SCUOLA DOTTORALE DIRITTO ED ECONOMIA
TULLIO ASCARELLI
SEZIONE IN CONSUMATORI E MERCATO
AREA SCIENZE MERCEOLOGICHE E DELLE
ORGANIZZAZIONI DELLE AZIENDE

CICLO XXVIII

"The impact of traceability in the agri-food industries: the case of the Italian poultry supply chain"

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Abstract (English)

Food traceability is an essential tool through which companies guarantee food security and achieve competitive market advantages. European regulations impose food operators to implement traceability, and consumers are increasingly demanding additional information on food origin and characteristics. Thus, it is crucial for firms figure out the appropriate level of traceability to implement. The main goal of this work is to investigate the relationship between traceability implementation and its consequences on firms' operations. The main research question is if the level of traceability influences or not perceived benefits, costs, and difficulties in its implementation. On this baseline, a survey is conducted to empirically test the theoretical construct.

The target of the investigation is the Italian poultry meat supply chain. With the support of UNAITALIA association (The National Union of meat and egg supply chains), it as been possible to in-Depth analyse the structure and operation of this supply chain. The industry is characterised by a high level of vertical integration and, since 2004, has implemented a voluntary labelling system in order to track and trace additional information of products. Processing industries are the leaders of the supply chain, able to influence all operators working upstream and downstream. Therefore, through a questionnaire the supply chain leader firms have been interviewed. The sample consisted of nine firms while respondents were eight. Despite the population selected is small, it represents over 90% of poultry meat produced in Italy.

Findings indicate that firms implement a Medium and Deep level of traceability. These two groups show a significant difference in terms of difficulties in implementing traceability. Conversely, no significant difference is found in relation to costs and benefits. In general firms with a lower level of traceability perceive all aspects investigated (benefits, costs, and difficulties of traceability implementation) as having a greater impact on their operations compared to Deep traceability group. Moreover, firms with lower traceability showed more significant difficulties in implanting the EC Reg. No. 1169/2011 on food labelling into force since May 2015.

The main limitation of the survey is the small sample due to the peculiar configuration of the industry and the limitation to a single food supply chain. Nevertheless, through a punctual measure of the traceability level in the supply chain, the research contributes to reduce the existing gap in the literature. On a practical side, it explores for the first time how traceability impact firms of the poultry supply chain.

Future development of the analysis should focus on the impact of traceability practices on consumers' satisfaction and willingness to pay for extra information on food products.

Abstract (Italiano)

La rintracciabilità nel settore agroalimentare è uno strumento essenziale attraverso cui le imprese garantiscono la sicurezza alimentare e ottengono vantaggi competitivi sul mercato. Le normative europee impongono agli operatori del settore alimentare l'implementazione di un sistema di rintracciabilità e, al tempo stesso, i consumatori sono sempre più esigenti riguardo le informazioni di qualità e provenienza fornite sui prodotti alimentari. Per rispondere a queste esigenze è fondamentale per le imprese capire il livello ottimale di rintracciabilità, che massimizzi obiettivi di profitto e che soddisfi le esigenze dei portatori d'interesse pubblici e privati. L'obiettivo principale di questo lavoro è indagare il rapporto che intercorre tra la rintracciabilità e i suoi effetti sulle imprese. La principale domanda di ricerca è verificare come il livello di rintracciabilità influenza i benefici, i costi e le difficoltà percepiti dalle imprese. Su questa base è stata condotta un'indagine per testare empiricamente il costrutto teorico, volto a determinare un indice sintetico che descriva il livello di rintracciabilità.

