring potential fraudsters and also in maximising the commitment of staff to combat fraud. Since many times frauds occur close to people who are generally unaware of it, it is indeed important to raise awareness through formal education and training programme as part of the overall risk management. Comprehensive ethics programs are associate with important outcomes such as the increase in reporting of misconduct (Trevino et al., 2014). All employees should be aware of what constitutes fraud, how to identify fraudulent behaviour, and how to respond if they suspect or detect instances of fraud (CIMA, 2008). However, sometimes employees can perceive ethical codes as a negative sign that they only represent window dressing, thus producing a cynical response that leads to more unethical behaviour (Trevino et al., 2014). Therefore, organizations need to attentively develop appropriate codes and ensure that all staff routinely declare adherence to them (Trevino et al., 2014).
Therefore, it can be assumed that ethical code of conduct is a crucial control measure in the process of mitigation fraudulent incidents. Low adequacy of this process may represent a potential vulnerability to fraud in dairy supply chains.

2.4.3.6 Application of integrity screening

There is a strong incentive for businesses to use pre-employment integrity screenings since when effective, they could be **beneficial tools for companies and reduce the proportion of new employees who are likely to commit fraudulent activities** within the workplace. Moreover, integrity tests may also go beyond the employer's desire for productive and honest workers, but also help to protect themselves from a variety of legal actions (United States Congress, 1990).

Therefore, it can be assumed that integrity screening is a crucial control measures in the process of mitigation fraudulent incidents. Low adequacy of this system may represent a potential vulnerability to fraud in dairy supply chains.

2.4.3.7 Adequacy of suppliers' contractual requirements

In order to develop a strong buyer-seller relationship, the food safety management of supplier's products need to be fulfilled (Pourkomailian, 2014). The identification of a quality supplier who can provide the desired ingredients is not an easy task. Management of suppliers and ingredients are regulated by different guidelines, such as GMP (Good manufacturing practices), GFSI, GHP (Good Hygienic Practice) and HACCP which help companies to assess suppliers' performances and establish high quality standards. Managing suppliers and raw materials with respect to food safety and quality consists of verifying adherence to standards such as GMP, HACCP and crisis management, which slight variate in focus depending on the position of the supplier in the chain. The first step in the management of suppliers and raw materials is the supplier identification based on the ability to supply desired raw materials and on the reputability. It follows the supplier selection based on a list of attributes which need to be fulfilled by the identified supplier such as: assured supply, assured quality products, appropriate qualified personnel, prerequisites programs and HACCP. Beginning the partnership requires building trust and it is at this point that verification of the food safety system is necessary to move the supplier into the approved phase. This phase is of vital importance for the vendor, as it provides information on the customer's expectations. By knowing the expectations, the vendor can more effectively and efficiently meet the customer's needs. The requirements within the expectations will come in the form of internal process assessment through their quality (including food safety) management system (Pourkomailian, 2014).

Therefore, it can be assumed that suppliers' contractual requirements are a crucial control measures in the process of mitigation fraudulent incidents. Low adequacy of this process may represent a potential vulnerability to fraud in dairy supply chains.

2.4.3.8 Established guidance for fraud prevention across supply chain and law enforcement

The United States Pharmacopeial Convention (2015) has provided Food Fraud Mitigation Guidance which helps companies in developing and implementing a preventive management system against food fraud. It consists of a qualitative, step-wise approach divided in 4 phases which aims at characterized the overall fraud vulnerabilities of ingredients by assessing the factors contributing to fraud occurrence and provides guidelines on how to use the outcome for developing a mitigation strategy. This Guidance is intended to be generally applicable to any food ingredient and to any user responsible for ensuring the safety and integrity of food ingredients.

Moreover, On December 22, 2016, FSSC 22000 released the new "Food Safety System Certification 22000" Version 4, which is based on the ISO 22000 Food Safety Management standard. The standard (which will enter in force in 2018) will require a separate (1) Food Fraud Vulnerability Assessment and (2) Prevention Strategy for all types of fraud, all products, and across the food supply chain, from raw materials to finished goods supplied to end users (Spink, 2016).

In addition, the Guidance note on "Fraud Risk Assessment and effective and proportionate antifraud-measures" provides assistance to managing authorities (MA) on how to adopt a proactive, structured and targeted approach to managing the risk of fraud. According to Article 59 (2) of the Financial Regulation,

Member States shall take all necessary measures, including legislative, regulatory and administrative measures, to protect the Union's financial interests, namely by preventing, detecting and correcting irregularities and fraud.
Therefore, in order to assess and prevent the impact and likelihood of common fraud risks occurring, the Commission has developed the fraud-risk assessment tool which needs to be used together with the guidance that indicates the recommend mitigation controls.
Therefore, it can be assumed that established guidance for food prevention and law enforcement are crucial control measures in the process of mitigation fraudulent incidents. Low adequacy of these factors may represent a potential vulnerability to fraud in dairy supply chains.

2.5 Risk factors which may not affect potential fraud vulnerabilities in dairy supply chains

The previous sections explain which risk factors of the SSAFE vulnerability tool may have an influence on potential vulnerabilities to fraud in dairy supply chains. However, after in-depth literature review, some factors of the SSAFE vulnerabilities tool have been identified and considered not to have a great impact on potential vulnerabilities in dairy supply chains. In order to assure the transparency of the research, this section contains a short analysis of these factors.

2.5.1 Opportunities-related risk factors

2.5.1.1 Accessibility to materials in production/processing lines

Within the category of opportunities of the SSAFE vulnerability tool, this is the only factor not included as risk factor in dairy supply chains. The main processing activities for milk production in dairy companies include filtration/clarification of the raw milk, pasteurisation; packaging and storage. All the activities are usually performed with automated and efficient equipment, which minimize the contact between workers and product (COWI Consulting Engineers et al., 2000). Moreover, companies have usually in place food security programmes to identify and control the movement of all persons on site with limit access to those who have a legitimate reason to be there (Coombs, 2008; Fortin, 2016). Dairy processing is continuously improving. Processes have become significantly more efficient and the use of electronic monitoring, control, and regulation systems has improved processing effectiveness (COWI Consulting Engineers et al., 2000).
Therefore, it can be assumed that accessibility to materials in production/processing lines may <u>not</u> represent a potential vulnerability to fraud in dairy supply chains.

2.5.2 Motivations-related risk factors

2.5.2.1 Price asymmetries in countries

The milk prices between western European countries differ slightly, as reported in the European farm gate milk prices published on the 9th of January 2017, which indicates an average milk price stood at €31.63/100kg for the month of November in 2016. Looking at the Dutch and Irish milk prices, the average was €33/100kg and €32.83/100kg respectively.
Therefore, it can be assumed that price asymmetries in countries may <u>not</u> represent a potential vulnerability to fraud in dairy supply chains.

2.5.2.2 Victimisation

Victimisation is considered as factor which may <u>not</u> represent a potential vulnerability to fraud in dairy supply chains, since no literature about previous irregularities across well-established dairy supply chains is found.

2.6 Hypothesis

All the risk factors summarized in the literature analysis in section 2.4 could lead to potential fraud vulnerabilities in dairy supply chains.

2.7 Research framework

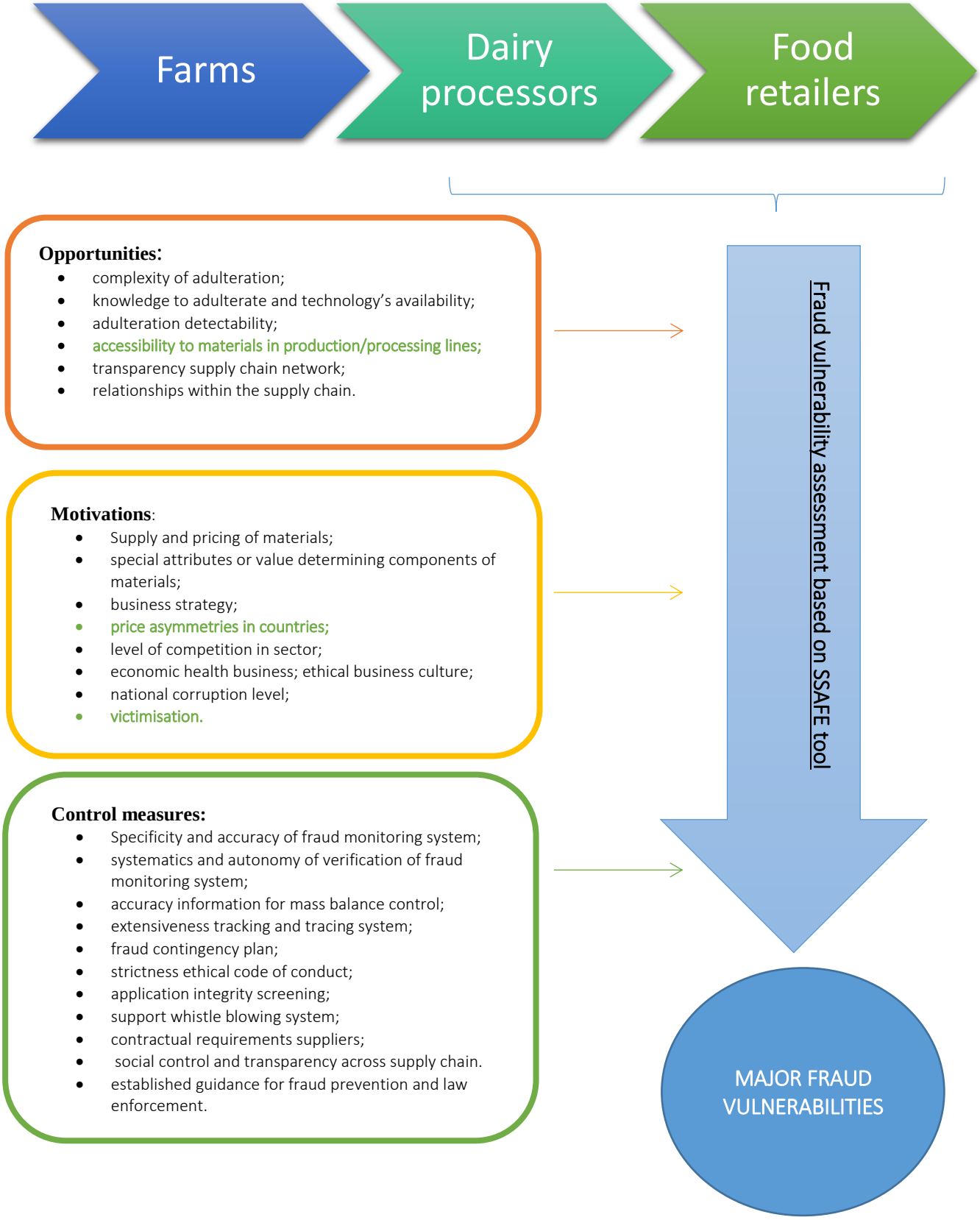


Figure 3. Research framework. Risk factors influencing fraud vulnerabilities in dairy supply chains.

The research framework of the research project is shown in figure 3. The research framework displays the overview of the literature analysis on potential vulnerabilities in well-established dairy supply chains. The three big boxes on the left side give the overview of the risk factors within the categories of opportunities and motivation as well as the control measures which, when combined, determine the fraud vulnerabilities in dairy supply chains. As a result of the literature analysis, the risk factors which may represent a potential vulnerability to fraud in dairy supply chains are indicated in black. While the risk factors in green colour are considered to have less impact on potential vulnerabilities in dairy supply chains. In the framework, the entire set of risk factors that the SSAFE vulnerability will assess among dairy processors and food retailers is displayed. The actors of the dairy supply chain, involved in the literature analysis, are displayed in the boxes of the upper row of the framework. The arrow indicates that the SSAFE vulnerability tool will be used for the assessment of major vulnerabilities among dairy processors and food retailers. The circle on the bottom right shows the outcome of the framework which consists in the assessment of major food fraud vulnerabilities among dairy processors and food retailers.

CHAPTER 3: RESEARCH METHODOLOGY

After in-depth literature analysis to determine which are the potential vulnerabilities in dairy supply chains, the assessment of SSAFE vulnerability tool on dairy processors and food retailers is performed in order to get insight in the major fraud vulnerabilities. The chapter explains and describes in details the methodology of the research study. The steps of the case study consist in: (1) selection and recruitment of the respondents, (2) data collection through interviews, after the adjustments of both questionnaires for dairy processors and food retailers, (3) data analysis through the use of different techniques and (4) data interpretation.

3.1 Research methodology and general study design

For the present research, the case study approach is used as method for the data collection. The research is a case study among dairy processing and food retailer companies in the Netherlands and in Ireland, consisting of interviews to Quality Assurance Managers. The case study method was selected because it enables the researcher to closely examine the data within a specific context, such as for instance a small geographical area or a very limited number of individuals (Zainal, 2007). It is considered a robust method particularly when a holistic, in-depth investigation is required (Zainal, 2007). According to Yin (1994), the main steps of a case study are: determine and define the research questions, select the cases and determine data gathering and analysis techniques, collect the data, evaluate and analyse the data, describe and discuss the results.

3.2 Selection and recruitment of the respondents

The first step of the process of selection and recruitment of the respondents was to identify and approach the target group. By surfing on internet, a list of all the dairy processors and the biggest food retailers' companies was obtained. As second step, all the companies, more than 20, were approached via e-mail. In the e-mail with the request, a brief introduction about the objective of the research project and the structure of the SSAFE vulnerability tool was given to the respondent. The final step, in case of positive answer, was to arrange the interviews with the companies which have shown willingness to participate in the research project.

In table 2, the main features of companies and respondents are displayed.

Table 2. Respondents' and companies' features

COMPANY	COMPANY'S INFORMATION	RESPONDENT'S INFORMATION
Processor 1	Number of employees: 100 Production of liquid milk per yr: 180 million liters Location: the Netherlands Type of products: conventional milk, pastured milk	Quality Assurance Manager; 37 years in the business
Processor 2	Number of employees: +/- 350 Production of liquid milk per yr: +/- 350 million Location: the Netherlands Type of products: fresh dairy products	Quality Assurance Manager; 15 years in the business
Processor 3	Number of employees: 120 Production of liquid milk per yr: 250 millions Location: Ireland Type of products: conventional milk	Quality Assurance Manager; 21 years in the business
Processor 4	Number of employees: 110 Production of liquid milk per yr: 100.000 tons	Quality Assurance Manager; 2 years in the business

	Location: the Netherlands Type of products: cheese, made from liquid cow's milk	
Retailer 1	Number of employees: 1800 Location: the Netherlands Type of products: Conventional milk, organic milk, private label	Quality Assurance Manager; 8 years in the business
Retailer 2	Number of employees: more than 100 Location: the Netherlands Type of products: conventional milk	Quality Assurance Manager And Sustainability Manager; 2 years and 6 years in the business respectively
Retailer 3	Number of employees: 60000 Location: the Netherlands Type of products: conventional and organic milk	Quality Assurance Manager; 4 years in the business
Retailer 4	Number of employees: 100000 Location: the Netherlands Type of products: conventional and organic milk	Quality Assurance Manager; 15 years in the business
Retailer 5	Number of employees: Location: Ireland Type of products: conventional and organic milk	Quality Assurance Manager 9 years in the business

3.3 SSAFE vulnerability tool

3.3.1 Principle of the tool

The SSAFE vulnerability tool has been used to perform the interviews. As described previously in Chapter 2, the tool is a questionnaire divided in three sections, namely opportunities, motivations and control measures. The design of the questionnaire, consisting of closed-ended questions, allows the respondent to choose only one answer (for each question) and it classifies them into levels of risk: low (score 1), medium (score 2) and high (score 3). For the control measure, the answers are classified into levels of adequacy: low level of adequacy (score 1), medium level of adequacy (score 2), high level of adequacy (score 3). Figure 4 shows the core concept of the SSAFE vulnerability tool. It describes that the actual fraud vulnerability is the result of the combination of opportunities and motivations which are defined as potential fraud risk factors. The potential risk resulting from these two elements can be mitigated by the third element: the control measures in place in the company (WUR-VU, 2015).

Figure 4. Principle of the SSAFE vulnerability tool

3.3.2 Adjustments of SSAFE vulnerability tool for dairy processors and food retailers

Since this tool can be applied to any food supply chain, some questions and answers were adapted by the PhD candidate involved in the project in order to make them applicable for the dairy case study and for the actors involved in the present research. The original SSAFE tool contains 50 questions, while in the questionnaires developed for dairy processors and food retailers some questions were deleted.

The questionnaire for dairy processors consisted of 48 questions: 9 questions within the opportunities' section, 20 questions within the motivations' section and 19 questions within the control measures' section. In comparison to the original SSAFE vulnerability tool, two questions were deleted: one question related to counterfeit since it is not part of this research and another one related to fraud history, which was overlapping with another similar question.

The questionnaire for food retailers consisted of 42 questions: 6 questions within the opportunities' section, 19 questions within the motivations' section and 17 questions within the control measures' section.
Some further adjustments were made in the questionnaire for food retailers. The questions related to counterfeit and fraud history were deleted, as in the questionnaire addressed for dairy processors. In addition, six more questions were considered not applicable and therefore not mentioned in the interviews: three questions related to final products and processing activities were deleted within the category of opportunity (indicators 4, 5 and 6), one question related to costumers was deleted within the category of motivations (indicator 25), two questions related to final product monitoring control system and verification were deleted within the category of control measures (indicators 32 and 33).
The indicators in both questionnaires had the same numbers in order to facilitate the process of analysis of the results and keep high degree of alignment of answers. The overview of all the indicators of SSAFE vulnerability tool and related number is displayed in table 3.

Table 3. Overview of the indicators in the SSAFE vulnerability tool

OPPORTUNITIES	MOTIVATIONS	CONTROL MEASURES
1. Complexity of adulteration 2. Availability technology and knowledge of adulteration 3. Adulteration's detectability (detection methods) 4. Availability technology and knowledge of adulteration final product (only processor 5. Knowledge required for detection final product 6. Accessibility to production/processing lines 7. Transparency of chain network 8. Relationship within the supply chain 9. Historical evidence of milk fraud	10. Supply and price of milk 11. Valuable components and attributes 12. Economic health 13. Business strategy 14. Ethical business culture 15. Previous irregularities 16. Corruption level 17. Financial pressure imposed by your company on supplier(s) 18. Supplier economic health 19. Supplier business strategy 20. Supplier ethical business culture 21. Supplier previous irregularities 22. Victimization of supplier 23. Supplier and customer's corruption level 24. Sector economic health 25. Costumer previous irregularities 26. Sector ethical business culture 27. Historical evidence of milk fraud, within sector 28. Level of competition in sector 29. Price asymmetries	30. Fraud monitoring system in place raw material 31. Systematics and autonomy of verification of fraud monitoring system raw material 32. Final product monitoring control system 33. Final product control system verification 34. Information system for mass balance control 35. Tracing and tracking system 36. Integrity screening of employees 37. Ethical code of conduct 38. Whistle blowing 39. Contractual requirement with suppliers 40. Supplier fraud control system 41. Supplier information system for mass balance control 42. Supplier tracing and tracking system 43. Social control and transparency chain network 44. Guidance for fraud prevention and control 45. National food policy 46. Law enforcement local chain 47. Law enforcement international chain 48. Contingency plan

An example of questions and answers according to the three levels of risk, for each category in the SSAFE vulnerability tool, for both dairy processors and food retailers is shown below in table 4 and 5.

Table 4. Example of questions (questionnaire for dairy processors)

	Indicator	Question	Low level	Medium level	High level
Opportunities	1.complexity of adulteration	Do you think it is easy or complex to add or remove something to/from liquid milk?	Composition of the liquid milk cannot be modified and milk products can only be replaced	Composition of the liquid milk can be modified by mixing with low-quality product-own material or foreign material, e.g. add reconstituted powder, melamine, sell conventional milk as organic, etc.	Composition of the liquid milk can be modified by mixing with low-quality or foreign material (e.g. powders, etc.) and by altering valuable food components (e.g. protein and/or fat content
Motivations	18.supplier economic health	How would you describe the economic health of your supplier?	The supplier(s) is profitable and achieving its financial targets	The supplier(s) profits are declining, and there is a gap between their financial targets and actual performance	There are financial losses and it has difficulty to meet financial targets
Control Measures	38.whistle blowing	Is there a whistle blowing system (system for reporting assumed fraudulent activities) in place in your company?	No whistle blowing system exists	Whistle blowing system is available, but no clear protection system for the whistle blower is in place, and reporting of fraudulent activity goes to supervisor (no independent officer)	Whistle blowing system is well-established and well-known among personnel, fraudulent practices can be reported to an independent officer, and anonymity of the whistle blower is strictly protected

Table 5. Example of questions (questionnaire for food retailers)

	Indicator	Question	Low level	Medium level	High level
Opportunities	1.complexity of adulteration	Do you think it is easy or complex to add or remove something to/from liquid milk?	Composition of the liquid milk cannot be modified and milk products can only be replaced	Composition of the liquid milk can be modified by mixing with low-quality product-own material or foreign material, e.g. add reconstituted powder, melamine, sell conventional milk as organic, etc.	Composition of the liquid milk can be modified by mixing with low-quality or foreign material (e.g. powders, etc.) and by altering valuable food components (e.g. protein and/or fat content
Motivations	24.sector economic health	How would you describe the economic health across your sector of the food supply chain (i.e. your company and your direct competitors)?	The company operates in a growing market(s)	The company operates in a stable or fluctuant market	The company operates in a declining market(s)
Control Measures	36.integrity screening of employees	Is integrity screening of employees common procedure in your company?	No integrity screening of employees	Use of established integrity screening methods for employees at key positions	Use of established integrity screening methods is standard for employment of all personnel

3.4 Data collection: interviews

In this stage, the companies which have shown willingness to participate in the research project were interviewed. In total four dairy processing companies and five food retailers were retrieved. The types of interviews included face to face interviews, e-mail and telephone interviews, depending on availability of time of the respondents and distance (in the case of Irish companies). Quality assurance managers were selected as respondents for the interviews. For all the interviews, the same approach was adopted: in the first phase of the interview, general information about respondent and company's characteristics was gathered; in the second phase, the questions in the SSAFE vulnerability tool were asked to the interviewer, who had the possibility to choose one between three possible answers. In case of not insight or answers were not given, the researcher was allowed to set the answer on level 2 (medium level of risk). During the interviews, the respondents were also allowed to provide qualitative information besides to the given answers. In order to avoid bias, the interviews were performed in the same manner and the questions were asked in the same way.
The interviews were carried out among Dutch and Irish respondents. They were lasting approximately 90 minutes and were recorded after permission of the interviewees.

3.5 Data analysis and interpretation

In the process of analysis of the outcomes of the SSAFE vulnerability tool, three techniques were used, namely radar chart, measures of averages scores and Multiple Correspondence Analysis (MCA).

3.5.1 Radar chart analysis

Firstly, the outcomes of the SSAFE vulnerability tool were analysed through the use of radar chart, which is a useful graphical method to display multivariate observations with an extensive number of variables.
The radar chart consists of a sequence of equiangular spokes which represent the indicators. The radar charts were created dividing the indicators by category of opportunities, motivations and control measures, as indicated in the SSAFE vulnerability tool. Therefore, three radar charts for each group of respondents (dairy processors and food retailers) were generated.
Due to the small sample's size (4 dairy processors and 5 food retailers), it has been decided to display all the companies' risk profiles in order to get better understanding of the companies' trends, make comparisons and identify the most vulnerable risk factors for each category.
For the interpretation of the radar charts: the numbers at the end of the spokes represent the numbers of the indicators, while the degree of opportunities, motivations and control measures is determined by the scale from 1 to 3, which classifies each indicator in the SSAFE tool as low, medium or high.
Within the category of opportunities and motivations, larger areas are associated with high potential fraud risks. An opposite interpretation is performed when comparing control measures' performances, since larger areas are associated with a more adequate control system in the company.
Moreover, the score 0 was assigned to all the questions which were not applicable for food retailers. These questions were excluded from the analysis.

3.5.2 Measures of average scores

The second method to analyse the outcomes obtained with SSAFE vulnerability tool was the use of average scores of answers in order to highlight similarities and differences between groups of respondents and consequently extract more in-depth information. SSAFE tool is based on categorical answering scale 1, 2 and 3, but for the present analysis, averages scores of the answer options for each category (opportunities,

motivations and control measures) of the SSAFE vulnerability tool were calculated. Moreover, within each category, the indicators were in turn further categorized, as indicated in figure 5. The indicators were analysed in groups to judge the situations at specific context level. Averages scores of the answer options for each sub-category were calculated. The table below shows the labels assigned to specific groupings of indicators.

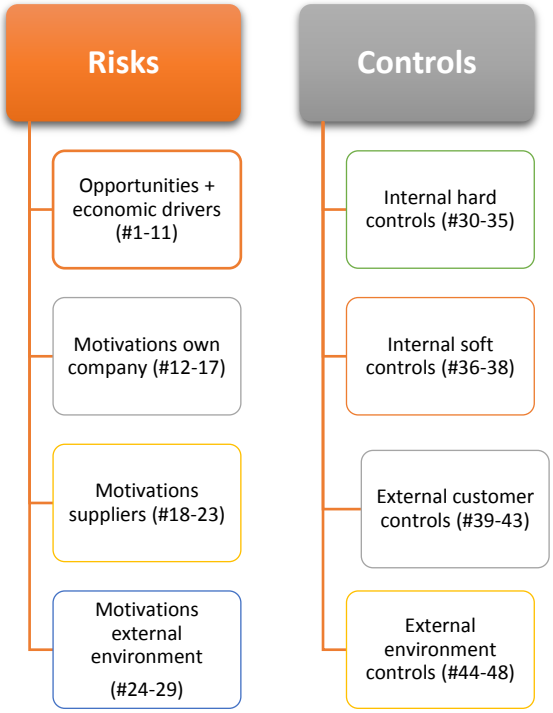


Figure 5. Division of indicators in sub-categories with including indicator numbers

For the interpretation of the table in Chapter 4, different labels were also assigned to the average score of the answers. The labels consist in: low (1 – 1.3), low-to-medium (1.4 – 1.6), medium (1.7 – 2.3), medium-to-high (2.4 – 2.6) or high (2.7 – 3). High scores for opportunities and motivations are related to high risks; while high scores for control measures are related to low risks.
All the questions which were not applicable for food retailers were excluded from the analysis.

3.5.3 Multiple Correspondence Analysis (MCA)

This third analysis of the outcomes of the SSAFE vulnerability tool was performed by using the function Multiple Correspondence Analysis (MCA) of the statistical software XLSTAT. The MCA is used to investigate the associations between categories of multiple qualitative variable and to identify the most correlated variables with a given dimension (Abdi & Valentin, 2007). In the present research the variables were represented by the indicators of the SSAFE vulnerability tool. The data were displayed through the use of symmetric plots: a plot showing only the categories of the variables (indicators and related level of risk) and a plot showing only the observations (nine companies) were generated. The data are represented as points in 2-dimensional space. The percentage of adjusted inertia that corresponds to each axis and the percentage of adjusted inertia cumulated over the two axes are displayed on the map as well. The plots help to identify variables that are the most correlated with each dimension. The squared correlations between variables and the dimensions are used as coordinates. All the questions which were not applicable for food retailers were excluded from the analysis.

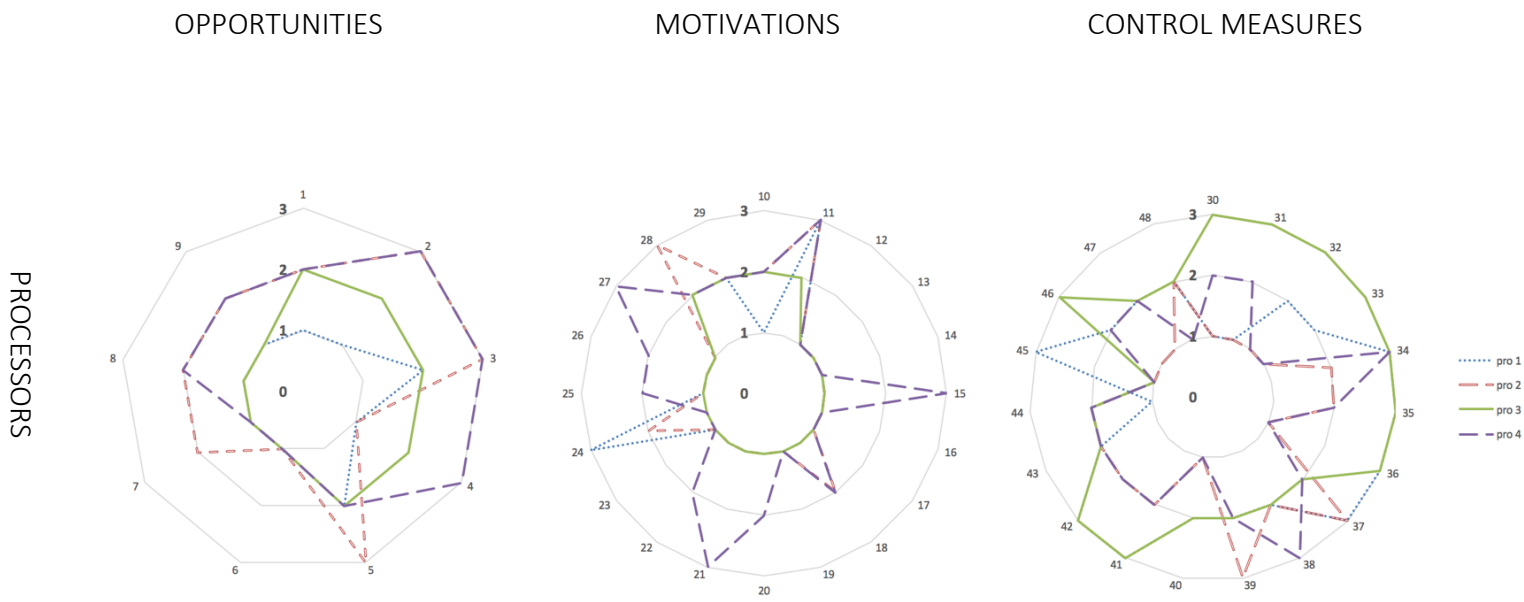
3.6 Interviews' transcription

All the face-to-face interviews were recorded with the consensus of the respondents. The qualitative data which refers to comments and personal opinions were transcribed in the table present in the Appendix 5 and 6. The table in Appendix 5 contains the answers given by dairy processors, while the table in Appendix 6 contains the answers given by food retailers. The tables display the indicators of the SSAFE vulnerability tool divided by category in column 1. The levels of risk/adequacy are displayed in column 2 (low) ,3 (medium) and 4 (high) with the number respondents who gave the answer for each level of risk, and column 5 shows the comments of the interviewees. These data are used to further analyse and interpret the outcomes of the SSAFE vulnerability tool.

In the present chapter, the outcomes obtained from the SSAFE vulnerability tool are displayed and discussed through the use of three methods: radar charts, the measures of averages and the MCA analysis.
The first section of this chapter contains radar charts, which help to display and identify which are the major risk factors inherent opportunities, motivations and control measures in well-established dairy supply chains that lead to potential vulnerabilities perceived by the two groups of respondents, namely dairy processors and food retailers. In the second section, the measure of averages by groups is shown in order to highlight possible similarities and differences between the two main groups, namely dairy processors and food retailers, but also between conventional dairy processors and organic dairy processor. Lastly, Multiple Correspondence Analysis is discussed to search for patterns of relationship among risk factors and between groups of respondents. This chapter aims at answering the second and the third specific research questions.

4.1 Radar chart analysis

For the analysis of the outcomes obtained during the interviews, radar charts were created for both dairy processors and food retailers. The overall fraud vulnerability profiles of dairy processors and food retailers are displayed in figure 6, classified by category of opportunities, motivations and control measures. This analysis aims at answering specific research question 2: "Which are the major vulnerabilities inherent opportunities, motivations and control measures based on the assessment of SSAFE vulnerability tool among dairy processors and food retailers?"



RETAILERS

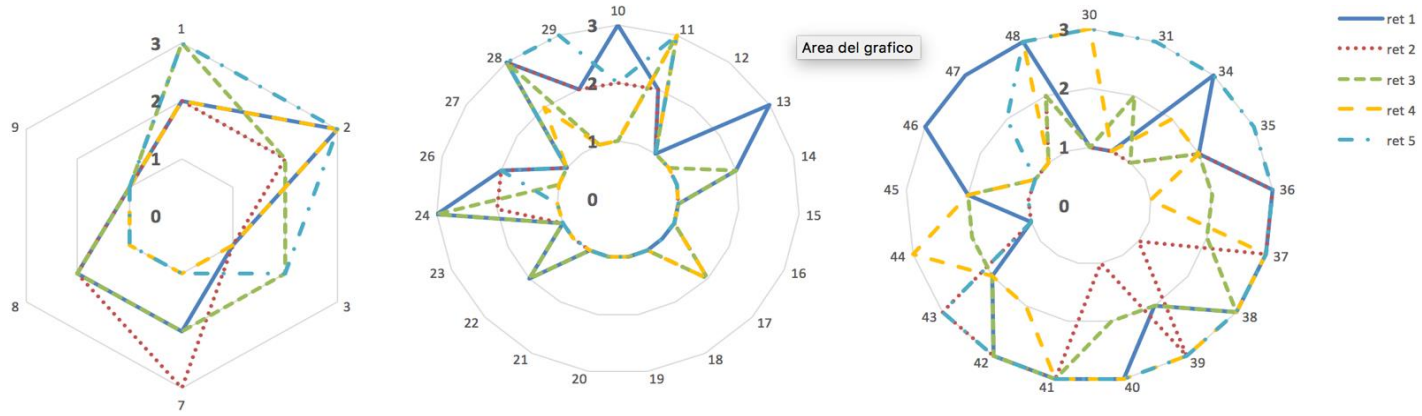


Figure 6. Radar charts divided by category of opportunities, motivations and control measures of dairy processors (upper row) and food retailers (lower row).

4.1.1 Outcomes of applying SSAFE vulnerability tool in dairy processors' companies

Opportunities

The radar chart related to opportunities for dairy processors in well-established supply chains is displayed on up-left side of figure 6. No specific trend can be identified for the Irish conventional dairy processor (pro 3), which scores similarly to the Dutch counterpart.

The radar chart displays that companies are associated with overall medium scores for this category. Major vulnerabilities are related to indicator 2, 3, 4 and 5, which are perceived as high risk from at least one of the four companies. Indicator 2 is related to availability of technology for adulteration. Respondents, during the interviews, indicated that simple methods and basic technologies are needed to adulterate liquid milk. As explained in Chapter 2, there is a wide variety of preservatives, adulterants and cheaper ingredients (Singh & Gandhi,2015; Kumar et al.,2010) that can be added to milk in order to modify its composition without the need of advanced technologies, facilities and methods.

Indicators regarding adulteration's detectability (3) and knowledge required for detection of the final product (5) are judged as medium-to-high risk by all the respondents who believe that the detection of adulteration required advanced laboratory analysis. This is in line with the literature analysis which indicates that the procedure for products' authentication is a technically challenge aspect of food prevention and security since the complexity of ingredient may interfere with the process of authentication (Moyer et al., 2017). In addition, detection is complex also because as soon as scientists are developing and improving detection methods for substances in milk (Singh & Gandhi, 2015; Food Chemical Codex, 2014), unscrupulous producers introduce new alternatives that cannot be detected by established techniques (Finete et al., 2013; Singh & Gandhi, 2015).

What is quite different from the literature analysis is availability of technology and knowledge of adulteration of the final product (4). From the literature, information about possible methods to adulterate products and how to perform them is generally available, however from the radar chart it seems that only one company is aware of this, while the rest of them are partially or totally unaware of technologies and methods for adulterating milk. According to the interviews, it is believed that information cannot be easily retrieved.

Medium-to-low scores are associated to transparency of the chain network (7) and relationship with supplier (8), as indication that information exchange is quite integrated and business relationship are characterized by trust. Companies indicated that their suppliers and customers are economically healthy, as shown also by the indicator regarding economic health of own company and suppliers/customers in the radar chart displaying the motivations' profiles. Therefore, it is assumed that this can have a positive influence on the

comprehensive exchange of information along the supply chain and on the long- term business relationship's strategy.

Motivations

The radar chart related to motivations for dairy processors in well-established supply chains is displayed in the middle of the upper row of figure 6.
Within the category of motivations, processors 1, 2 and 3 score in a very similar way with a general low-to-medium risk profile, while some differences can be pointed out regarding the dairy processor 4. Among the processors, the Irish conventional dairy processor (pro 3) has the lower fraud risk profile for this category, even though no big differences with the Dutch counterpart can be highlighted. The areas in the spider plot are overall small.
Major vulnerabilities to fraud are related to indicator 11, 15, 21, 24, 27 and 28, which are perceived as high level of risk from at least one of the four companies.
The indicator "valuable components of the milk" (11) is perceived as high level of risk for vulnerabilities by most of the companies (pro 1,2,4), while processor 3 indicates it as medium level of risk. As identified in literature (Chapter 2), the introduction of milk pricing on a component basis represents a vulnerability, since fraudsters have tendency to operate where there are more possibilities of economic gain (Capuano et al., 2014).
Another relevant indicator is "sector economic health" (24), which has obtained very dissimilar perceptions. The Dutch dairy processors gave three different answers. The tendency is that Dutch processors are nowadays facing more issues compared to the past and are active in a declining market. This may be related with new policies introduced at European level, high price volatility in the last years and the new regulations which have led to increased pressure and more financial implications on the economic performance of dairy companies (Soboh et al., 2011). Moreover, level of competition in the sector (indicator 28) is also perceived as medium-to-high risk. Respondents indicates that companies are competitive against each-other's and are seeking for more market share and better prices for their products. In addition, new emerging markets, such as in New Zealand, are becoming more powerful and competitive since the lowest prices of their products, leading to drawbacks in European dairy markets.
The other indicators are perceived as medium-to-low risk by the four companies; only some differences are shown related to dairy processor 4, which scores a bit differently in indicators 15, 21 and 27, pointing out that itself, its suppliers and the dairy processing sector have been involved in irregularities and fraudulent activities previously. This may be due to the fact that processor 4 is getting milk from a large variety of suppliers as well as other dairy processors. The length of the supply chain may have increased the possibilities of fraudulent incidents.

Control measures

The radar chart related to control measures of dairy processors in well-established supply chains is displayed on up-right side of figure 6. The profiles of control measures show the situations of current control measures adopted by the different companies. Within this category, it can be seen that companies score very differently and no special trend is shown. Every company has strengths and weaknesses that need to be improved. However, among the processors, the Irish conventional dairy processor (pro 3) scores medium-to-high for the majority of indicators, showing that the Irish company is performing very well in its control measure system. Dutch dairy processors are performing good as well, with an overall medium risk profile.
Major vulnerabilities are related to indicators 44, 47 and 48, which are associated with low scores as indication of weaknesses in enforcement and controls from a law perspective. The profiles show that law enforcement is perceived as limited: the interviewees were not fully aware of the extent of legislation on fraud prevention. As describe previously in Chapter 2, in Europe, specific regulations to counter food fraud are still not present since the current EU legislative framework is mostly focused on food safety (FDA, 2014).

Regarding the indicator "social control and transparency of chain network" (44), companies think that communication across the supply chain is not systematic and well integrated and unethical behaviours are generally not reported. This is a bit in contradiction with indicator 7 about transparency of chain network in the category of opportunities, indicating that respondents have opposite feelings regarding the relations with other players in the dairy supply chain.

4.1.2 Outcomes of applying SSAFE vulnerability tool in food retailers

Opportunities

The radar chart related to opportunities for food retailers in well-established supply chains is displayed in the left side of lower row of figure 6. No specific trend can be identified for the Irish food retailer (ret 5), which scores similarly to the Dutch counterpart.
Major vulnerabilities are related to indicators 1, 2 and 7, which are perceived as high risk from at least one of the five companies. More specifically, indicator 1 and 2, related to complexity of adulteration and availability of technology of adulteration respectively, are perceived medium-to high risk by all the companies, which believe that milk composition can be easily modified by adding substances and basic technologies are available to perform adulteration on milk. Retailers' perception is in line with what found in the literature (Chapter 2), which describes the presence of a large variety of adulterants and preservatives (Singh & Gandhi,2015) and many methods that can be applied for the adulteration of milk.
Indicator 7 about transparency of chain network shows different perceptions. The majority of the companies indicate that information is partially dispersed or no information exchange occurs between suppliers and customers with the result in lack of transparency of the supply chain. This can be due to the fact that retailers are the last actors of the dairy supply chain and in comparison, to dairy processors, have less comprehensive information about the players at the front of the chain (farmers).
Lastly, indicator 9 regarding the historical evidences of milk fraud is indicated as low level by all respondents, showing that not milk incidents are reported among food retailers.