La filiera della carne avicola italiana è stata scelta come target dell'indagine. Con il supporto dell'associazione UNAITALIA (Unione Nazionale delle Filiere delle carni e uova), è stato possibile analizzare in profondità la struttura e il funzionamento di questa filiera. Il settore è caratterizzato da un elevato grado d'integrazione verticale e dall'attuazione di un sistema di etichettatura volontaria, che ha lo scopo di monitorare e rendere disponibili informazioni aggiuntive sulla carne prodotta. Le industrie di trasformazione sono i leader della filiera, in grado di influenzare tutti gli operatori che lavorano nelle altre fasi a valle. Per questo queste imprese a capo della filiera sono state selezionate come destinatarie del questionario condotto. Vista la forte concentrazione del settore, la propalazione oggetto dell'indagine è costituita da nove imprese, mentre i rispondenti sono otto e rappresentano più del 90% della carne di pollame prodotta in Italia.

I risultati indicano che le imprese intervistate appartengono a due gruppi in funzione del livello di rintracciabilità: livello di rintracciabilità medio (sei imprese) e profondo (2 imprese). Questi due gruppi mostrano differenze significative in relazione alla difficoltà di attuazione del sistema di rintracciabilità. Al contrario, nessuna differenza significativa è stata individuata in relazione ai costi e benefici. In generale le imprese con un più basso livello di rintracciabilità percepiscono tutti gli aspetti indagati (benefici, costi e difficoltà di attuazione rintracciabilità) con un maggiore impatto sulle loro attività rispetto alle imprese con un livello di rintracciabilità più elevato. Inoltre, le imprese con un livello di rintracciabilità inferiore hanno mostrato maggiori

difficoltà nell'implementare il Regolamento UE 1169/2011 sull'etichettatura dei prodotti alimentari in vigore da Maggio del 2015.

L'indagine si è occupata di descrivere la rintracciabilità nelle industrie di trasformazione della carne avicola in Italia. L'analisi di questo specifico settore è sia un punto di forza dell'analisi, che una limitazione dovuta al ristretto numero di aziende intervistiate, che rispecchia però la forte concentrazione esistente nel settore. Nonostante ciò, la ricerca contribuisce ad arricchire la letteratura esistente che si è occupata di misurare il livello di rintracciabilità nelle filiere agroalimentari. Inoltre esplora per la prima volta la filiera avicola dal punto di vista dell'impatto della rintracciabilità sulle imprese. Un possibile futuro sviluppo dell'analisi dovrebbe concentrarsi sul punto di vista del consumatore, per meglio capire se l'aumento del livello della rintracciabilità, e dunque delle informazioni fornite sul prodotto, impattano positivamente sulla soddisfazione e sulla disponibilità a pagare.

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“The impact of traceability in the agri-food industries: the case of the Italian poultry supply chain”

Introduction

Context

Increasing trade exchanges and globalisation in the last decades have increased the distance covered by food products from the producer to the consumer. In this framework, maintaining food integrity has become a major challenge, both for safety and quality assurance. Since the 90s the food industry experienced a series of foodborne crisis, which has determined the necessity to face new challenges in order to recover reliability and consumers’ confidence (Aung and Chang, 2014; Bosona and Gebresenbet, 2013). Given the modern globalised food system, food scandals are not circumscribed to single countries. The European Community by the end of the 90s experimented the BSE (Bovine Spongiform Encephalopathy) and Dioxins crisis. In the US the outbreak of Escherichia coli O157:H7 determined serious damages to public health (Aung and Chang, 2014; Buhr, 2003; Dabbene et al., 2014). More recently in China broke out the milk powder contamination with melamine, causing significant harm to nearly 300,000 infants across the country (Ortega et al., 2011; Pei et al., 2011; Xu and Wu, 2010). These scandals determined a growing citizens’ awareness toward food safety issues, to which food industries and public authorities are called to take action. Furthermore, consumers are not just moved by food safety issues, demanding for instruments to ensure food quality and transparency. To meet these expectations, firms need to implements tools through which deliver reliable information to the public (Aung and Chang, 2014; Bosona and Gebresenbet, 2013; Dabbene et al., 2014; Karlsen et al., 2013; Van Rijswijk and Frewer, 2012; van Rijswijk et al., 2008).