Motivations

The radar chart related to motivations for food retailers in well-established supply chains is displayed in the middle of lower row of figure 6. No specific trend can be identified for the Irish food retailer (ret 5), which scores similarly to the Dutch counterpart.
Within the category of motivations, the major vulnerabilities are related to indicators 10, 11, 13, 24, 28 and 29, which are perceived as high risk from at least one company. This set of indicators is interconnected since they all refer to motivations for adulteration lead by economic purposes. Respondents have different opinions regarding supply and milk prices and sector economic health in general. As a result, a large variety of answers, which touch every level of risk were given by the respondents. Indicator 24 is among the others, very explicative since when it was asked to respondents to describe the economic health across their sector of dairy supply chain, the answers were that companies operates in growing, fluctuant and declining market. This indicates that the health situation of the dairy supply chain is quite unclear and the indicator can be therefore taken as starting point to explain the others.
Indicator 10, related to supply and price of milk, shows that some respondents deem that prices of liquid milk are generally stable, while others believe that price spikes are quite common. This outcome is probably due to large variety of liquid milk sold in retailing shops and due to the fact the supply chains of the five food retailers are very various, with suppliers involved from different countries. As explain in Chapter 2, price volatility is determined by a complex set of factors, such as weather patterns, seasonality, geographic region, farm management practices. Moreover, differences in regulations among countries may also interfere in the stability of milk prices. Indicator 29 related to price asymmetries shows a large variety in answers, indicating that some respondents deem that price policy of liquid milk varies across countries. In addition, level of competition in retail sector (indicator 28) is regarded to be high.

Indicator 11 is judged as medium-to high level of risk by all the companies, indicating that respondents consider that the value of milk is determined by special attributes. Indicator 13, which was used to assess business strategy, is judged low level of risk by all the companies, with the exception of one food retailer (ret 1) which indicates it as high level of risk.
Lastly, the other indicators are perceived as medium-to-low risk by all the companies.

Control measures

The radar chart related to control measures of food retailers in well-established supply chains is displayed on down-right side of figure 6. The profiles of control measures show the situations of current control measures adopted by the different companies. Within this category, it can be seen that companies score differently and no special trend is shown. The profiles of the five food retailers' companies show the variety of extent of control measures applied in the company. Generally, the areas are quite large, indicating that companies have medium-to high level of adequacy of control measures for the majority of the indicators.
Potential vulnerabilities have been assessed in relation to indicators 31, 32, 34, 44, 46 and 47.
Indicators 31 and 32 are indicating that the fraud monitoring system in companies has generally low level of adequacy, highlighting that authenticity tests for fraud detection and monitoring are not well established and systematically performed. From the interview, it is emerged that companies believe that this system is not of high priority in food retailers, since the product arrives packed in retail units and therefore, it is quite complicated to adulterate and modify milk composition on this stage of the supply chain.
Indicators 44, 46 and 47 are associated with low scores as indication of weaknesses in enforcement and controls from a law perspective. The literature explains that in European countries, regulatory requirements are still not enforced and generally countries have not really incorporated food defence principles into their legal framework (Bogadi et al., 2015).

4.2 Measures of average scores by groups of respondents

Table 6 displays the average scores by main categories and subcategories of indicators, highlighting similarities and differences between groups of respondents. The division of the respondents is made by major groups, namely dairy processors and food retailers, and additionally between conventional and organic dairy processors. The green boxes indicate low or low-to-medium risk level, while yellow boxes indicate medium risk level. Lastly, the red boxes represent medium-to-high or high risk level.

With this further analysis, more in-depth information can be extracted and the specific research question 3: "Which are similarities and differences between conventional and organic milk processors in relation to opportunities, motivations and control measures?" can be answered.

Table 6. Overview of the level of average scores by category of SSAFE vulnerability tool. Low risk=1-1.3, low-to-medium risk= 1.4-1.6, medium risk=1.7-2.3, medium-to-high risk=2.4-2.6, high risk=2.7-3. High average scores for opportunities and motivations are labelled with low risk; while high averages scores for control measures are labelled as low risk.

		ALL PROCESSORS	ALL RETAILERS	CONVENTIONAL PROCESSORS	ORGANIC PROCESSOR
Main categories	OPPORTUNITIES	Medium (1,8)	Medium (1,8)	Low-to-medium (1,6)	Medium (2,1)
	MOTIVATIONS	Low-to-medium (1,4)	Low-to-medium (1,4)	Low-to-medium (1,4)	Low-to-medium (1,4)
	CONTROL MEASURES	Medium (2)	Medium (2,2)	Medium (2,2)	Medium-to-high (1,6)
Technical	Opportunities and economic drivers	Medium (1,8)	Medium (1,9)	Medium (1,7)	Medium (2,2)
	Internal hard controls	Medium (2)	Medium (1,9)	Medium (2,3)	High (1,3)
Own company	Motivations	Low (1)	Low (1,2)	Low (1,1)	Low (1)
	Internal soft controls	Medium (2,2)	Medium-to-low (2,6)	Medium (2,3)	Medium (2)
Direct suppliers and customers	Motivations	Low (1,3)	Low (1)	Low (1,3)	Low-to-medium (1,7)
	Control measures	Medium (2,1)	Medium-to-low (2,6)	Medium (2,2)	Medium (2)
Environment	Motivations	Low-to-medium (1,6)	Medium (1,8)	Low-to-medium (1,6)	Low-to-medium (1,6)
	Control measures	Medium (1,8)	Medium (1,8)	Medium (1,8)	Medium-to-high (1,4)

4.2.1 Main differences between dairy processors and food retailers

Some differences between dairy processors and food retailers can be pointed out regarding own company internal soft controls, control measures on direct suppliers and customers, and motivations in relation with the environment.

Overall, the group of retailers have a higher level of adequacy of control measures compared to the processors' group. This outcome is probably due to the fact, that the organic processor's internal hard control measures are weaker in comparison to conventional processors, influencing therefore the overall processors' average. A part from the organic processor, the interviews with conventional processors and food retailers reveal that these companies have very similar levels of control measures in place.

Regarding the group of indicators related to motivations in relation with the environment: the interviews reveal that dairy processors are operating in an environment with less competition, better ethical business culture, resulting in low-to-medium level of risk for this subcategory. The competition among food retailers may be perceived as higher due to the large variety of competitors in retail sectors.

4.2.2 Main differences between conventional and organic processors

The two columns on the right side of table 6 display the average scores of conventional dairy processors and organic dairy processor by main category and by each sub-category of the SSAFE vulnerability tool.
The differences consist in:

- Opportunities;
- Control measures, specifically internal hard controls and control measures in the environment.

From the table, it is shows that organic processor scores as medium risk in the opportunity profile compared to the conventional counterpart which score as low-to-medium risk. Literature supports that organic milk may be more vulnerable in terms of opportunities, since fraudulent activities are more likely to happened for products with special attributes and where the margin of profits is bigger. Therefore, quality labels, such as organic label, may be attractive for unscrupulous people who want to enhance their profits (Capuano et al., 2014).
Moreover, the control measures in place in the organic processor have a minor level of adequacy in comparison to conventional dairy processors. Vulnerabilities are highlighted specifically in relation to internal hard control measures and control measures in the environment. The average scores for both categories are indicated as high and medium-to-high respectively. From the interview, it has been reported that fraud monitoring system is not developed and authenticity analysis are not performed in the organic processor. Moreover, weaknesses in legislation for organic products may lead to perception of being more vulnerable at environmental level. Despite the introduction of new regulations for organic products, organic food markets still feature a high degree of information asymmetry (Janssen & Hamm, 2012). In addition, due to the irregular distribution of information between enterprises in the supply chain, credence good markets are prone to fraud and opportunistic behaviour (Janssen & Hamm, 2012).

4.2.3 Similarities between dairy processors and food retailers

Some similarities can be reported within and between the two main groups of respondents by looking at the main categories and sub-categories in table 6, and additionally by cross-checking the answers of the questionnaires used for the assessment of the SSAFE vulnerability tool among dairy processors and food retailers. The following similarities are underlined, classified by category of SSAFE vulnerability tool.

All the respondents within the group of dairy processors indicated the same answers for the following indicators:

- Opportunities: indicator 7 is indicated as low level of risk by all the companies. Within the category of opportunities, companies score similarly in only this indicator, namely the accessibility to production/processing line, which means that the access to production area is limited, since the system is designed only to be accessed by authorized personnel and protect against potential safety hazards and also against potential fraudulent activities. According to the literature analysis, this risk factor is also indicated as less relevant for the determination of potential vulnerabilities to fraud in dairy supply chains.
- Motivations: indicators 12, 13, 14, 16, 17, 19 are indicated as low level of risk by all the companies. All companies estimate their own motivations lower than the motivations at supplier, supply chain, industry and international environment level.
- Control measures: indicator 43 about social control and transparency in chain network is indicated as medium level of adequacy by all the companies. This is indication that the supply chain has a good degree of self-regulation and communication between companies is perceived as quite active, but the respondents indicate that usually unethical conduct or incidents are not communicated between firms because of confidentiality reasons.

All the respondents within the group of food retailers indicated the same answers for the following indicators:

- Opportunities: indicator 9 is indicated as low level of risk by all the companies. No milk incidents have been reported in food retailers.
- Motivations: indicators 12, 15, 16, 18, 19, 20, 21, 23, 27 are indicated as low level of risk by all the companies. For the group of food retailers, the highest degree of similarities within this category is related to the indicators which refer to motivations at supplier level. From the interviews, it has been reported that relationship with suppliers, suppliers' contractual requirements and information exchange are characterized by trust, respect and long term financial targets.
- Control measures: indicator 41 is indicated as high level of adequacy by all the companies which deem that the supplier information system for mass balance control is well-established, comprehensive and accurate.

4.3 Multiple Correspondence Analysis on the food fraud vulnerability assessment data of dairy processors and food retailers

The MCA is used to investigate the associations between categories of multiple qualitative variable. Figure 7 displays the symmetric observation plot with the outcome of the MCA, in which the data of 4 dairy processors and 5 food retailers is included. While the symmetric variable plot in appendix 7 shows which indicators have a high degree of association with the various groups of respondents. Both symmetric plots include the overall analysis of all the indicators belonging to the three categories of SSAFE vulnerability tool. The level of correlation between indicators in the first dimension (X-axis) is regarded to be 37% (F1), while the level of correlation between indicators in the second dimension (Y-axis) is regarded to be 16% (F2). The percentage of adjusted inertia cumulated over the two axes corresponds to 54%.

In figure 7 the two groups of respondents, namely dairy processors and food retailers are displayed. By looking at the symmetric observation plot the only visible pattern is that all the Dutch food retailers 1, 2, 3 and 4 are grouped together, as indication of similarities in answering some indicators. Moreover, processor 1 and 3 are grouped together since the degree of association among answers is regarded to be high for these two companies as well. From figure 7, it can be seen that the other two processors, namely processor 2 and 4, are located in different squares of the symmetric observation plot. This is due to the fact that the organic processor (pro 2) scores differently in some indicators in the category of opportunities and control measures, in comparison to processor 1 and 3. Processor 4 is located in the right side of the plot, however it has some degree of association with processor 1 and 3 in relation to the first dimension (F1-axis). It is important to remember that processor 4 is supplied by a large variety of farmers and as well dairy processors, therefore different answers were given to some indicators in the category of motivations. Overall, the three conventional processors (pro 1, pro 3 and pro 4) have a higher degree of similarities in answers compared to the organic processor (pro 2). This information was already obtained through radar chart analysis and average scores analysis, but the plot displays in more evident manner this correlation but also the tighter correlation between processor 1 and 3.

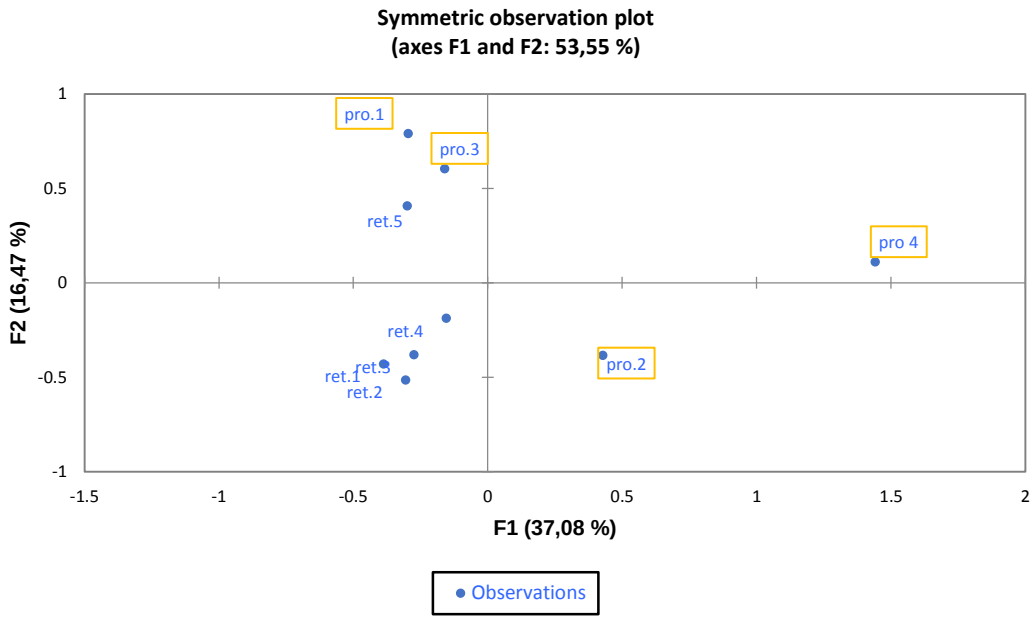


Figure 7. Symmetric observation plot: projections on the first 2 dimensions.

The Multiple Correspondence Analysis has been performed also separating the indicators in opportunities, motivations and control measures, but no patter is visible, since processors and retailers are mixed together in the plots. The MCA symmetric plots can be found in Appendix 7.

4.4 Comparisons between literature approach and assessment of SSAFE vulnerability tool on dairy processors and food retailers

This paragraph is created to sum up the highlights found with the literature analysis as well as the outcomes obtained with the assessment of SSAFE vulnerability tool among dairy processors and food retailers.
During the literature analysis, all the risk factors based on SSAFE vulnerability tool were indicated to have an effect on potential fraud vulnerabilities in well-established dairy supply chains, with the exception of three indicators, namely the accessibility to production/processing lines, price asymmetries between countries and victimization. From the in-depth literature review, relatively general information about risk factors in dairy supply chains was retrieved. Literature analysis is overall not detailed for the specific actors involved in the case study as well as for the specific types of milk investigated in the research (conventional and organic milk), therefore it was not possible to indicate the level of risk for each indicator in relation to both dairy processors and food retailers. However, it was possible for some risk factors, namely valuable components and law enforcement and policy, to indicate a potential higher level of risk in relation to organic milk.
In this sense, the case study based on the assessment of SSAFE vulnerability tool on dairy processors and food retailers allows to proceed a step deeper in the analysis of dairy supply chains and indicate which risk factors are concretely perceived to have a major impact on fraud vulnerabilities.

Literature analysis indicates that within the category of opportunities, all the risk factors may have effect on potential fraud vulnerabilities. Based on the outcomes obtained with the case study, three risk factors can be pointed out since they score higher in comparison to the others. Technologies' availability and knowledge for adulteration are indicated by the literature to be widely reported, and therefore may represent an important opportunity for fraudulent activities. The case study shows a similar perception also among all the respondents who assigned to this indicator relatively high scores. Therefore, it can be assumed that it may

represent a major risk factor. The second risk factor that needs to be mentioned refers to **adulteration's detectability**. Based on literature analysis, it seems that detection methods are very important risk factor since the ability to actively detect fraud represents the most technically challenge aspect of food fraud prevention. The case study shows that dairy processors do believe that testing products for adulteration is quite challenging and in fact this indicator received the highest overall score for this group of respondents, while food retailers judge detection method as medium-to-low level of risk factor since they deem that basic analysis can be performed to check products' adulteration. Lastly, **complexity of adulteration** which is indicated by literature as potential vulnerability due to the very dynamic composition of milk, it is perceived by food retailers as major vulnerability. It scores second, after technologies' availability and knowledge for adulteration.

Literature analysis indicates that, within the category of motivation, all the risk factors may have effect on potential fraud vulnerabilities. Among the others, valuable components are indicated by the literature as high risk factor especially in relation to organic milk. This is also confirmed with the case study. Based on it, it can be assumed that **valuable components** can be considered as major risk factor since the averages scores for this indicator of both dairy processors and food retailers are closed to 3 (highest level of risk). Moreover, the case study reveals that the other major risk factor is **level of competition.** Both dairy processors and food retailers indicates it with scores very closed to 3 (highest level of risk). However, what is a bit in contradiction with the literature analysis is that the case study reveals that many risk factors are perceived as low risk from the respondents. It is indicated that ethical business culture, business strategies, previous irregularities at own company level as well as at suppliers' level are judged as level of risk for potential fraud vulnerabilities in dairy supply chains. It seems that there is the perception that motivations are not the driven force for committing frauds. It is indeed true that the companies which participated in the assessments are economically healthy, therefore motivations for committing fraudulent activities are considered vague or baseless. However, it is important to keep in mind that the aspect of fraud which is the hardest to assess and control lies with the individual (Tippett, n.d).

Within the category of control measures, literature analysis indicates that all the control measures are crucial in the prevention of fraudulent activities. Generally, control measures are well-established and in place in food companies, but from the literature it can be concluded that there are some lacks in relation to **fraud monitoring systems**, which need to be implemented by taking into consideration the new concept of VACCP. Moreover, it is also indicated that **law enforcement and national policy** are not yet well-defined, since food fraud is relatively new issue in European political. These risk factors are indicated as the least adequate within the category of control measures by both groups of respondents, while the other control measures such as employees integrity screening, mass balance controls, tracing and tracking systems and so on are usually well established and performed, as indicated in the literature.

CHAPTER 5: CONCLUSIONS

The present chapter describes the conclusions for each specific research question obtained by in-depth literature review and assessment of SSAFE vulnerability tool on dairy processors and food retailers.

5.1 First specific research question

"Which are the potential vulnerabilities inherent the category of opportunities, motivations and control measures in well-established dairy supply chains?". This specific research question is answered via literature analysis and the outcomes are displayed in the table 7.

Table 7. Overview of risk factors influencing potential vulnerability to fraud in dairy supply chains

OPPORTUNITIES	MOTIVATIONS	CONTROL MEASURES
complexity of adulteration; knowledge to adulterate and technology's availability; adulteration's detectability; transparency supply chain network; relationships within the supply chain.	Supply and pricing of materials; special attributes or value determining components of materials; level of competition in sector; economic health business; ethical business culture; business strategy.	Specificity and accuracy of fraud monitoring system; systematics and autonomy of verification of fraud monitoring system; accuracy information for mass balance control; extensiveness tracking and tracing system; fraud contingency plan; strictness ethical code of conduct; application integrity screening; support whistle blowing system; contractual requirements suppliers; social control and transparency across supply chain; established guidance for fraud prevention.

It is concluded, as a result of in-depth literature analysis that the risk factors mentioned in table 7 may have an effect on potential vulnerabilities to fraud on dairy supply chains.

5.2 Second specific research question

"Which are the major vulnerabilities inherent opportunities, motivations and control measures based on the assessment of SSAFE vulnerability tool among dairy processors and food retailers?"
This question is answered in Chapter 4 as a result of the assessment of SSAFE vulnerability tool on dairy processors and food retailers in the Netherlands and in Ireland. The summary of the major vulnerabilities to fraud inherent the categories of opportunities, motivations and control measures for both dairy processors and food retailers is indicated in table 8.

Table 8. Major vulnerabilities inherent opportunities, motivations and control measures after the assessment of SSAFE vulnerability tool among dairy processors and food retailers. Ret=retailers, pro=processors.

OPPORTUNITIES	MOTIVATIONS	CONTROL MEASURES
RET complexity of adulteration **PRO-RET** knowledge to adulterate and technology's availability **PRO** adulteration's detectability	**PRO-RET** special attributes or value determining components of materials **PRO-RET** level of competition in sector	**PRO-RET** specificity and accuracy of fraud monitoring system **PRO-RET** established guidance for fraud prevention.

5.3 Third specific research question

"Which are similarities and differences between conventional and organic milk processors in relation to opportunities, motivations and control measures?"

The third specific research question is answered in Chapter 4, as a result of the assessment of SSAFE vulnerability tool on conventional and organic dairy processors. From the analysis, it is not possible to indicate specifically for which risk factors the organic processor scores similarly or differently compared to the conventional counterpart. Therefore, conclusions need to be estimated by category of indicators of SSAFE vulnerability tool. It has been seen that there are similarities in relation to opportunities and motivations, where the organic and conventional processors have similar vulnerability profiles. The differences from the conventional dairy processors are identified in relation to the category of control measures where the organic processor shows low level of adequacy in many more control measures, such as employees integrity screening, mass balance control and tracking and tracing system.

CHAPTER 6: CRITICAL REFLECTION ON RESEARCH

In this chapter, the evaluation of the research is performed from a critical perspective. Moreover, it offers some recommendations for future research based on the evaluation. Overall, the research is supported by literature analysis but there are also some limitations, especially in the case study which can be ameliorated in the future.

1st limitation: sample size

At early stages, the goal was to obtain a large group of respondents in order to enhance the reliability of the research and have a better understanding of the dynamics in dairy supply chains. Due to time restrictions and difficulties in the recruitment of respondents (i.e. many companies did not react to the preliminary email) only a small group of companies were interviewed. Therefore, fully reliable conclusions about fraud vulnerabilities in dairy processor and final distribution phases cannot be drawn.

2nd limitation: one organic processor

The research also aimed at gaining understanding about similarities and differences between conventional and organic milk processors in relation to opportunities, motivations and control measures. However, only one organic processor participated in the research, therefore, the results and the conclusions may not be fully representative of the fraud vulnerabilities situation in the organic dairy sector.

3rd limitation: different methods of data collection

The SSAFE vulnerability tool has been assessed through 3 different methods of data collection: face to face interviews, e-mail and telephone interviews. Therefore, since the data were obtained in different ways, there may be a decrease in the reliability of the results. Moreover, no qualitative data could have been retrieved from the questionnaires sent by e-mail, which may have been helpful for the explanation of some outcomes.

For future research it could be useful to retrieve a large group of companies from different countries where dairy supply chains are well-established, in order to increase the representativeness of the results. Moreover, it can be convenient to perform only face-to-face interviews, in which qualitative data can also be retrieved.

CHAPTER 7: BIBLIOGRAPHY

Abdi, H., & Valentin, D. (2007). *Multiple correspondence analysis. Encyclopedia of measurement and statistics*, 651-657.

Aitken, JM. (1998). *Supply chain integration within the context of a supplier association: case studies of four supplier associations*, Cranfield University.

Afzal, A., Mahmood, M. S., Hussain, I., & Akhtar, M. (2011). Adulteration and microbiological quality of milk (a review). *Pakistan Journal of Nutrition, 10*(12), 1195-1202.

Akhtar, S. (2015). Food safety challenges—a Pakistan's perspective. *Critical reviews in food science and nutrition*, 55(2), 219-226.

Albersmeier, F., Schulze, H., Spiller, A. (2010). System dynamics in food quality certifications: development of an audit integrity system. *International Journal on Food System Dynamics 1* (19), pp 69-81.

Ambrose, E., Marshall, D., & Lynch, D. (2010). Buyer supplier perspectives on supply chain relationships. *International Journal of Operations & Production Management, 30*(12), 1269-1290.

Anica-Popa, I. (2012). Food traceability systems and information sharing in food supply chain. *Management & Marketing, 7*(4), 749.

Arienzo, A., Coff, C., & Barling, D. (2008). The European Union and the regulation of food traceability: from risk management to informed choice?. *In Ethical traceability and communicating food* (pp. 23-42). Springer Netherlands.

Avery, G. (2014). European Parliamentary Research. Fighting food fraud - Service 130679REV1.

Azad, T., & Ahmed, S. (2016). Common milk adulteration and their detection techniques. *International Journal of Food Contamination, 3(*1), 22.

Ball, G.A., Treviño, L.K., & Sims, H.P. (1994) Just and unjust punishment: Influences on subordinate performance and citizenship. *Academy of Management Journal 37*(2): 299–322.

Beulens, A. J., Broens, D. F., Folstar, P., & Hofstede, G. J. (2005). Food safety and transparency in food chains and networks Relationships and challenges. *Food control, 16*(6), 481-486.

Bird, F.B. & Waters J.A. (1989). The moral muteness of managers. *California Management Review 32*(1): 73–88.

Benton, W. C., & Maloni, M. (2005). The influence of power driven buyer/seller relationships on supply chain satisfaction. *Journal of Operations Management, 23*(1), 1-22.

Bogadi, N. P., Banović, M., & Babić, I. (2016). Food defence system in food industry: perspective of the EU countries. *Journal für Verbraucherschutz und Lebensmittelsicherheit*, 1-10.

Borkova, M. A. R. K. É. T. A., & Snaselova, J. (2005). Possibilities of different animal milk detection in milk and

dairy products-a review. *Czech J. Food Sci, 23*(2), 41-50.

Capuano, E., Rademaker, J., van den Bijgaart, H., & van Ruth, S. M. (2014). Verification of fresh grass feeding, pasture grazing and organic farming by FTIR spectroscopy analysis of bovine milk. *Food Research International, 60,* 59-65.

Carter, N., Bryant-Lukosius, D., DiCenso, A., Blythe, J., & Neville, A. J. (2014, September). The use of triangulation in qualitative research. *In Oncology nursing forum* (Vol. 41, No. 5).

CBS (2015). Factsheet Melkveehouderij 1984-201429. Retrieved September 2016.

CIMA (2008). Fraud Risk Management: A Guide to Good Practice.

Cohen, Lawrence E. & Marcus Felson. (1979). "Social Change and Crime Rate Trends: A Routine Activity Approach." *American Sociological Review, Volume Number: 44-04.*

Coombs, W. T. (2008). PSI Handbook of Business Security. Greenwood Publishing Group.

Commission Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. Retrieved January 2017.

Commission Regulation (EC) No 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control. Retrieved January 2017.

Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91. Retrieved December 2016.

COWI Consulting Engineers, Planners, United Nations Environment Programme. Division of Technology, Economics, & Denmark. Miljøstyrelsen. (2000). *Cleaner production assessment in fish processing.* UNEP/Earthprint.

Cox, A. (2001). Understanding buyer and supplier power: a framework for procurement and supply competence. *Journal of Supply Chain Management, 37*(1), 8-15.

Cox, A. (2004). Business relationship alignment: on the commensurability of value capture and mutuality in buyer and supplier exchange. Supply Chain Management: *An International Journal, 9(*5), 410-420.

Crain M.A., Hopwood W.S., & Pacini C. (2016). Essentials of Forensic Accounting. *Business & Economics.*

Dabbene, F., Gay, P. (2011). Food traceability systems: Performance evaluation and optimization. *Computers and Electronics in Agriculture, Vol. 75,* No. 1, pp. 139-146

Dani, S. (2015). *Food supply chain management and logistics: From farm to fork*. Kogan Page Publishers.

Daud, A. R., Putro, U. S., & Basri, M. H. (2015). Risks in milk supply chain; a preliminary analysis on smallholder dairy production. *Livest Res. Rur. Dev, 27*(7).

de la Fuente, M. A., & Juárez, M. (2005). Authenticity assessment of dairy products. *Critical Reviews in Food Science and Nutrition, 45*(7–8), 563–85.

Downey, G (2016). Advance in Food Authenticity Testing. *Elsevier.*

Dutch Dairies in Figures (2014). http://www.idfwds2016.com/wp-content/uploads/2016/07/Dutch-dairy-in-figures-2014.pdf. Retrieved January 2017.

EKO-Keurmerk. (n.d.). EKO-Quality Mark. http://www.eko-keurmerk.nl/eko-quality-labels. Retrieved December 2016.

European Commission (2016) http://ec.europa.eu/food/safety/official_controls/food_fraud/index_en.htm Retrieved September 2016.

European Commission. (2016a). EU law on organic production: An overview. http://ec.europa.eu/agriculture/organic/eu-policy/eu-legislation/brief-overview_en. Retrieved November 2016.

European Commission (2016) https://ec.europa.eu/food/safety/rasff_en. Retrieved December 2016.

European Commission (2017) https://ec.europa.eu/food/safety/official_controls/food_fraud_en. Retrieved January 2017.

Everstine, K., Spink, J., & Kennedy, S. (2013). Economically motivated adulteration (EMA) of food: common characteristics of EMA incidents. *Journal of Food Protection, 76*(4), 723-735.

Farrell, B.R., & Healy, P. (2000), "White collar crime: a profile of the perpetrator and an evaluation of the responsibilities for its prevention and detection", *Journal of Forensic Accounting, Vol. I,* pp. 17-34.

FDA, Food and Drug Administration. (2009). Economically Motivated Adulteration; Public Meeting; Request for Comment [Docket No. FDA-2009-N-0166] [Electronic Version]. Federal Register, 74, 15497. Available from:http://edocket.access.gpo.gov/2009/pdf/ E9–7843.pdf. Retreived January 2017.

FAO, 2016 http://www.fao.org/economic/est/issues/volatility/en/#.WICFhrGh3R0 Retreived December 2016.

FAO, 2017. http://www.fao.org/economic/est/issues/volatility/en/#.WICFhrGh3R0 Retreived January 2017.

Finete, V. D. L. M., Gouvêa, M. M., de Carvalho Marques, F. F., & Netto, A. D. P. (2013). Is it possible to screen for milk or whey protein adulteration with melamine, urea and ammonium sulphate, combining Kjeldahl and classical spectrophotometric methods?. *Food chemistry, 141*(4), 3649-3655.

Food Chemical Codex. (2014). Appendix XVII: Guidance on Food Fraud Mitigation, 723–735.

Fortin, N. D. (2016). Food regulation: law, science, policy, and practice. John Wiley & Sons.

Fraud risk management. A guide to good practice (2008). http://www.cimaglobal.com/documents/importeddocuments/cid_techguide_fraud_risk_management_feb09.pdf.pdf. Retrieved December 2016.

Fritz, M., & Schiefer, G. (2009). Tracking, tracing, and business process interests in food commodities: A multi-level decision complexity. *International Journal of Production Economics, 117(*2), 317-329.

Gantner, V., Mijić, P., Baban, M., Škrtić, Z., & Turalija, A. (2015). The overall and fat composition of milk of various species. *Mljekarstvo/Dairy, 6*5(4).

Gellynck, X. and Verbeke, W. (2001), "Consumer perception of traceability in the meat chain". *Agrarwirtschaft, Vol. 50*, pp. 368-374.

Ghadge A, Dani S, Kalawsky R (2012). Supply chain risk management: present and future scope. The *International Journal of Logistics Management 23*(3), 313-339.

Golan, E., Krissoff, B., Kuchler, F., Calvin, L., Nelson, K., & Price, G. (2004). Traceability in the US food supply: Economic theory and industry studies. *Agricultural Economic Report Number 830,* Economic Research Service, US Department of Agriculture, Washington, DC.)

Gorton, M., Angell, R., Dries, L., Urutyan, V., Jackson, E., & White, J. (2015). Power, buyer trustworthiness and supplier performance: Evidence from the Armenian dairy sector. *Industrial Marketing Management, 50*, 69-77.

Greenberg J. (1997) The STEAL motive: Managing the social determinants of employee theft. I*n: Giacalone RA and Greenberg J (eds) Antisocial Behavior in Organizations*. Thousand Oaks, CA: SAGE, 85–108

Grunert, K.G. (2005), "Food quality and safety: consumer perception and demand", European. *Review of Agricultural Economics, Vol. 32*, pp. 369-391

Grunert, K. G., & Aachmann, K. (2016). Consumer reactions to the use of EU quality labels on food products: A review of the literature. *Food Control, 59*, 178-187.

Guidance for Dairy Product Enhanced Traceability Voluntary Practices and Protocols for Strengthening the U.S. Dairy Supply Chain (2016)

Handford, C. E., Campbell, K., & Elliott, C. T. (2016). Impacts of milk fraud on food safety and nutrition with special emphasis on developing countries. *Comprehensive Reviews in Food Science and Food Safety, 15*(1), 130-142.

Hoorfar, J., Pruggerl, R., Butler, F., Jordan, K., Hoorfar, J., Jordan, K., Butler, F., Prugger, R., (2011). 18-Future trends in food chain integrity. In: Food Chain Integrity. *Woodhead Publishing, Cambridge, UK.* pp. 303–308.

Huang, H. (2015). Establishing Fraud Vulnerabilities Profile along Extra Virgin Oil Supply Chain. MSc Thesis.

Initiative report (2013/2091 (INI))
http://www.europarl.europa.eu/sides/getDoc.do?type=REPORT&mode=XML&reference=A7-2013-0434&language=EN#_part1_def1 Retrieved January 2017

Iyer, N. K., & Samociuk, M. (2006). *Fraud and corruption: Prevention and detection.* Gower Publishing, Ltd.

Jackson,T., (2000) Management ethics and corporate policy: A cross-cultural comparison. *Journal of Management Studies 37*(3): 349–369.

Janssen, M., & Hamm, U. (2012). Product labelling in the market for organic food: Consumer preferences and willingness-to-pay for different organic certification logos. *Food Quality and Preference, 25*(1), 9-

22.

Janssen, M., & Hamm, U. (2014). Governmental and private certification labels for organic food: Consumer attitudes and preferences in Germany. *Food Policy, 49*, 437-448.

Jesson, J., & Lacey, F. (2006). How to do (or not to do) a critical literature review. *Pharmacy education, 6*.

Jensen, K. D., Denver, S., & Zanoli, R. (2011). Actual and potential development of consumer demand on the organic food market in Europe. *NJAS-Wageningen Journal of Life Sciences, 58(*3), 79-84.

Johnson, R. (2014). Food fraud and economically motivated adulteration of food and food ingredients.

Johnston, R.H., Vitale, M.R. (1988). Creating Competitive Advantage with Interorganizational Information Systems. *MIS Quarterly, Vol. 12,* No. 2, pp. 153-165

Junqueira, R. V. (2010). Governance structure and supply chain management practices in the dairy value chain: a comparative study between New Zealand and Brazil: a thesis presented in partial fulfilment of the requirements for the degree of Master of Logistics and Supply Chain Management at Massey University, Auckland, New Zealand (Doctoral dissertation, Massey University).

Kamthania, M., Saxena, J., Saxena, K., & Sharma, D. K. (2014). Milk Adultration: Methods of Detection &Remedial Measures. *Int. J. Engg. and Technical Res, 1*, 2321-0869.

Kandpal S.D., Srivastava A.K., Negi K.S. (2012). Estimation of quality of raw milk (open & branded) by milk adulteration testing kit. I*ndian J Community Health 24*(3):188–92.

Kaptein, M. (2011). Understanding unethical behavior by unraveling ethical culture. *Human Relations, 64*(6), 843–869.

Kasemsumran, S., Thanapase, W., & Kiatsoonthon, A. (2007). Feasibility of near-infrared spectroscopy to detect and to quantify adulterants in cow milk. *Analytical Sciences, 23*(7), 907-910.

Kim, K.K., Ryoo, S.Y., Jung, M.D. (2011). Inter-organizational information systems visibility in buyer–supplier relationships: The case of telecommunication equipment component manufacturing industry. *Omega - International Journal of Management Science, Vol. 39*, No. 6, pp. 667-676

Krol, P (2016). Food Fraud Vulnerabilty Assessment in the White Fish Supply Chain. BSc Thesis

Kumar, A., Lal, D., Seth, R., & Sharma, V. (2010). Detection of milk fat adulteration with admixture of foreign oils and fats using a fractionation technique and the apparent solidification time test. *International journal of dairy technology, 63*(3), 457-462.

Leat, P., Marr, P. & Ritchie, C. (1998), "Quality assurance and traceability – the Scottish agric-food industry's quest for competitive advantage". *Supply Chain Management, Vol. 3*, pp. 115-117.

Levine, T. R. (2014). Truth-Default Theory (TDT) A Theory of Human Deception and Deception Detection. *Journal of Language and Social Psychology, 33*(4), 378-392.

Limnios, E. M., Schilizzi, S. G., Burton, M., Ong, A., & Hynes, N. (2016). Willingness to pay for product ecological footprint: Organic vs non-organic consumers. *Technological Forecasting and Social Change.*

Linn, J. G. (1988). Factors affecting the composition of milk from dairy cows. Designing Foods: Animal Product Options in the Marketplace. *National Research Council (US) Committee on Technological Options to Improve the Nutritional Attributes of Animal Products, ed. Natl*. Acad. Press, Washington, DC, 224.

Lipp M, Moore J. (2013). Understanding food fraud, its impact on global supplies. http://www.fnbnews.com/article/detnews.asp?articleid=33596&sectionid=32. Retrieved September 2016.

Lotta, F., & Bogue, J. (2015). Defining food fraud in the modern supply chain. E*uropean Food and Feed Law Review, 10*(2), 114–122.

Luning, P. A., & Marcelis, W. J. (2009). A food quality management research methodology integrating technological and managerial theories. *Trends in Food Science & Technology, 20*(1), 35-44.

Mai, N., Bogason, S. G., Arason, S., Arnason, S. V., & Matthiasson, T. G. (2010). Benefits of traceability in fish supply chains - case studies. *British Food Journal, Vol. 112,* No. 8-9, pp. 976-1002

Mahalik, N., & Kim, K. (2015). The Role of Information Technology Developments in Food Supply Chain Integration and Monitoring. Innovation and Future Trends in Food Manufacturing and Supply Chain Technologies, 21.

Manikas, I., & Manos, B. (2009). Design of an integrated supply chain model for supporting traceability of dairy products. *International journal of dairy technology, 62*(1), 126-138.

Manning, L., & Soon, J. M. (2014). Developing systems to control food adulteration. *Food Policy, 49*, 23-32.

Manning, L. (2016). Food fraud: policy and food chain. *Current Opinion in Food Science*, 10, 16-21.

Manning, L., & Smith, R. (2015). Providing authentic(ated) food: An opportunity-driven framework for small food companies to engage consumers and protect the integrity of the food supply chain. *The International Journal of Entrepreneurship and Innovation, 16*(2), 97–110. https://doi.org/10.5367/ijei.2015.0180

Marian, L., Chrysochou, P., Krystallis, A., & Thøgersen, J. (2014). The role of price as a product attribute in the organic food context: An exploration based on actual purchase data. *Food Quality and Preference, 37,* 52-60.

Mauser, A. M. (2001). The greening of business. Environmental management and performance evaluation: an empirical study of the Dutch dairy industry.

Mayer, D. M., Nurmohamed, S., Treviño, L. K., Shapiro, D. L., & Schminke, M. (2013). Encouraging employees to report unethical conduct internally: It takes a village. *Organizational Behavior and Human Decision Processes, 121*(1), 89-103.

McDonald, R., Pierce, K., Fealy, R., & Horan, B. (2013). Characteristics, intentions and expectations of new entrant dairy farmers entering the Irish dairy industry through the New Entrant Scheme. *International Journal of Agricultural Management, 2(*4), 189-198.

Miceli, M. P., Near, J. P., & Dworkin, T. M. (2008). Whistle-blowing in organizations. Mahwah, NJ: Taylor and Francis, LEA Organization and Management Series

Mishra P.K., Shekhar B.R. (2011). Impact of Risks and Uncertainties on Supply Chain: A Dairy Industry Perspective. J*ournal of Management Research 3*(2): 1-18.

Molkentin, J. (2013). Applicability of organic milk indicators to the authentication of processed products. *Food chemistry, 137*(1), 25-30.