Traceability becomes a crucial part of the global strategy to supply safe and high quality food. Ensure traceability, as the “*the ability to follow the movement of a feed or food through specified stage(s) of production, processing and distribution*” (Iso, 2007), jointly with tools to ensure food authenticity, prevent food safety hazards, and preserving the identity and wholesomeness of novel foods, is an essential to ensure quality along complex food supply chains. Thus, traceability is an essential to implement a preventative strategy for food quality and safety management, and for detecting and facilitating product recall and determination of liability (Dabbene et al., 2014; Opara and Mazaud, 2001; Opara et al., 2003).

Traceability itself is not enough to guarantee food safety and quality but enables to keep product information records during all stages of food production, processing and distribution. Furthermore, it effectively reduces risk exposure by enabling food producers to identify, isolate and correct the problem quickly and efficiently, protecting public health (Elise Golan et al., 2004; Samarasinghe et al., 2009)

In 2005, entered info force in Europe the General Food Law (EC Reg. No. 178/2002), according to which food and feed business operators are legally bound to implement traceability systems (Bosona and Gebresenbet, 2013; Kher et al., 2010; Schwägele, 2005). Article No. 18 of the General Food Law defines traceability as "*the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution*", introducing the concept *from farm to fork* (European Commission, 2004). In 2015 entered into force the Regulation "*on the provision of food information to consumers*" (EC Reg. No. 1169/2011). It introduces further requirements especially for of the labelling fresh meat products, offering to consumers the opportunity to access further information on food traceability.

Literature review

Traceability is broad concept. It led to an heterogeneity of definitions, as a consequence of food products complexity and of the wide range of objectives that this tool can pursuit (Elise Golan et al., 2004). According to Olsen and Borit (2013), who performed an extensive literature review on its definitions, traceability is "*the ability to access any or all information relating to that which is under consideration, throughout its entire life cycle, by means of recorded identifications*" (Olsen and Borit, 2013).

Even though a common theoretical framework for food traceability do not exists (Karlsen et al., 2013), in literature there are some common elements shared by International Organizations and Authors that define the concept (Bosona and Gebresenbet, 2013; Dabbene et al., 2014; Karlsen et al., 2013; Olsen and Borit, 2013). First, traceability has two main functions: tracking and tracing. Given the product flow along the supply chain, one function is to carry information downstream, from the first agent (primary producer) to the end user. The second function performed is the system capability to find the information required in the opposite direction, upstream from the end user to the primary producer (Bosona and Gebresenbet, 2013; Dabbene et al., 2014; Dupuy et al., 2005; GS1, 2012; Jansen-Vullers et al., 2003; Karlsen et al., 2013; Perez-Aloe et al., 2007; Schwägele, 2005; Thompson et al., 2005; Wang et al., 2011;

Zhang and Bhatt, 2014). Another crucial element to achieve an efficient supply chain traceability system is the linkage between information and physical product flow (Bosona and Gebresenbet, 2013; GS1, 2012). The scope of traceability may vary in relation to its goal. Nevertheless, there is a general consensus that to achieve full chain traceability all agents involved shall implement both internal and external (chain) traceability (Arienzo et al., 2008; Aung and Chang, 2014; GS1, 2012; Hu et al., 2013; Porto et al., 2011; Taillard, 2011; Thakur et al., 2009).

Asses the performance of a traceability system is a board task, as the evaluation process should consider the efficiency and effectiveness its goals (Bosona and Gebresenbet, 2013; Van der Vorst and Vorst, 2004). According to Goal et Al. (2004) cost and benefits perceived by firms determine the level of *Breadth*, *Depth*, and *Precision* of traceability systems, through which the system can be evaluated (Elise Golan et al., 2004). McEntire et Al. (2010) suggested to integrate the three characteristics with a new one: *Access* (McEntire et al., 2010).

Several drivers, related to regulatory compliance, food safety, process optimizations, marketing, quality, internal process and supply chain optimization, welfare, certification, bioterrorism, and anti-counterfeiting influence the implementation of a traceability system (Dabbene et al., 2014; Karlsen et al., 2013). According to Bosona et Al. (2013), these drivers can be categorised into five areas: food safety and quality, regulatory, social, economic, and technological concerns.

As well as drives, several benefits descend from the application of traceability. Moe (1998) describes them differentiating between internal traceability and chain traceability benefits (Moe, 1998). Moreover, along the supply chain different stakeholders are potentially positively affected by traceability (Van der Vorst and Vorst, 2004). Traceability has positive return both on the private and public sphere, varying its intensity in relation to the benefit considered. If the most valuable public benefit is related to public health and safety, for private the main benefits may be the enhancement of supply chain efficiency (Mcentire and Bhatt, 2012; Sparling et al., 2011). Principally the positive outcomes for firms implementing traceability derive from several areas of potential operations improvements (Bosona and Gebresenbet, 2013). Process improvements, enables several benefits distributed on supply chain actors and single firms (Mai, 2010). It reinforces the level of coordination between partners of food supply network and the effectiveness of process within a single organization (Rábade and Alfaro, 2006). Traceability allows firms to take market advantages from enhanced food safety, protecting brand name, assuring

product claims, and maintaining consumer confidence (Meja et al., 2010). Conversely, the lack of traceability systems determine market failure as a result of asymmetric or missing information for consumers (Elise Golan et al., 2004). Without traceability consumers are not aware of products quality, determining increased costs arising from quality verification (Jill E. Hobbs, 2004). Traceability supports the assurance of quality attributes, especially those that are not visible, as credence attributes (Darby and Karni, 1973). Thus, traceability helps firms to meet market and consumers requirements, assuring responsiveness to consumers more demanding of quality, control and information (Banterle and Stranieri, 2008a; Can-Trace, 2004; Donnelly et al., 2013; FoodLinks Project, 2003; Sparling et al., 2006). After the introduction of mandatory traceability regulations, firms implementing traceability systems, can reduce the cost of non-compliance, ensuring the commitment with mandatory legislation (Asioli, 2009; Banterle and Stranieri, 2008a; Bertolini et al., 2006; Bosona and Gebresenbet, 2013; Elise Golan et al., 2004; Hammoudi et al., 2010; Heyder et al., 2010; Resende-Filho and Hurley, 2012; Schwägele, 2005; Souza-monteiro et al., 2010).

Concurrently to benefits, firms will incur the cost of having a new system to implement. However these costs may widely vary in relation to several factors such as the nature of firm, products and activities, and its role and position in the supply chain (Can-Trace, 2004; Gooch and Sterling, 2013; McEntire et al., 2010). Cost for its implementation may vary significantly with the level of desired traceability. Costs increase in relation to system Breadth, Depth, Precision, and Access (Elise Golan et al., 2004).

Although costs are considered as a main obstacol to traceability system adoption, other factors affect its diffusion in food supply chains (Mcentire et al., 2010). Concerning supply chain the main barriers are: defined and different traceability performance level among members, lack of organisation and transparency, and lack of shared standars (Kher et al., 2010; McEntire et al., 2010; Van der Vorst and Vorst, 2004; Wang et al., 2009). Furthermore, ofter firms have no clear understandign of benefits and are not willing to invest in traceability infrastructures (Van der Vorst, 2004; Wang et al., 2009). In general barriers may be split into organizational and technological (Aung and Chang, 2014).

Research gaps

Even if traceability in Europe is compulsory for all food operators, there is no common agreement on its definition and on its impact on firm's performances (Bosona

and Gebresenbet, 2013; Karlsen et al., 2013; Olsen and Borit, 2013). Thus, the starting point of this works is contributing to a better definition of the theoretical framework behind traceability. Even if traceability has a broader meaning that varies significantly in relation to the scope, location, and aim of its application, there are some elements that are commonly accepted and shared by authors' that investigated this topic.