Moore, J.C., Spink, J., & Lipp, M. (2012). Development and application of a database of food ingredient fraud and economically motivated adulteration from 1980 to 2010. *Food Science 77*(4):108–16

Moyer, D. C., DeVries, J. W., & Spink, J. (2017). The economics of a food fraud incident–Case studies and examples including Melamine in Wheat Gluten. *Food Control, 71*, 358-364.

Nollet, L. M., & Toldrá, F. (Eds.). (2016). *Safety analysis of foods of animal origin*. CRC Press.

Nyaga, G. N., Whipple, J. M., & Lynch, D. F. (2010). Examining supply chain relationships: do buyer and supplier perspectives on collaborative relationships differ?. *Journal of Operations Management, 28*(2), 101-114.

NZO (2013). Fit for the future http://china.nlambassade.org/binaries/content/assets/postenweb/c/china/zaken-doen-in-china/2014/fit-for-the-future.pdf Retrieved January 2017.

Padala S., Pulloor N., Srinivas P., & Seshu A.R. (2014). Milk adulteration rampant in Karimnagar district. Deccan Chronicle [Online]. http://www.deccanchronicle.com/141117/nation-crime/article/milk-adulteration-rampant-karimnagar-district Retrieved September 2016

Pourkomailian B. (2014). *Management of Supplier and Raw Material.* McDonald's Europe, London, UK

Quested, T. E., Cook, P. E., Gorris, L. G. M., & Cole, M. B. (2010). Trends in technology, trade and consumption likely to impact on microbial food safety. I*nternational Journal of Food Microbiology, 139,* S29-S42.

Ryan, J. M. (2015). Food fraud. Academic Press.

Reckers-Sauciuc, A. K., & Lowe, D. J. (2010). The influence of dispositional affect on whistle-blowing. *Advances in Accounting, 26*(2), 259-269.

Sarpong, S. (2014). Traceability and supply chain complexity: confronting the issues and concerns. *European Business Review, 26*(3), 271-284.

Schröder, M., Yousefi, F., & Vetter, W. (2011). Investigating the day-to-day variations of potential marker fatty acids for organic milk in milk from conventionally and organically raised cows. *European Food Research and Technology, 232(*1), 167-174.

Shamsuzzoha, A., & Helo, P. T. (2011). Real-time tracking and tracing system: Potentials for the logistics network. *In Proceedings of the 2011 international conference on industrial engineering and operations management* (pp. 22-24).

Skarlicki D.P., Folger R. & Tesluk P. (1999) Personality as a moderator in the relationship between fairness and retaliation. *Academy of Management Journal* 42: 100-108.

Singh, P., & Gandhi, N. (2015). Milk preservatives and adulterants: processing, regulatory and safety issues. *Food Reviews International, 31(*3), 236-261.

Smith, G. C., Tatum, J. D., Belk, K. E., Scanga, J. A., Grandin, T., & Sofos, J. N. (2005). Traceability from a US perspective. *Meat science, 71*(1), 174-193.

Soboh, R. A. M. E. R., Oude Lansink, A., & van Dijk, G. (2011). Distinguishing dairy cooperatives from investor-owned firms in Europe using financial indicators. *Agribusiness, 27*(1), 34-46.

Spekman, R. E. (1988). Strategic supplier selection: Understanding long-term buyer relationships. *Business horizons, 31*(4), 75-81.

Spink, J. (2011). The challenge of intellectual property enforcement for agriculture technology transfers, additives, raw materials and finished goods against product fraud and counterfeiters. *J Intellectual Prop Rights 16*(2):183–193.

Spink, J. (2014). Safety of food and beverages: risks of food adulteration. *Encyclopedia of Food Safety*, 413-416.

Spink, J. (2014).GFSI Direction on Food Fraud and Vulnerability Assessment (VACCP).

Spink, J., & Moyer, D. C. (2011). Defining the Public Health Threat of Food Fraud. J*ournal of Food Science, 76*(9), R157-R163.

Spink J., Helferich O.K., Griggs J.E. (2010). Combating the impact of product counterfeiting. *Distribution Bus Manage J 10*(1):6.

Spink, J. (2016). Review- NewReview – New FSSC 22000 Version 4 Regarding Food Fraud and Food Defense

SSAFE (2015) - Food Fraud Vulnerability Assessment Tool.

Stier, R. F. (2014) Food Safety Assurance Systems: Documentation and Record Keeping.

Strange E.D., Malin E.L., Van Hekken D.L., Basch J.J. (1992). Chromatographic and electrophoretic methods used for analysis of milk proteins. J*ournal of Chromatography A*, 624: 81–102.

Subbaiah, K. V., Narayana, K., & Nookesh, R. K. (2009). Supply Chain Management in a Dairy Industry–A Case Study.

Swathi, J. K., & Kauser, N. (2015). A study on adulteration of milk and milk products from local vendors. *International Journal of Biomedical and Advance Research, 6*(9), 678-681.

Tacken, G. M. L., Banse, M., Batowska, A., Gardebroek, C., Turi, K. N., Wijnands, J. H. M., & Poppe, K. J. (2009). Competitiveness of the EU dairy industry. Project code, 20964, 2009-011.

Tietze M., Majewski T. (1997): Chemical composition and sanitary value of cow and sheep milk. *Bulletin of International Dairy Federation, No. 9702*: 303–307.

Tippett, K.E (n.d). The Individual's Motivation for Fraud.

Transparency International website, https://www.transparency.org/cpi2015/ Retrieved January 2017.

Trienekens, J. H., Wognum, P. M., Beulens, A. J., & van der Vorst, J. G. (2012). Transparency in complex dynamic food supply chains. A*dvanced Engineering Informatics, 26*(1), 55-65.

Tummala, R., & Schoenherr, T. (2011). Assessing and managing risk using the Supply Chain Management Process (SCRMP). Supply Chain Management: *An International Journal 16* (6), 474-483.

Tyler, T. R., & Blader, S. L. (2005). Can businesses effectively regulate employee conduct? The antecedents of rule following in work settings. *Academy of Management Journal, 48*(6), 1143-1158.

Treviño, L. K., den Nieuwenboer, N. A., & Kish-Gephart, J. J. (2014). (*Un) ethical behavior in organizations. Annual Review of Psychology, 65,* 635-660.

Treviño, L.K., & Weaver, G.R. (2003). Managing Ethics in Business Organizations: Social Scientific Perspectives. Stanford, CA: Stanford University Press.

Uchendu, F. N., & Abolarin, T. O. (2015). Corrupt practices negatively influenced food security and live expectancy in developing countries. The *Pan African medical journal, 20.*

Verbeke, W. (2005), "Agriculture and the food industry in the information age", *European Review of Agricultural Economics, Vol. 32*, pp. 347-368.

Verma, A., & Ambatipudi, K. (2016). Challenges and opportunities of bovine milk analysis by mass spectrometry. *Clinical proteomics, 13*(1), 1.

United States. Congress. Office of Technology Assessment. (1990). The use of integrity tests for pre-employment screening. Office of Technology Assessment

Upadhyay, N., Goyal, A., Kumar, A., Ghai, D. L., & Singh, R. (2014). Preservation of milk and milk products for analytical Purposes. *Food Reviews International, 30*(3), 203-224.

Wognum, P. N., Bremmers, H., Trienekens, J. H., van der Vorst, J. G., & Bloemhof, J. M. (2011). Systems for sustainability and transparency of food supply chains–Current status and challenges. *Advanced Engineering Informatics, 25*(1), 65-76.

WUR-VU. (2015). Introduction to SSAFE Food Fraud Vulnerability Assessment tool.

Xiu, C., & Klein, K. K. (2010). Melamine in milk products in China: examining the factors that led to deliberate use of the contaminant. *Food Policy*, *35*(5), 463-470.

Yin, R. K. (1984). *Case study research: Design an*d methods (1 ed.). Beverly Hills, CA: Sage Publications.

Zainal, Z. (2007). Case study as a research method. *Jurnal Kemanusiaan, 9.*

Zucker, D. M. (2009). How to do case study research.

APPENDIX 1. Questionnaire for dairy processors

No.	Indicator	Question	answer1 (low level)	answer 2 (medium level)	answer 3 (high level)
1	complexity of adulteration	Do you think it is **easy or complex** to add or remove something to/from liquid milk?	Composition of the liquid milk cannot be modified and milk products can only be replaced	Composition of the liquid milk can be modified by mixing with low-quality product-own material or foreign material, e.g. add reconstituted powder, melamine, sell conventional milk as organic, etc.	Composition of the liquid milk can be modified by mixing with low-quality or foreign material (e.g. powders, etc.) and by altering valuable food components (e.g. protein and/or fat content
2	availability technology and knowledge of adulteration	Do you think that the **technology and knowledge** to adulterate liquid milk are generally available?	Technologies and/or methods to adulterate the liquid milk are neither available, known, or reported; Knowledge to adulterate liquid milk is neither available, known or reported.	Advanced technologies, methods, facilities are required to adulterate the liquid milk; Professional and technical knowledge is required to adulterate the liquid milk	**Simple/basic** technologies and methods are available, and no specialist facilities are required, to adulterate the liquid milk; Knowledge required for adulteration is generally available.
3	detection method	How simple or complex are the test methods to detect the adulteration of liquid milk, do you think?	Detection of adulteration of milk is easy and performed with common/simple methods (e.g. visual inspection, smelling)	Established on-site methods are available for fraud screening (e.g. test kits) but confirmation of adulteration requires additional testing	Detection and confirmation of adulteration of milk products requires advanced laboratory analyses, or testing for adulteration is not available at all
4	availability technology and knowledge of adulteration final product	How available is the **technology and knowledge** to enable the **adulteration** of your final products?	No technologies and/or adulteration methods are known or available to adulterate final products	Advanced technologies, methods, facilities and knowledge are required to adulterate final products	Simple/basic technologies and methods are available, and no specialist facilities are required, to adulterate final products; The knowledge required for adulteration is generally available
5	knowledge required for detection final product	How easily would **adulteration** of your final products be **detected** and what kind of methods are available?	Detection of adulteration of final products is easy and performed with common/simple methods (e.g. visual inspection, smelling)	Established on-site methods are available for fraud screening (e.g. test kits) but confirmation of adulteration requires additional testing	Detection and confirmation of adulteration of final products requires advanced laboratory analyses, or testing for adulteration is not available at all
6	accessibility to production line	How would you describe the processing activities in your company?	Production lines and processing activities are characterized by continuous flow processes and minor equipment modifications between batches, with only authorized personnel access both day and night	Production lines and processing activities are characterized by large batches with minor equipment modifications between batches (repetitive flow), with the opportunity for unauthorized access to equipment but no night processing	Production lines and processing activities are characterized by relatively small batches with major modifications between batches (intermittent flow), and the opportunity for unauthorized access both during day and night
7	transparency of chain network	How would you describe generally the transparency in the milk supply chain?	The supply chain is transparent, integrated, well-coordinated, with comprehensive information exchange across the supply chain, each sector has good insight into the supplier and customer.	Some degree of integration exists across the supply chain; only direct supplier and customer are known; and information exchange occurs mainly with direct suppliers and customers	The supply chain is complex and lacks transparency; typically customers and suppliers are geographically dispersed, No information exchange occurs between direct suppliers and customers
8	relationship within the supply chain	How do you characterize generally the relationships in the milk	Business relationships are long-term relationships and	Business relationships are variable; some relationships are long-	Business relationships are ad-hoc and price is the main driver for selecting suppliers

		supply chain you are part of?	characterized by trust	term, others short-term	
9	historical evidence of milk fraud	Are you aware of any milk fraudulent incidents? Or have fraudulent incidents of liquid milk been reported?	No milk fraudulent incidents are known; No documentation or evidence of milk incidents is available	A few fraudulent incidents have occurred; Limited documentation and few/no media reports are available	Many fraudulent incidents have occurred; Incidents are well known and documented, and have received substantial media attention
10	supply and price of milk	How would you describe the supply and price of the liquid milk?	Price of liquid milk is stable and independent of the geographical origin price of substitute of liquid milk is equivalent liquid milk are readily available; No export bans on liquid milk exist	Price of liquid milk fluctuates slightly and somehow depends on the geographical origin export bans on liquid milk exist in some counties; liquid milk is not readily available	Price spikes of liquid milk are common; price depends on geographical original largely; prices of substitute vary greatly export bans on liquid milk exist in many countries, tight global supplies of liquid milk and/or shortages exist
11	valuable components/ attributes	Do special attributes or components determine the value of the liquid milk? E.g. protein or fat contents, outdoor grazing (pasture milk), organic production, etc.	The value of liquid milk is not determined by its composition, way of production or origin	The value of liquid milk is influenced by its composition (e.g. protein or fat content)	Value of liquid milk is greatly determined by its composition, way of production and/or origin
12	economic health	How would you describe the economic health of your company?	The company is profitable, achieving its financial goals	Profits are declining and there is a gap between financial targets and actual performance	There are financial losses and it is difficult to meet financial targets
13	business strategy	What are the characteristics of the business strategy of your company?	Long term financial targets, coupled with food quality and safety goals, and the means by which the objectives should be achieved, are well specified	Financial targets and food quality and safety goals are ambiguous There is a lack of clarity about the means to achieve these objectives	There is a strong emphasis to achieve (short-term) financial goals, while the means to achieve them legitimately is not specified
14	ethical business culture	How would you describe the ethical business culture of your company?	Mutual trust, interest & respect between all employees across the company; Standards, codes and requirements are taken seriously by all employees; Discussions on unethical conduct & moral issues/dilemmas are common; Reports on unethical conduct are always taken seriously, and corrections of unethical activities are encouraged and acknowledged; Ethical conduct is highly valued and rewarded by senior management	Mutual trust, interest & respect between some of the employees but not the whole company; Standards, codes and requirements are taken seriously by most of the employees; Discussions on unethical conduct & moral issues/dilemmas are limited to specific incidents; Reports on unethical conduct are not always taken seriously, and corrections of unethical activities are not acknowledged to all the employees; Ethical conduct is not equally valued, nor rewarded by senior management	there is no mutual trust, interest & respect between employees across the company; Standards, codes and requirements are not taken seriously in the whole company; there is no discussions on unethical conduct or moral issues/dilemmas; there is no reports on unethical conduct nor the corrections of unethical activities are encouraged or acknowledged; Ethical conduct is not valued or rewarded by senior management
15	previous irregularities	Has your company been involved in irregularities (quality, safety, authenticity) previously?	The company has not been involved in irregularities in the past	There is no information whether the company has been involved in irregularities in the past	The company has been involved in irregularities in the past
16	corruption level	How would you rate the corruption level (according to the Transparency International Corruption Perception Index) in the countries where your	The company is active in countries with low levels of corruption (rated 1-25 on the Index)	The company is active in countries with medium levels of corruption (rated 26-75 on the Index)	The company is active in countries with high levels of corruption (rated 76 and above on the Index)

		company is active?			
17	financial pressure imposed by your company on supplier(s)	How would you describe the financial strains of imposed by your company on your direct supplier(s)?	The company sets fixed prices for farm in line with market prices, and the farm has several customers	The company typically buys from farmers that offer the lowest price and the farm is somewhat (but not solely) dependent on the company for their financial survival	The company always buys from farmers that offer the lowest prices and the farm is completely dependent on the company for their financial survival
18	**supplier** economic health	How would you describe the economic health of your supplier?	The supplier(s) is profitable and achieving its financial targets	The supplier(s) profits are declining, and there is a gap between their financial targets and actual performance	There are financial losses and it has difficulty to meet financial targets
19	**supplier** business strategy	What are the characteristics of the business strategy of your supplier(s)?	Long term financial targets, coupled with food quality and safety goals, and the means by which the objectives should be achieved, are well specified	Financial targets and food quality and safety goals are ambiguous, and there's a lack of clarity about the means to achieve these objectives	There is a strong emphasis to achieve (short-term) financial goals, while the means to achieve them legitimately is not specified
20	**supplier** ethical business culture	How would you describe the ethical business culture of your supplier(s)?	Mutual trust, interest & respect between all employees across the dairy farm; Discussions on unethical conduct & moral issues/dilemmas are common; Reports on unethical conduct are always taken seriously, and corrections of unethical activities are encouraged and acknowledged; Ethical conduct is highly valued and rewarded by senior management	Mutual trust, interest & respect between some of the employees but not the whole farm; Standards, codes and requirements are taken seriously by most of the employees; Discussions on unethical conduct & moral issues/dilemmas are limited to specific incidents; Reports on unethical conduct are not always taken seriously, and corrections of unethical activities are not acknowledged to all the employee; Ethical conduct is not equally valued, nor rewarded by senior management	There is no mutual trust, interest & respect between employees across the suppplier farm; Standards, codes and requirements are not taken seriously in the whole farm; There is no discussions on unethical conduct or moral issues/dilemmas; There is no reports on unethical conduct nor the corrections of unethical activities are encouraged or acknowledged; Ethical conduct is not valued or rewarded by senior management
21	**supplier** previous irregularities	Has your supplier(s) been involved in irregularities (safety, quality, authenticity or otherwise) previously ?	The supplier has not been involved in irregularities in the past	There is no information whether the supplier has been involved in irregularities in the past	The supplier has been involved in irregularities in the past
22	Victimization of **supplier**	Has your supplier(s) been a victim of food fraud committed by their suppliers, customers or other parites?	The supplier has not been a victim of food fraud in the past	There is no information available as to whether the supplier has been a victim of food fraud in the past	The supplier has been a victim of food fraud in the past
23	**supplier and customer**'s corruption level	How would you rate the corruption level (according to the Transparency International Corruption Perception Index) in the countries where your direct supplier(s) and customers are active?	Suppliers and customers are active in countries with low levels of corruption	Suppliers and customers are active in countries with medium levels of corruption	Suppliers and customers are active in countries with high levels of corruption

24	sector economic health	How would you describe the economic health across your sector of the food supply chain (i.e. your company and your direct competitors)?	The company operates in a growing market(s)	The company operates in a stable or fluctuant market	The company operates in a declining market(s)
25	**customer** previous irregularities	Has your **customer(s)** been involved in **criminal offences** previously?	The customer has not committed irregularities in the past	There is no information whether the customer has committed irregularities in the past The customer may have been committed irregularities in the past	The customer has committed irregularities in the past
26	**sector** ethical business culture	How would you describe the ethical business culture across your sector of the food supply chain (i.e. your company and your direct competitors)?	Branch of industry culture is characterized by a high level of mutual trust and respect, ethical discussions and ethical conduct is highly valued between companies	Branch of industry culture is characterized by overall mutual trust, limited and ad hoc ethical discussions and ethical conduct is moderately valued between companies	Branch of industry culture is characterized by lack of mutual trust & interests, restricted/no moral/ethical discussions and ethical conduct is not valued between companies
27	historical evidence of milk fraud, within sector	How common are irregularities across your sector of the food supply chain? (i.e. your company and your direct competitors)?	There is no evidence of fraudulent activity or other forms of law breaking in our sector	There may have been incidences of fraud across the sector but there is no specific information available	There is well-known and documented evidence of fraudulent activity across our sector of the food industry
28	level of competition in the sector	How would you rate the level of competition across your sector of the food supply chain (i.e. your company and your direct competitors)?	Low levels of competition across the sector	Medium levels of competition across the sector	Highly competitive sector of the food industry
29	price asymmetries	Are there price differences as a result of regulatory differences across countries?	The price policy of liquid milk is similar for all countries	The price policy of liquid milk is different in some countries	The price policy of liquid milk varies considerably across different countries
30	fraud monitoring system in place raw material	How would you rate your company's raw material monitoring control systems' ability to **detect fraud**?	Sampling plan only for safety and quality analyses but not for authenticity check; No methods for fraud detection in place external authenticity analysis only in case of inspection demands/fraud issues; No procedures for fraud monitoring tasks; No record keeping on adulterated or suspicious raw materials and no documentation of fraud procedures	No systematic, ad-hoc sampling for fraud analysis; General screening (quick) methods in place but no or ad-hoc (external) confirmatory fraud testing; General procedure for sampling and screening for ad-hoc monitoring of products for fraud issues; Mainly record-keeping in case of deviations; limited documentation on fraud monitoring procedures/system	Systematic, evidence-based (using both historical and scientific data) sampling plan for fraud-related analyses; Specific fraud screening methods and systematic use of fit-for-purpose confirmatory techniques (in house or in collaboration with accredited laboratory); Customized procedures for fraud monitoring and handling of non- conformities; Systematic-record keeping and detailed documentation of fraud monitoring procedures & fraud monitoring system design
31	systematics and autonomy of verification of fraud monitoring system raw material	Are the fraud monitoring tasks of your raw material control system **verified** in your company?	No verification of actual compliance to monitoring tasks at final product control	Ad hoc and/or announced verification of compliance to monitoring tasks mainly based on analysis of records and check of presence of procedures (e.g. as part of auditing); Ad-hoc reporting of verification outcomes; mainly in case of deviations	Systematic, comprehensive (document & record analysis, observations, and actual verification testing) and unannounced verification by autonomous controller; Systematic documentation of verification activities and outcomes