Several investigations were carried out to evaluate the impact of traceability in food industries in terms of benefits, cost, and barriers (Alfaro and Rábade, 2009; Donnelly et al., 2012; Henson et al., 2005; Kher et al., 2010; Liao et al., 2011; Mai, 2010; Manos and Manikas, 2010; Miao et al., 2011; Poghosyan et al., 2004; Sparling et al., 2006; Van der Vorst and Vorst, 2004; Wang et al., 2009). Only few attempted to establish the level of traceability in a food supply chain (Breadth, Precision, Depth) as proposed by Golan et Al. (2004), correlating it with firms' perceived benefits, costs and difficulties (Asioli, 2009; Asioli et al., 2012; Banterle and Stranieri, 2008a; Stranieri and Banterle, 2015). Thus, the linkage between the level of traceability and firms' perception on its impact should be further investigated.

Aim of the research

First aim of this work is to clarify and examine the theoretical aspects of the traceability, in order to describe and organise main findings of scholars that previously investigated on it.

Despite a general consensus on the importance to assess the level of traceability in diversified food supply chains, only few scholars investigated this aspect of the topic. The goal of this work is to contribute to assess traceability performance in terms of Breadth, Precision, Depth in a food supply chain that has not been investigated yet. To enrich the study of this topic to these three components, the novelty of the research is to add two dimension not yet investigated: Access and Technology. Even though Technology and the ability of a supply chain to respond promptly to an emergency (Access) are reported as a crucial in order to improve traceability system performance, currently no investigation on these two aspects have been identified in the literature review performed. Thus, this work aims at reducing this gap. Furthermore, aims at investigate the linkage between traceability performance assessment and resulting impact on firms'. Apart from mandatory regulations, firms choice the level of traceability in relation to expected benefits. So it is worth understating how this impact varies with the level of traceability.

As well as to link traceability impact assessment and its impact on firms, the contribution of the research will add up with other empirical studies carried out

helping to increase knowledge on the effect of traceability in different agro-food supply chains. It will be a valuable contribution that will help to create a more solid basis for the formulation of a theoretical framework on the topic, analysing it from firms' viewpoint.

In May 2015 entered into force the new regulation on food labelling, determining new requirements for food operators. Given, the concurrence of this work with this event, in this investigation is presented a first result of firms' perception on its impact in terms of necessity to upgrade their traceability operations.

Research questions

The Italian poultry supply chain is selected as the target of the study to assesses the impact of traceability on firms. Thus, the main research question is "Which is the impact of traceability in the Italian poultry supply chain?". From this generic questions arise other more detailed, which take into account also the level of traceability implemented by firms:

- Which is the relationship between traceability level and traceability benefits?
- Which is the relationship between traceability level and traceability costs?
- Which is the relationship between traceability level and difficulties in its implementation?
- Which is the impact of the new labelling Regulation on firms' traceability operations?

The objective is not only to assess main benefits, costs, and difficulties, but also to figure out how these vary in relation to different levels of Breadth, Depth, Precision, Access, and Technology.

Scope of research

The meat supply chain is one of the most regulated sectors. Recently were issued to important regulations concerning food labelling and traceability (EC Reg. No. 1169/2011 and EC Reg. No. 1337/2013). This Thesis investigates the Italian meat poultry supply chain. The reasons are the distinct characteristics of the supply chain, the recent mandatory regulations, and the marked proactivity in terms of traceability. The poultry production in Italy is characterized by a high vertical integration, where the leaders are the processing companies, which control the rearing phase of the animal. Thus, there is a high concentration in the processing phase, determining that meat and eggs consumed arrive from few producers. Therefore, from a traceability viewpoint the Italian poultry supply chain is a mature industry. This might make easier to observe and evaluate potential positive or negative effects of traceability systems.

In Italy UNAITALIA association represents more than 90% of the national poultry meat production. Today, the organization promotes a voluntary labelling for poultry meat. These labels, allow consumers to have additional information on the product and require participant industries to implement traceability procedures that go further than regulation mandatory prescriptions. Therefore, UNAITALIA plays a remarkable role in addressing industry's choices, especially orientating traceability practices. The investigation has been carried out with the collaboration of UNAITALIA. The association's contribution has been determinant in the research design. Specifically, the association supported the identification of the survey target and the definition of data collection method.