32	final product monitoring control system	How would you describe the **fraud related parts** of your final product monitoring control system of your company?	Sampling plan only for safety and quality analyses but not for authenticity check; No methods for fraud detection in place external authenticity analysis only in case of inspection demands/fraud issues; No procedures for fraud monitoring tasks; No record keeping on adulterated or suspicious raw materials and no documentation of fraud procedures	No systematic, ad-hoc sampling for fraud analysis; General screening (quick) methods in place but no or ad-hoc (external) confirmatory fraud testing; General procedure for sampling and screening for ad-hoc monitoring of products for fraud issues; Mainly record-keeping in case of deviations; limited documentation on fraud monitoring procedures/system	Systematic, evidence-based (using both historical and scientific data) sampling plan for fraud-related analyses; Specific fraud screening methods and systematic use of fit-for-purpose confirmatory techniques (in house or in collaboration with accredited laboratory); Customized procedures for fraud monitoring and handling of non- conformities; Systematic-record keeping and detailed documentation of fraud monitoring procedures & fraud monitoring system design
33	final product control system verification	Are the fraud monitoring tasks of your final product control system **verified** in your company?	No verification of actual compliance to monitoring tasks at final product control	Ad hoc and/or announced verification of compliance to monitoring tasks mainly based on analysis of records and check of presence of procedures (e.g. as part of auditing); Ad-hoc reporting of verification outcomes; mainly in case of deviations	Systematic, comprehensive (document & record analysis, observations, and actual verification testing) and unannounced verification by autonomous controller; Systematic documentation of verification activities and outcomes
34	information system for mass balance control	How extensive is the information system for internal control of mass balance flows in your company?	Basic administrative system with limited information or no specific information on mass balances of incoming milk and final milk products; Data is only analysed in case of inspection requirements	Process monitoring information system with accurate information on mass balances of mainly bulk ingredients; No integral analysis of mass flow data throughout the company (including internal suppliers)	Established and comprehensive (accurate mass balance data, of all crucial ingredients, materials, & final product flows) process monitoring information system dedicated for control of mass balance flows; Structured record keeping of mass flow information and systematic analysis of integral data of whole company (including internal suppliers)
35	tracing and tracking system	How extensive is the tracking & tracing system of your company?	Traceability system without clearly defined traceability resource units or units cannot be exactly defined (e.g. because of continuous flow); Uncertainty about accuracy of information, and limited/no fraud relevant information; Data capturing and retrieval system is not fraud proof	System with clearly defined traceability resource units; Collection of accurate information but not specifically addressing fraud issues, only information on company level; Computer-based data capturing & retrieval system but not systematically controlled (restricted possibilities for fraud)	System with clearly defined traceability resource units (product level; collection of accurate information including fraud-relevant issues from direct supplier up to direct customer; Advanced automated and systematically controlled robust data capturing and data retrieval system (fraud proof)
36	integrity screening of employees	Is integrity screening of employees common procedure in your company?	No integrity screening of employees	Use of established integrity screening methods for employees at key positions	Use of established integrity screening methods is standard for employment of all personnel
37	ethical code of conduct	Is there an ethical code of conduct or guideline in place and embedded in your company?	No written code of ethical conduct or guideline exist	General written code of ethical conduct or guidelines is available, but not acknowledged to all employees, or code is not explicitly embedded in management activities	Detailed written code of ethical conduct or guideline is available and well embedded; awareness amongst all personnel is stimulated (e.g. posters, communication) and demonstrated in management activities

38	whistle blowing	Is there a whistle blowing system (system for reporting assumed fraudulent activities) in place in your company?	No whistle blowing system exists	Whistle blowing system is available, but no clear protection system for the whistle blower is in place, and reporting of fraudulent activity goes to supervisor (no independent officer)	Whistle blowing system is well-established and well-known among personnel, fraudulent practices can be reported to an independent officer, and anonymity of the whistle blower is strictly protected
39	contractual requirement with **suppliers**	Do contractual requirements with your suppliers include elements that limit opportunities for fraud?	Contractual requirements for suppliers are mainly set on logistic parameters: cost, amount and availability	Contractual requirements are established together with supplier(s) for both logistic and safety & quality parameters	Comprehensive contractual requirements established in close collaboration with supplier(s) addressing logistics, safety and quality, but also requirements on adoption of ethical code/guidelines, and adoption of similar technical fraud control measures
40	**supplier** fraud control system	What best describes the **fraud control system** of your **supplier**(s)?	Direct supplier(s) don't have a FSMS or the FSMS is limited (not audited externally, no fraud measures in place)	Direct supplier(s) has a well-established FSMS in place that is regularly audited by a 3rd party and uses basic fraud screening methods	Direct supplier(s) has a well-established FSMS in place that is regularly audited by a 3rd party and systematically uses fraud screening methods and confirmatory tests to identify suspicious materials
41	**supplier** information system for mass balance control	How extensive is the information system for control of mass balance flows of your supplier(s)?	Basic administrative system with limited information or no specific information on mass balances of incoming milk and final milk products; Data is only analysed in case of inspection requirements	Process monitoring information system with accurate information on mass balances of mainly bulk ingredients; No integral analysis of mass flow data throughout the supplier (including internal suppliers)	Established and comprehensive (accurate mass balance data, of all crucial ingredients, materials, & final product flows) process monitoring **information system** dedicated for control of mass balance flows; Structured **record keeping** of mass flow information and systematic analysis of integral data of whole supplier(including internal suppliers)
42	**supplier** tracing and tracking system	How extensive is the traceability system of your direct **supplier**(s)?	**Traceability system** without clearly defined traceability resource units or units cannot be exactly defined (e.g. because of continuous flow); Uncertainty about accuracy of information, and limited/no fraud relevant information; **Data capturing and retrieval system** is not fraud proof	System with clearly defined traceability resource units; Collection of accurate information but not specifically addressing fraud issues, only information on company level; Computer-based data capturing & retrieval system but not systematically controlled (restricted possibilities for fraud)	System with clearly defined traceability resource units (product level; collection of accurate information including fraud-relevant issues from direct supplier up to direct customer; Advanced automated and systematically controlled robust data capturing and data retrieval system (fraud proof)
43	social control and transparency chain network	How would you describe the social control and transparency of actions across your supply chain?	No self-regulation and poor communication between companies across the supply chain; Limited/no self-regulating tools (e.g. code of conduct, certification scheme) exist, limited/no monitoring on compliance; Unethical conduct is rarely communicated	The supply chain has a certain degree of self-regulation but communication depends on individual companies (i.e. not systematic); Self-regulating tools (e.g. code of conduct, certification scheme) exist but are not widely implemented and compliance is not monitored systematically; Only serious/obvious unethical conduct and/or incident are communicated	The supply chain self-regulates and communication between companies is very active; Self-regulating tools (e.g. code of conduct, certification scheme) are widely implemented and compliance is monitored systematically; All unethical conduct is systematically communicated across the supply chain and information is widely shared

44	guidance for fraud prevention and control	How well established is guidance for fraud prevention and control across your sector of the food supply chain? (i.e. your company and your direct competitors)	Specific guidelines for fraud mitigation does not exist or aren't shared; guidelines focus on safety only	General guidelines (mainly via websites) for fraud mitigation measures are available, but there are no examples of best practices of mitigation measures	Specific guidelines and examples of best practices for fraud monitoring & mitigation are provided actively via website, training, information brochures and other mediums
45	national food policy	How would you describe your national food policy? (i.e. country-level. E.g. NVWA, COKZ)	Only a general national food policy exists without specific legislative requirements for food fraud mitigation	National food policy with generally defined legislation for food fraud mitigation but it is not harmonized with internationally recognized recommendations for food fraud mitigation	Well established national food policy with detailed specifically defined legislation to mitigate against food fraud that is harmonized with internationally recognized recommendations for food fraud mitigation
46	law enforcement local chain	How well are fraud prevention laws enforced locally?	No national fraud related enforcement practice exists; no fines/sanctions or very limited fines	Fraud-related enforcement practices exist but with low frequency of inspections by regulatory/law enforcement agencies; Low level of fines/sanctions with little financial impact	Systematic fraud-related enforcement practices with risk-based frequency of inspections by regulatory/law enforcement agencies; High level of fines/sanctions with substantial financial impact
47	law enforcement international chain	How well are fraud related laws enforced across your international supply chain?	No national fraud related enforcement practice exists; no fines/sanctions or very limited fines	Fraud-related enforcement practices exist but with low frequency of inspections by regulatory/law enforcement agencies; Low level of fines/sanctions with little financial impact	Systematic fraud-related enforcement practices with risk-based frequency of inspections by regulatory/law enforcement agencies; High level of fines/sanctions with substantial financial impact
48	contingency plan	Does your company have fraud contingency measures in place?	No documented risk/contingency plan for fraud issues is in place	A documented risk/contingency plan is in place with communication principles and tools for safety issues and recalls, but fraud issues not explicitly addressed	An integrated risk/contingency plan for both fraud and safety issues is in place, with detailed communication principles and tools that are well documented and updated regularly

APPENDIX 2. Questionnaire for food retailers

No.	Indicator	Question	answer1 (low level)	answer 2 (medium level)	answer 3 (high level)
1	complexity of adulteration	Do you think it is easy or complex to add or remove something to/from liquid milk?	Composition of the liquid milk cannot be modified and milk products can only be replaced	Composition of the liquid milk can be modified by mixing with low-quality product-own material or foreign material, e.g. add reconstituted powder, melamine, sell conventional milk as organic, etc.	Composition of the liquid milk can be modified by mixing with low-quality or foreign material (e.g. powders, etc.) and by altering valuable food components (e.g. protein and/or fat content
2	availability technology and knowledge of adulteration	Do you think that the technology and knowledge to adulterate liquid milk are generally available?	Technologies and/or methods to adulterate the liquid milk are neither available, known, or reported; Knowledge to adulterate liquid milk is neither available, known or reported.	Advanced technologies, methods, facilities are required to adulterate the liquid milk; Professional and technical knowledge is required to adulterate the liquid milk	**Simple/basic** technologies and methods are available, and no specialist facilities are required, to adulterate the liquid milk; Knowledge required for adulteration is generally available.

3	detection method	How simple or complex are the test methods to detect the adulteration of liquid milk, do you think?	Detection of adulteration of milk is easy and performed with common/simple methods (e.g. visual inspection, smelling)	Established on-site methods are available for fraud screening (e.g. test kits) but confirmation of adulteration requires additional testing	Detection and confirmation of adulteration of milk products requires advanced laboratory analyses, or testing for adulteration is not available at all
4	availability technology and knowledge of adulteration final product	Not applicable	Not applicable	Not applicable	Not applicable
5	knowledge required for detection final product	Not applicable	Not applicable	Not applicable	Not applicable
6	accessibility to production line	Not applicable	Not applicable	Not applicable	Not applicable
7	transparency of chain network	How would you describe generally the transparency in the milk supply chain?	The supply chain is transparent, integrated, well-coordinated, with comprehensive information exchange across the supply chain, each sector has good insight into the supplier and customer.	Some degree of integration exists across the supply chain; only direct supplier and customer are known; and information exchange occurs mainly with direct suppliers and customers	The supply chain is complex and lacks transparency; typically customers and suppliers are geographically dispersed, No information exchange occurs between direct suppliers and customers
8	relationship within the supply chain	How do you characterize generally the relationships in the milk supply chain you are part of?	Business relationships are long-term relationships and characterized by trust	Business relationships are variable; some relationships are long-term, others short-term	Business relationships are ad-hoc and price is the main driver for selecting suppliers
9	historical evidence of milk fraud	Are you aware of any milk fraudulent incidents? Or have fraudulent incidents of liquid milk been reported?	No milk fraudulent incidents are known; No documentation or evidence of milk incidents is available	A few fraudulent incidents have occurred; Limited documentation and few/no media reports are available	Many fraudulent incidents have occurred; Incidents are well known and documented, and have received substantial media attention
10	supply and price of milk	How would you describe the supply and price of the liquid milk?	Price of liquid milk is stable and independent of the geographical origin price of substitute of liquid milk is equivalent liquid milk are readily available; No export bans on liquid milk exist	Price of liquid milk fluctuates slightly and somehow depends on the geographical origin export bans on liquid milk exist in some counties; liquid milk is not readily available	Price spikes of liquid milk are common; price depends on geographical original largely; prices of substitute vary greatly export bans on liquid milk exist in many countries, tight global supplies of liquid milk and/or shortages exist
11	valuable components/ attributes	Do special attributes or components determine the value of the liquid milk? E.g. protein or fat contents, outdoor grazing (pasture milk), organic production, etc.	The value of liquid milk is not determined by its composition, way of production or origin	The value of liquid milk is influenced by its composition (e.g. protein or fat content)	Value of liquid milk is greatly determined by its composition, way of production and/or origin
12	economic health	How would you describe the economic health of your company?	The company is profitable, achieving its financial goals	Profits are declining and there is a gap between financial targets and actual performance	There are financial losses and it is difficult to meet financial targets
13	business strategy	What are the characteristics of the business strategy of your company?	Long term financial targets, coupled with food quality and safety goals, and the means by which the objectives should be achieved, are well specified	Financial targets and food quality and safety goals are ambiguous There is a lack of clarity about the means to achieve these objectives	There is a strong emphasis to achieve (short-term) financial goals, while the means to achieve them legitimately is not specified

14	ethical business culture	How would you describe the ethical business culture of your company?	Mutual trust, interest & respect between all employees across the company; Standards, codes and requirements are taken seriously by all employees; Discussions on unethical conduct & moral issues/dilemmas are common; Reports on unethical conduct are always taken seriously, and corrections of unethical activities are encouraged and acknowledged; Ethical conduct is highly valued and rewarded by senior management	Mutual trust, interest & respect between some of the employees but not the whole company; Standards, codes and requirements are taken seriously by most of the employees; Discussions on unethical conduct & moral issues/dilemmas are limited to specific incidents; Reports on unethical conduct are not always taken seriously, and corrections of unethical activities are not acknowledged to all the employees; Ethical conduct is not equally valued, nor rewarded by senior management	there is no mutual trust, interest & respect between employees across the company; Standards, codes and requirements are not taken seriously in the whole company; there is no discussions on unethical conduct or moral issues/dilemmas; there is no reports on unethical conduct nor the corrections of unethical activities are encouraged or acknowledged; Ethical conduct is not valued or rewarded by senior management
15	previous irregularities	Has your company been involved in irregularities (quality, safety, authenticity) previously?	The company has not been involved in irregularities in the past	There is no information whether the company has been involved in irregularities in the past	The company has been involved in irregularities in the past
16	corruption level	How would you rate the corruption level (according to the Transparency International Corruption Perception Index) in the countries where your company is active?	The company is active in countries with low levels of corruption (rated 1-25 on the Index)	The company is active in countries with medium levels of corruption (rated 26-75 on the Index)	The company is active in countries with high levels of corruption (rated 76 and above on the Index)
17	financial pressure imposed by your company on supplier(s)	How would you describe the financial strains of imposed by your company on your direct supplier(s)?	The company sets fixed prices for supplier in line with market prices, and the supplier has several customers	The company typically buys from supplier(s) that offer the lowest price and the supplier is somewhat (but not solely) dependent on the company for their financial survival	The company always buys from suppliers that offer the lowest prices and the suppliers are completely dependent on the company for their financial survival
18	**supplier** economic health	How would you describe the economic health of your supplier?	The supplier(s) is profitable and achieving its financial targets	The supplier(s) profits are declining, and there is a gap between their financial targets and actual performance	There are financial losses and it has difficulty to meet financial targets
19	**supplier** business strategy	What are the characteristics of the business strategy of your supplier(s)?	Long term financial targets, coupled with food quality and safety goals, and the means by which the objectives should be achieved, are well specified	Financial targets and food quality and safety goals are ambiguous, and there's a lack of clarity about the means to achieve these objectives	There is a strong emphasis to achieve (short-term) financial goals, while the means to achieve them legitimately is not specified
20	**supplier** ethical business culture	How would you describe the ethical business culture of your supplier(s)?	Mutual trust, interest & respect between all employees across the dairy farm; Discussions on unethical conduct & moral issues/dilemmas are common; Reports on unethical conduct are always taken seriously, and corrections of unethical activities are encouraged and acknowledged; Ethical conduct is highly valued and rewarded by senior management	Mutual trust, interest & respect between some of the employees but not the whole farm; Standards, codes and requirements are taken seriously by most of the employees; Discussions on unethical conduct & moral issues/dilemmas are limited to specific incidents; Reports on unethical conduct are not always taken seriously, and corrections of unethical activities are not acknowledged to all the employee;	There is no mutual trust, interest & respect between employees across the suppplier farm; Standards, codes and requirements are not taken seriously in the whole farm; There is no discussions on unethical conduct or moral issues/dilemmas; There is no reports on unethical conduct nor the corrections of unethical activities are encouraged or acknowledged; Ethical conduct is not valued or rewarded by senior management

				Ethical conduct is not equally valued, nor rewarded by senior management	
21	**supplier** previous irregularities	Has your supplier(s) been involved in irregularities (safety, quality, authenticity or otherwise) previously ?	The supplier has not been involved in irregularities in the past	There is no information whether the supplier has been involved in irregularities in the past	The supplier has been involved in irregularities in the past
22	Victimization of **supplier**	Has your supplier(s) been a victim of food fraud committed by their suppliers, customers or other parites?	The supplier has not been a victim of food fraud in the past	There is no information available as to whether the supplier has been a victim of food fraud in the past	The supplier has been a victim of food fraud in the past
23	**supplier and customer**'s corruption level	How would you rate the corruption level (according to the Transparency International Corruption Perception Index) in the countries where your direct supplier(s) and customers are active?	Suppliers and customers are active in countries with low levels of corruption	Suppliers and customers are active in countries with medium levels of corruption	Suppliers and customers are active in countries with high levels of corruption
24	sector economic health	How would you describe the economic health across your sector of the food supply chain (i.e. your company and your direct competitors)?	The company operates in a growing market(s)	The company operates in a stable or fluctuant market	The company operates in a declining market(s)
25	**customer** previous irregularities	Not applicable	Not applicable	Not applicable	Not applicable
26	**sector** ethical business culture	knowledge required for detection final product	Branch of industry culture is characterized by a high level of mutual trust and respect, ethical discussions and ethical conduct is highly valued between companies	Branch of industry culture is characterized by overall mutual trust, limited and ad hoc ethical discussions and ethical conduct is moderately valued between companies	Branch of industry culture is characterized by lack of mutual trust & interests, restricted/no moral/ethical discussions and ethical conduct is not valued between companies
27	historical evidence of milk fraud, within sector	accessibility to production line	There is no evidence of fraudulent activity or other forms of law breaking in our sector	There may have been incidences of fraud across the sector but there is no specific information available	There is well-known and documented evidence of fraudulent activity across our sector of the food industry
28	level of competition in the sector	How would you rate the level of competition across your sector of the food supply chain (i.e. your company and your direct competitors)?	Low levels of competition across the sector	Medium levels of competition across the sector	Highly competitive sector of the food industry
29	price asymmetries	Are there price differences as a result of regulatory differences across countries?	The price policy of liquid milk is similar for all countries	The price policy of liquid milk is different in some countries	The price policy of liquid milk varies considerably across different countries
30	fraud monitoring system in place raw material	How would you rate your company's **milk product** monitoring control systems' ability to **detect fraud**?	Sampling plan only for safety and quality analyses but not for authenticity check; No methods for fraud detection in place external authenticity analysis only in case of inspection demands/fraud issues; No procedures for fraud monitoring tasks; No record keeping on adulterated or suspicious raw materials and no documentation of fraud	No systematic, ad-hoc sampling for fraud analysis; General screening (quick) methods in place but no or ad-hoc (external) confirmatory fraud testing; General procedure for sampling and screening for ad-hoc monitoring of products for fraud issues; Mainly record-keeping in case of deviations; limited documentation on fraud monitoring procedures/system	Systematic, evidence-based (using both historical and scientific data) sampling plan for fraud-related analyses; Specific fraud screening methods and systematic use of fit-for-purpose confirmatory techniques (in house or in collaboration with accredited laboratory); Customized procedures for fraud monitoring and handling of non-conformities; Systematic-record keeping and detailed documentation

			procedures		of fraud monitoring procedures & fraud monitoring system design
31	systematics and autonomy of verification of fraud monitoring system raw material	Are the fraud monitoring tasks of **milk product** control system **verified** in your company?	No verification of actual compliance to monitoring tasks at final product control	Ad hoc and/or announced verification of compliance to monitoring tasks mainly based on analysis of records and check of presence of procedures (e.g. as part of auditing); Ad-hoc reporting of verification outcomes; mainly in case of deviations	Systematic, comprehensive (document & record analysis, observations, and actual verification testing) and unannounced verification by autonomous controller; Systematic documentation of verification activities and outcomes
32	final product monitoring control system	Not applicable	Not applicable	Not applicable	Not applicable
33	final product control system verification	Not applicable	Not applicable	Not applicable	Not applicable
34	information system for mass balance control	How extensive is the information system for internal control of mass balance flows in your company?	Basic administrative system with limited information or no specific information on mass balances of incoming and final milk products; Data is only analysed in case of inspection requirements	Process monitoring information system with accurate information on mass balances of milk products; No integral analysis of mass flow data throughout the company (including internal suppliers)	Established and comprehensive process monitoring information system dedicated for control of mass balance flows; Structured record keeping of mass flow information and systematic analysis of integral data of whole company (including internal suppliers)
35	tracing and tracking system	How extensive is the tracking & tracing system of your company?	Traceability system without clearly defined traceability resource units or units cannot be exactly defined (e.g. because of continuous flow); Uncertainty about accuracy of information, and limited/no fraud relevant information; Data capturing and retrieval system is not fraud proof	System with clearly defined traceability resource units; Collection of accurate information but not specifically addressing fraud issues, only information on company level; Computer-based data capturing & retrieval system but not systematically controlled (restricted possibilities for fraud)	System with clearly defined traceability resource units (product level; collection of accurate information including fraud-relevant issues from direct supplier up to direct customer; Advanced automated and systematically controlled robust data capturing and data retrieval system (fraud proof)
36	integrity screening of employees	Is integrity screening of employees common procedure in your company?	No integrity screening of employees	Use of established integrity screening methods for employees at key positions	Use of established integrity screening methods is standard for employment of all personnel
37	ethical code of conduct	Is there an ethical code of conduct or guideline in place and embedded in your company?	No written code of ethical conduct or guideline exist	General written code of ethical conduct or guidelines is available, but not acknowledged to all employees, or code is not explicitly embedded in management activities	Detailed written code of ethical conduct or guideline is available and well embedded; awareness amongst all personnel is stimulated (e.g. posters, communication) and demonstrated in management activities
38	whistle blowing	Is there a whistle blowing system (system for reporting assumed fraudulent activities) in place in your company?	No whistle blowing system exists	Whistle blowing system is available, but no clear protection system for the whistle blower is in place, and reporting of fraudulent activity goes to supervisor (no independent officer)	Whistle blowing system is well-established and well-known among personnel, fraudulent practices can be reported to an independent officer, and anonymity of the whistle blower is strictly protected
39	contractual requirement with **suppliers**	Do contractual requirements with your suppliers include elements that limit opportunities for fraud?	Contractual requirements for suppliers are mainly set on logistic parameters: cost, amount and availability	Contractual requirements are established together with supplier(s) for both logistic and safety & quality parameters	Comprehensive contractual requirements established in close collaboration with supplier(s) addressing logistics, safety and quality, but also requirements on

					adoption of ethical code/guidelines, and adoption of similar technical fraud control measures
40	**supplier** fraud control system	What best describes the **fraud control system** of your **supplier**(s)?	Direct supplier(s) don't have a FSMS or the FSMS is limited (not audited externally, no fraud measures in place)	Direct supplier(s) has a well-established FSMS in place that is regularly audited by a 3rd party and uses basic fraud screening methods	Direct supplier(s) has a well-established FSMS in place that is regularly audited by a 3rd party and systematically uses fraud screening methods and confirmatory tests to identify suspicious materials
41	**supplier** information system for mass balance control	How extensive is the information system for control of mass balance flows of your supplier(s)?	Basic administrative system with limited information or no specific information on mass balances of incoming milk and final milk products; Data is only analysed in case of inspection requirements	Process monitoring information system with accurate information on mass balances of mainly bulk ingredients; No integral analysis of mass flow data throughout the supplier (including internal suppliers)	Established and comprehensive (accurate mass balance data, of all crucial ingredients, materials, & final product flows) process monitoring **information system** dedicated for control of mass balance flows; Structured **record keeping** of mass flow information and systematic analysis of integral data of whole supplier (including internal suppliers)
42	**supplier** tracing and tracking system	How extensive is the traceability system of your direct **supplier**(s)?	**Traceability system** without clearly defined traceability resource units or units cannot be exactly defined (e.g. because of continuous flow); Uncertainty about accuracy of information, and limited/no fraud relevant information; **Data capturing and retrieval system** is not fraud proof	System with clearly defined traceability resource units; Collection of accurate information but not specifically addressing fraud issues, only information on company level; Computer-based data capturing & retrieval system but not systematically controlled (restricted possibilities for fraud)	System with clearly defined traceability resource units (product level; collection of accurate information including fraud-relevant issues from direct supplier up to direct customer; Advanced automated and systematically controlled robust data capturing and data retrieval system (fraud proof)
43	social control and transparency chain network	How would you describe the social control and transparency of actions across the dairy supply chain?	No self-regulation and poor communication between companies across the supply chain; Limited/no self-regulating tools (e.g. code of conduct, certification scheme) exist, limited/no monitoring on compliance; Unethical conduct is rarely communicated	The supply chain has a certain degree of self-regulation but communication depends on individual companies (i.e. not systematic); Self-regulating tools (e.g. code of conduct, certification scheme) exist but are not widely implemented and compliance is not monitored systematically; Only serious/obvious unethical conduct and/or incident are communicated	The supply chain self-regulates and communication between companies is very active; Self-regulating tools (e.g. code of conduct, certification scheme) are widely implemented and compliance is monitored systematically; All unethical conduct is systematically communicated across the supply chain and information is widely shared
44	guidance for fraud prevention and control	How well established is guidance for fraud prevention and control across your sector of the dairy supply chain? (i.e. your company and your direct competitors)	Specific guidelines for fraud mitigation does not exist or aren't shared; guidelines focus on safety only	General guidelines (mainly via websites) for fraud mitigation measures are available, but there are no examples of best practices of mitigation measures	Specific guidelines and examples of best practices for fraud monitoring & mitigation are provided actively via website, training, information brochures and other mediums
45	national food policy	How would you describe your national food policy? (i.e. country-level. E.g. NVWA, COKZ)	Only a general national food policy exists without specific legislative requirements for food fraud mitigation	National food policy with generally defined legislation for food fraud mitigation but it is not harmonized with internationally recognized recommendations for food fraud mitigation	Well established national food policy with detailed specifically defined legislation to mitigate against food fraud that is harmonized with internationally recognized recommendations for food fraud mitigation

46	law enforcement local chain	How well are fraud prevention laws enforced locally?	No national fraud related enforcement practice exists; no fines/sanctions or very limited fines	Fraud-related enforcement practices exist but with low frequency of inspections by regulatory/law enforcement agencies; Low level of fines/sanctions with little financial impact	Systematic fraud-related enforcement practices with risk-based frequency of inspections by regulatory/law enforcement agencies; High level of fines/sanctions with substantial financial impact
47	law enforcement international chain	How well are fraud related laws enforced across your international supply chain?	No national fraud related enforcement practice exists; no fines/sanctions or very limited fines	Fraud-related enforcement practices exist but with low frequency of inspections by regulatory/law enforcement agencies; Low level of fines/sanctions with little financial impact	Systematic fraud-related enforcement practices with risk-based frequency of inspections by regulatory/law enforcement agencies; High level of fines/sanctions with substantial financial impact
48	contingency plan	Does your company have fraud contingency measures in place?	No documented risk/contingency plan for fraud issues is in place	A documented risk/contingency plan is in place with communication principles and tools for safety issues and recalls, but fraud issues not explicitly addressed	An integrated risk/contingency plan for both fraud and safety issues is in place, with detailed communication principles and tools that are well documented and updated regularly

APPENDIX 3. Dairy processors: interviews' outcomes

No.	Indicator	Processor 1	Processor 2	Processor 3	Processor 4
1	complexity of adulteration	1	2	2	2
2	availability technology and knowledge of adulteration	1	3	2	3
3	detection method	2	3	2	3
4	availability technology and knowledge of adulteration final product	1	1	2	3
5	knowledge required for detection final product	2	3	2	2
6	accessibility to production line	1	1	1	1
7	transparency of chain network	1	2	1	1
8	relationship within the supply chain	1	2	1	2
9	historical evidence of milk fraud	1	2	1	2
10	supply and price of milk	1	2	2	2
11	valuable components/ attributes	3	3	2	3
12	economic health	1	1	1	1
13	business strategy	1	1	1	1
14	ethical business culture	1	1	1	1
15	previous irregularities	1	1	1	3

16	corruption level	1	1	1	1
17	financial pressure imposed by your company on supplier(s)	1	1	1	1
18	**supplier** economic health	1	2	1	2
19	**supplier** business strategy	1	1	1	1
20	**supplier** ethical business culture	1	1	1	2
21	**supplier** previous irregularities	1	1	1	3
22	Victimization of **supplier**	1	1	1	2
23	**supplier and customer'**s corruption level	1	1	1	1
24	sector economic health	3	2	1	1
25	**customer** previous irregularities	1	1	1	2
26	**sector** ethical business culture	1	1	1	2
27	historical evidence of milk fraud, within sector	1	1	1	3
28	level of competition in the sector	2	3	2	2
29	price asymmetries	2	2	2	2
30	fraud monitoring system in place raw material	1	1	3	2
31	systematics and autonomy of verification of fraud monitoring system raw material	1	1	3	2
32	final product monitoring control system	2	1	3	1
33	final product control system verification	2	1	3	1
34	information system for mass balance control	3	2	3	3
35	tracing and tracking system	3	2	3	2
36	integrity screening of employees	3	1	3	1
37	ethical code of conduct	3	3	2	2
38	whistle blowing	2	2	2	3
39	contractual requirement with **suppliers**	2	3	2	2
40	**supplier** fraud control system	2	1	2	1
41	**supplier** information system for mass balance control	3	2	3	2
42	**supplier** tracing and tracking system	3	2	3	2
43	social control and transparency chain network	2	2	2	2
44	guidance for fraud prevention and control	1	2	2	2
45	national food policy	3	1	1	1
46	law enforcement local chain	2	1	3	2
47	law enforcement international chain	2	1	2	2
48	contingency plan	2	2	2	1

APPENDIX 4. Food retailers: interviews' outcomes

No.	Indicator	Retailer 1	Retailer 2	Retailer 3	Retailer4	Retailer 5
1	complexity of adulteration	2	2	3	2	3
2	availability technology and knowledge of adulteration	3	2	2	3	3
3	detection method	1	1	2	1	2
7	transparency of chain network	2	3	2	1	1
8	relationship within the supply chain	2	2	2	1	1
9	historical evidence of milk fraud	1	1	1	1	1
10	supply and price of milk	3	2	1	1	2
11	valuable components/ attributes	2	2	3	3	3
12	economic health	1	1	1	1	1
13	business strategy	3	1	1	1	1
14	ethical business culture	2	1	2	1	1
15	previous irregularities	1	1	1	1	1
16	corruption level	1	1	1	1	1
17	financial pressure imposed by your company on supplier(s)	1	2	2	2	1
18	**supplier** economic health	1	1	1	1	1
19	**supplier** business strategy	1	1	1	1	1
20	**supplier** ethical business culture	1	1	1	1	1
21	**supplier** previous irregularities	1	1	1	1	1
22	Victimization of **supplier**	2	1	2	1	1
23	**supplier and customer's** corruption level	1	1	1	1	1
24	sector economic health	3	2	3	1	1
26	**sector** ethical business culture	2	2	1	1	2
27	historical evidence of milk fraud, within sector	1	1	1	1	1
28	level of competition in the sector	3	3	3	2	3
29	price asymmetries	2	2	1	1	3
30	fraud monitoring system in place raw material	1	1	1	3	3

31	systematics and autonomy of verification of fraud monitoring system raw material	1	1	2	1	3
34	information system for mass balance control	3	1	1	2	3
35	tracing and tracking system	2	2	2	2	3
36	integrity screening of employees	3	3	2	1	3
37	ethical code of conduct	3	3	2	3	3
38	whistle blowing	3	1	3	3	3
39	contractual requirement with **suppliers**	2	3	2	3	3
40	**supplier** fraud control system	3	1	2	3	3
41	**supplier** information system for mass balance control	3	3	3	3	3
42	**supplier** tracing and tracking system	3	3	3	2	3
43	social control and transparency chain network	2	3	2	2	3
44	guidance for fraud prevention and control	1	1	2	3	1
45	national food policy	2	1	2	2	1
46	law enforcement local chain	3	1	1	1	1
47	law enforcement international chain	3	1	1	1	2
48	contingency plan	3	2	2	3	3

APPENDIX 5. Dairy processors' qualitative data gathered during the interviews

The only face-to-face interview was performed with processor 1.

Indicator	Low level	Medium level	High level	Qualitative data
complexity of adulteration	1	3	0	**PRO 1** I think is answer 1
availability technology and knowledge of adulteration	1	1	2	**PRO 1** I think is answer 1: technologies and knowledge are not generally available
detection method	0	2	2	**PRO 1** I think is answer 2: there are some available methods
availability technology and knowledge of adulteration final product	2	1	1	**PRO 1** I think is answer 1: for fresh milk no methods are available
knowledge required for detection final product	0	3	1	**PRO 1** I think is answer 2
accessibility to production line	4	0	0	**PRO 1** I think answer 1: continuous flow processes and only authorized personnel
transparency of chain network	3	1	0	**PRO 1** Answer 1: it is easy to obtain information about farmers, and milk produced by every farmer is control by Q-Lip

				(independent lab)
relationship within the supply chain	2	2	0	**PRO 1** I think is answer 1
historical evidence of milk fraud	2	2	0	**PRO 1** I think is answer 1
supply and price of milk	1	3	0	**PRO 1** I think the prices are low, but there are some increases in price for farmers. The price is quite stable, there are some little fluctuations during the year. Answer 1.
valuable components/ attributes	0	1	3	**PRO 1** I think is answer 3: the amount of fat and protein are important
economic health	4	0	0	**PRO 1** The company is profitable. Answer 1
business strategy	4	0	0	**PRO 1** I think is answer 1
ethical business culture	4	0	0	**PRO 1** Answer 1: open discussion between our factory workers and management team
previous irregularities	3	0	1	**PRO 1** Answer 1: no previous irregularities
corruption level	4	0	0	
financial pressure imposed by your company on supplier(s)	4	0	0	**PRO 1** Answer 1: agreement on prices between processor and its supplier
supplier economic health	2	2	0	**PRO 1** Answer 1: supplier is economically healthy
supplier business strategy	4	0	0	**PRO 1** Answer 1: long term financial targets
supplier ethical business culture	3	1	0	**PRO 1** I think is answer 1
supplier previous irregularities	3	0	1	**PRO 1** Answer 1: no previous irregularities
Victimization of supplier	3	1	0	**PRO 1** Answer 1: no information as far as I know
supplier and customer's corruption level	4	0	0	**PRO 1** I think is answer 1
sector economic health	2	1	1	**PRO 1** Answer 3: declining market for fresh milk products
customer previous irregularities	3	1	0	**PRO 1** Answer 1: no information as far as I know
sector ethical business culture	3	1	0	**PRO 1** Answer 1: all competitors want to have high standards of quality for fresh milk and the discussion is open.
historical evidence of milk fraud, within sector	3	0	1	**PRO 1** I think is answer 1
level of competition in the sector	0	3	1	**PRO 1** I think is answer 2: there is fair competition in this moment for fresh milk
price asymmetries	0	4	0	**PRO 1** Answer 2: price policy is different in some countries such as Belgium and Germany
fraud monitoring system in place raw material	2	1	1	**PRO 1** Answer 1: no
systematics and autonomy of verification of fraud monitoring system raw material	2	1	1	**PRO 1** I think is answer 1
final product monitoring control system	2	1	1	**PRO 1** I think is answer 1
final product control system verification	2	1	1	**PRO 1** I think is answer 2
information system for mass balance control	0	1	3	**PRO 1** Answer 3.
tracing and tracking system	0	2	2	**PRO 1** Answer 3: it is very easy to get information; we know exactly for every batch from where it comes from
integrity screening of employees	2	0	2	**PRO 1** Answer 3: for every new employee
ethical code of conduct	0	2	2	**PRO 1** Answer 3: there is an ethical code. We speak to each other
whistle blowing	0	3	1	**PRO 1** Answer 2. There is no whistle blowing system but we hope that employees will tell us when something is wrong. There is a dedicated person with who employees can speak with confidentially.
contractual requirement with suppliers	0	3	1	**PRO 1** I think it is 3, heading a bit towards 2. Suppliers have to comply with conditions in the contract.
supplier fraud control system	2	2	0	**PRO 1** I think is answer 2 **PRO 2** Answer 1: it is part of X' Supplier Audit, however we don't have all the relevant information

supplier **information system for mass balance control**	0	2	2	**PRO 1** I think for most of our suppliers is answer 3
supplier **tracing and tracking system**	0	2	2	**PRO 1** I think is answer 3
social control and transparency chain network	0	4	0	**PRO 1** I think is answer 2
guidance for fraud prevention and control	1	3	0	**PRO 1** I think is answer 1, no written guidelines so far
national food policy	3	0	1	**PRO 1** I think is answer 3
law enforcement local chain	1	2	1	**PRO 1** I think is answer 2
law enforcement international chain	1	3	0	**PRO 1** We have no international supply chain
contingency plan	1	3	0	**PRO 1** I think is answer 2: We have a contingency plan but not for fraud, only for quality problem.

APPENDIX 6. Food retailers' qualitative data gathered during the interviews

Face-to-face interviews were performed with retailers 1, 2, 3 and 4.

Indicator	Low level	Medium level	High level	Qualitative data
complexity of adulteration	0	3	2	RET 1-2-4 I think is answer 2: it is quite easy to mix milk RET 3-5 I think is answer 3
availability technology and knowledge of adulteration	0	2	3	Ret 1: it is the third answer because many knowledges are available for adulteration RET 2: answer 2. There are technology present, but we can still further develop methods to detect RET 3: answer 2 RET 4: answer 3. I think basically it is simple to adulterate
detection method	3	2	0	RET 1: I don't really know but I choose answer 1 because with all the systems present, it should be easy to detect RET 2: answer 1. It is difficult to detect because you do not know what you are looking for. We are at the beginning stage for fraud RET 3: answer 2. A normal lab would be able to check RET 4: answer 1. It is not so easy to detect adulterants in milk, and it is even more complicated to make differences between organic and conventional milk (as far as I know)
transparency of chain network	2	2	1	RET 1: I choose the answer 2. Information exchange mainly with direct suppliers and customers, not all over the chain RET 2: answer 3. We know from where we are buying the milk. No knowledge about who is supplying milk to milk's processors. It is complex also because of the many farmers that supply milk RET 3: answer 2. The transparency is not fully, we don't know from which farms the milk is from RET 4: answer 1, open discussion. I can also go to the factories with (un)announced visits and see the process
relationship within the supply chain	2	3	0	Ret 1: answer 2 because some relationships are long terms, other are short terms. It depends on suppliers and type of product which is supplied RET 2: answer 2. We want to have the best price for the milk, we have a pool of suppliers and it is always between them. RET 3: answer 2. RET 4: answer 1. Long term relationships
historical evidence of milk fraud	5	0	0	RET 1: answer 1, no I am not aware of any incidents RET 2: answer 1 RET 3: answer 1 RET 4: answer 1. In addition, there is in place a product integrity standard: audit to search if suppliers have been involved in irregularities. Database with records on supplier's fraudulent

				incidents
supply and price of milk	2	2	1	RET 1: I think is answer 3, milk price spikes a lot and is very volatile RET 2: answer 2. We do not really know, but I think the price fluctuates RET 3: answer 1. If you look at the short time pries are stable, while in the long term they fluctuate. But I would pick 1. RET 4: answer 1. There is not really a price problem. Prices are quite stable also because they are restricted by law
valuable components/ attributes	0	2	3	RET 1: answer 2, we have a private label and we review the prices every 3 months based on average milk price and also on protein and fat level. RET 2: answer 2. But the company is going in the direction to answer 3 RET 3: answer 3. Protein and fat content are valuable RET 4: answer 3. Valuable components are more related to organic milk, rather than conventional milk
economic health	5	0	0	RET 1: answer 1, company is profitable RET 2: answer 1, the company is healthy, but since it is a buying –association it cannot be defined profitable RET 3: answer 1 RET 4: answer 1
business strategy	4	0	1	RET 1: answer 3, short business strategy RET 2: answer 1, but it is hard to say that we have long term financial targets because it depends on the market RET 3: answer 1. It is a family business and we have clear goals in the company RET 4: answer 1. Long term financial targets.
ethical business culture	3	2	0	RET 1: answer 2 RET 2: answer 1, we trust each other's and we have code of conduct. Relatively small company so everybody knows each other RET 3: answer 2. RET 4: answer 1
previous irregularities	5	0	0	RET 1-2: answer 1, no previous irregularities RET 2: answer 1 RET 3: answer 1 RET 4: answer 1. Not in milk, but safety issues on other products, for instance meat
corruption level	5	0	0	RET 1-2-3-4-5: answer 1
financial pressure imposed by your company on supplier(s)	2	3	0	RET 1: answer 1, we do not push our processors to ask to farmers for lower prices. RET 2: answer 2. We don't set a fixed price, but there is a bit of negotiation between companies and suppliers in the setting of the prices. However, it depends also on the suppliers' power in the market. RET 3: answer 2. Buyers try to be fair when buy products from suppliers without push too much (buyers are trained to make good deals, without "kill" our suppliers). Mutual dependency between suppliers and retailers. RET 4: answer 2. Discussion between our buyers and the suppliers in order to set the prices. Moreover, the buyers are trained that they can not only choose a product based on a better price, but they also need to choose a product that meet the standards set by the retailer.
supplier **economic health**	5	0	0	RET 1-2-3-4: answer 1, profitable
supplier **business strategy**	5	0	0	RET 1: answer 1, long term financial targets RET 2: answer 1, very professional companies. RET 3: answer 1. For milk, mostly long term financial targets RET 4: answer 1. Long term financial targets, we discuss the quality and food safety aspects.
supplier **ethical business culture**	5	0	0	RET 1: answer 1 RET 2: answer 1, mutual trust RET 3: answer 1 RET 4: answer 1. Especially in fresh products there is mutual trust, there is a lot of communication between suppliers and retail
supplier **previous irregularities**	5	0	0	RET 1: answer 1 RET 2: answer 1, we haven't heard about any irregularities

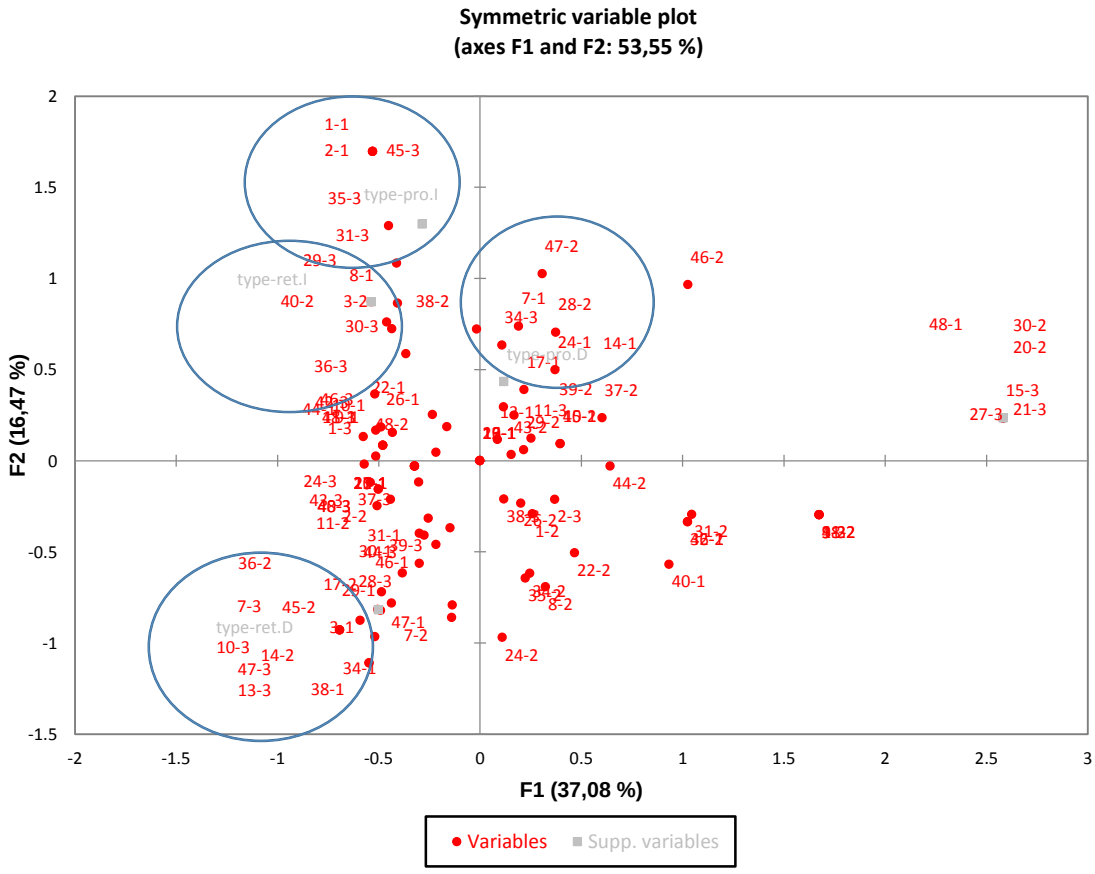
				RET 3: answer 1, in milk, not that I am aware of. RET 4: answer 1. We have product integrity standards and we did internet researches on our suppliers
Victimization of supplier	3	2	0	RET 1: answer 2, no information available to me RET 2: answer 1 RET 3: answer 2. Not that I am aware of, but maybe some farmers didn't comply with conditions RET 4: answer 1. I don't think so
supplier and customer**'s corruption level**	5	0	0	RET 1-2-3-4: answer 1
sector economic health	2	1	2	RET 1: answer 3, I think is a declining market because of changes in people's diets and habits, moreover cows are bad for the environment. RET 2: answer 2. Depends a bit on the economic situation, in one hand is growing, on the other hand is a bit stable RET 3: answer 3. The image of the milk is not seen as healthy anymore RET 4: answer 1. We are still growing in the market share
sector **ethical business culture**	2	3	0	RET 1: answer 2. We are not that proactive but we keep in line with what is in the market RET 2: answer 2. The discussion is open, but not all the information is shared because of competitive reasons RET 3: answer 1 RET 4: answer 1. Between companies there is always open discussion
historical evidence of milk fraud, within sector	5	0	0	RET 1-2- 3: answer 1. No evidence of fraudulent activities RET 4: answer 1. Product is with packaging; therefore, it is hard to mix
level of competition in the sector	0	1	4	RET 1: answer 3. Highly competitive. The price level of milk in supermarkets is the lowest in Europe. We are watching our competitors and we adjust the prices based on the other retailers' prices. RET 2: answer 3. Very high competitive RET 3: answer 3. There is competition between companies for prices RET 4: answer 2. For milk is medium level of competition
price asymmetries	2	2	1	RET 1: answer 2. The price policy is different in some countries RET 2: answer 2. I think there are some price asymmetries but I do not really know RET 3: answer 1. No, I don't think so. RET 4: answer 1. Even if the suppliers are supplied with milk from different European countries, then they sell liquid milk to retailers at the same prices.
fraud monitoring system in place raw material	3	0	2	RET 1: answer 1. it is difficult for us to check; we only check our private label and that the product delivered meet the specifications RET 2: answer 1. The analysis is mainly focused on safety and quality. But when it is time to look for food fraud, we do not really know what to look for. RET 3: answer 1. Controls are mainly on food safety and quality issues. There is not really fraud detection. We are growing in this aspect. RET 4: answer 3. Increasing number of integrity audits, analysis and unannounced visits
systematics and autonomy of verification of fraud monitoring system raw material	3	1	1	RET 1: answer 1 RET 2: answer 1 RET 3: answer 2. We are starting to monitor. Unannounced audits to suppliers RET 4: answer 1. We have our internal audits, but retailers are not certified by autonomous controllers
information system for mass balance control	2	1	2	RET 1: answer 3. We know exactly the amount of product sold RET 2: answer 1. Very basic administrative system RET 3: answer 1 RET 4: answer 2. Mass balance control in the warehouses, but not in the stores.
tracing and tracking system	0	4	1	RET 1: answer 2. We know from the moment we receive what happens to the product until the moment we deliver it to customers. We rely on suppliers that they know everything about the product before us, but we cannot guarantee that this is done. RET 2: answer 2. Our tracking and tracing systems can be done

				on products' level and it stops at processors level. RET 3: answer 2. Retailers receive a lot of digital information about the products that suppliers deliver. Good traceability system until the warehouses RET 4: answer 2.
integrity screening of employees	1	1	3	RET 1: answer 3 RET 2: answer 3 RET 3: answer 2. Not for everyone, only for key-person positions RET 4: answer 1. QA is not aware if there is an integrity screening. He has never been checked
ethical code of conduct	0	1	4	RET 1: answer 3. We have a manual and it is very detailed. RET 2: answer 3 RET 3: answer 2. There is some attention for some ethical code methods and there is a general guideline RET 4: answer 3. There is mandatory course within the learning system of the company to refresh knowledge. Attention for ethical code methods
whistle blowing	1	0	4	RET 1: answer 3. Anonymous phone line RET 2: answer 1. Somebody is in place with whom you can talk with, but there is no system in place RET 3: answer 3. There is an independent person RET 4: answer 3
contractual requirement with suppliers	0	2	3	RET 1: answer 2 RET 2: answer 3. In the contract with suppliers there are conditions which describe what they expect from suppliers RET 3: answer 2. Requirements are for safety and quality RET 4: answer 3. In the contract with suppliers there are conditions that describe what they expect from suppliers
supplier fraud control system	1	1	3	RET 1: answer 3 RET 2: answer 1. I do not really think that suppliers have fraud control system in place. Suppliers have basic FSMS RET 3: answer 2. They check a lot RET 4: answer 3. I do not know if the suppliers have fraud control systems in place for milk
supplier information system for mass balance control	0	0	5	RET 1: answer 3 RET 2: answer 3. Really extensive RET 3: answer 3 RET 4: answer 3. Very good
supplier tracing and tracking system	0	1	4	RET 1: answer 3 RET 2: answer 3 RET 3: answer 3. We ask a lot of information before they deliver milk to us, so suppliers need to have very good tracing and tracking system in place. RET 4: answer 2. Heading to answer 3
social control and transparency chain network	0	3	2	RET 1: answer 2. There is some self-regulation RET 2: answer 3. Communication between companies is very active. Companies do not wait for legislation to come into force RET 3: answer 2. There are some schemes and self-regulations, but information is not widely shared. RET 4: answer 2.
guidance for fraud prevention and control	3	1	1	RET 1: answer 1 but I do not really know RET 2: answer 1 moving toward answer 2. The NVWA is starting to react about fraud. RET 3: answer 2. There is not really a guidance for us on how to check RET 4: answer 3
national food policy	2	3	0	RET 1: answer 2. The NWVA does not seem very smooth at the moment. They visit us regularly but there are still scandals which they are not able to prevent. RET 2: answer 1, general food policy. The NVWA is starting to react about fraud. RET 3: answer 2. On food safety, national policy is very well-established, but not specific for fraud. RET 4: answer 2. The national food policy is not enough. The organisations (i.e. NWVA) cannot be open towards retailers when fraud occurs, because of confidentiality reasons and restrictions in legislation. On food safety, regulations are well established, but not for food fraud.
law enforcement local chain	4	0	1	RET 1: answer 3

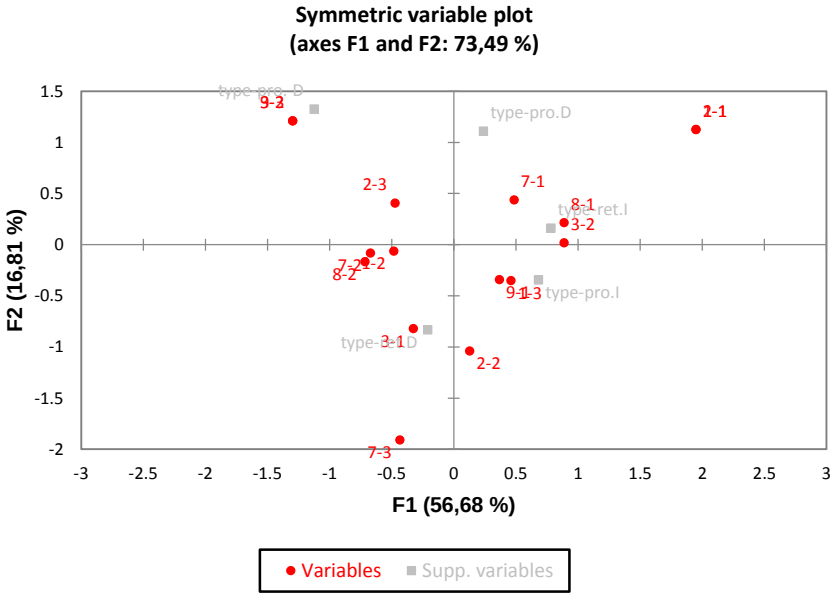
				RET 2: answer 1 RET 3: answer 1 RET 4: answer 1
law enforcement international chain	3	1	1	RET 1: answer 3 RET 2: answer 1. There is not international supply chain for fresh milk, since mostly processors and retailers sell milk within the NL RET 3: answer 1. Very limited RET 4: answer 1. I do not know how it works RET 5: answer
contingency plan	0	2	3	RET 1: answer 3 RET 2: answer 2 RET 3: answer 2. Risk plan is starting to be developed within the company. RET 4: answer 3. We have a PR department which communicate if there are issues

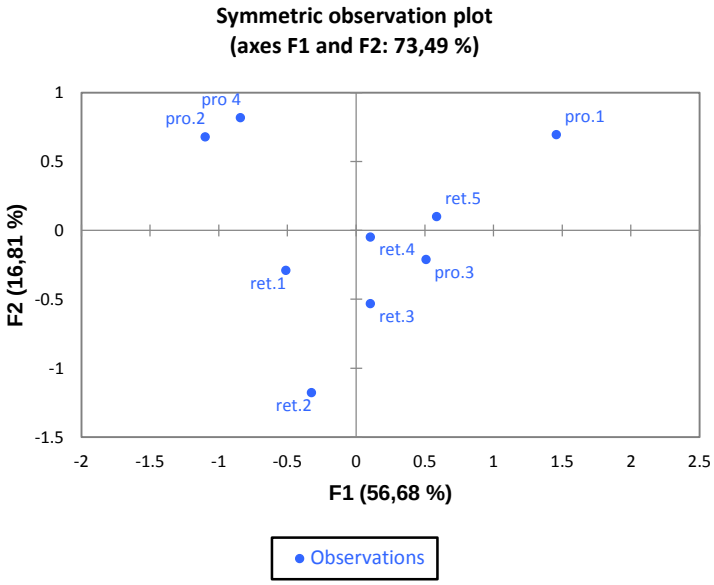
APPENDIX 7. Multiple Correspondence Analysis

1. Symmetric variable plot on opportunities, motivations and control measures.

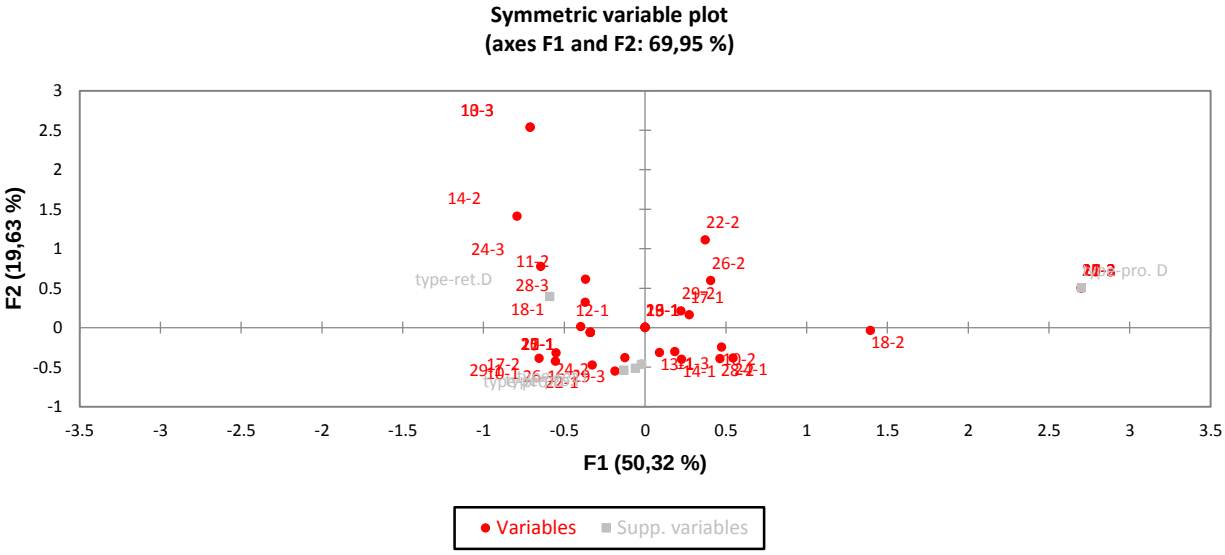


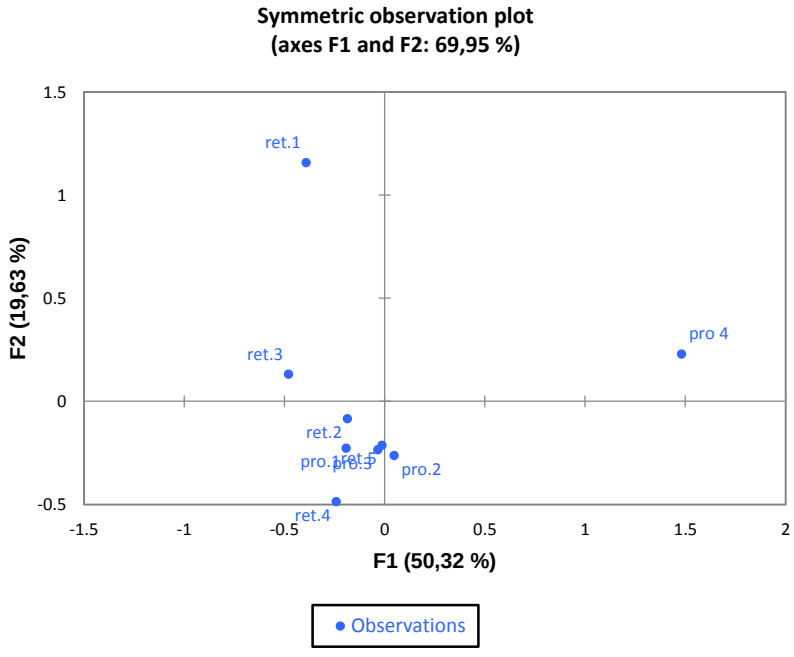
2. Symmetric variable and observation plots on opportunities





3. Symmetric variable and observation plots on motivations





4. Symmetric variable and observation plots on control measures