Research method and target

Once performed the analysis of the context with the help of previous literature and the support of UNAITALIA association, the work is conducted through a survey. Original data Are collected, involving a primary data collection method. The questionnaire is chosen as the proper way to gather information and answer research questions.

In Italy many firms are involved in the poultry supply chain. Nevertheless, over 90% of poultry meat is produced with a vertically integrated system, composed of few firms (Giacomini et al., 2004; Sanfrancesco, 2015; UNAITALIA, 2005, 2004). Therefore, the majority of production is regulated through production specifications set by Integrator firms. Given this context, traceability related aspects are affected by this peculiar supply chain shape. In agreement with UNAITALIA has been decided that the Integrator firms (or head of the supply chain) would be the more appropriate actors in poultry meat production in terms of capacity to evaluate how traceability practices affect positively or negatively supply chain operators. Thus, the target population are the main Integrator firms (called Group Operators) of the Italian poultry meat industry. With UNAITALIA were selected 9 Group operators, which are responsible for roughly 90% of the poultry meat production.

Outline of the work

This work is structured in six chapters. Initially, a literature review analyses in detail the concept of traceability. It compares multiple definitions provided both from scholars who published in peer review journals and from international organizations. In order to figure out their differences and common points, the definitions are break up into action, direct object, location, and means to provide traceability. The more complete definitions are selected as reference in the work. Then, are analysed key

concepts, explaining their functions in relation to traceability. Specifically, the concept of track and trace, physical and information flow, and internal and external traceability are discussed. After, the Chapter explains which elements are crucial in the implementation of a traceability system: Unique Identification, Data Capturing and Recording, Traceability Links Management, and Data Communication. Finally, the indicators used for traceability performance assessment are presented: Breadth, Depth, Precision, and Access. The Chapter aims at clarifying the theoretical framework of traceability implementation in food supply chains.

Chapter II focuses on the impact of traceability systems in food supply chain. Through the analysis of previous investigations, it points out how traceability impacts on firms' performances in terms of benefits, barriers, and costs. Benefits are categorised into process improvement, food safety management, product differentiation form market and consumers, and regulatory benefits. Even if in many cases cost and barriers are similar in previous investigations, no common framework on their categorisation is outlined from literature.

After the analysis of literature, is presented the research process adopted. A critical analysis of previous investigations led to the identification of main research gaps in the topic and to the definition of the potential contribution and novelty of the works. Chapter III introduces then research goals and questions. Next, the context and scope of the analysis. Eventually, research methodology and method are presented. In this section it is explained how the survey is conducted and the target population of the questionnaire proposed.

To better contextualise the research Chapter IV presents an overview of the poultry supply chain, which is the object of the survey. The analysis is structured into two levels. The first describes the scope, value, and trends of the poultry supply chain at global, European, and Italian level. The second illustrates how contemporary poultry supply chains are structured in developed countries and more specifically in Europe and Italy, in terms of coordination and integration among operators.

Chapter V goes through the evolution of European legislation on food safety, with specific regard to regulations that involve traceability implementation in food supply chains. Then, the focus shifts to the Italian context, with the analysis of traceability regulations that effect the poultry supply chain. Wide emphasis is given to the Italian experience of voluntary labelling implementation in poultry meat sector supported by the UNAITALIA association. The analysis of these voluntary labelling production

specifications served as baseline to develop the survey. Thus, an in-depth analysis of it, and of its consequences for traceability in the poultry sector is presented.

Chapter VI illustrates the survey. After the description of firms, object of the analysis, is presented the survey design, with a detailed explanation of the questionnaire and how traceability level index was formulated.

The final Chapter reports the characteristics of respondents and main results of the questionnaire. In first part are presented the characteristics of respondents firms, in the second the traceability level assessment, and in the third respondents perceptions on benefits, barriers, and costs of traceability. The last part will test the assumption made through the research questions. Starting from questionnaire questions is checked if empirical results lead to accept or reject the research hypothesis made in Chapter III.

Chapter I. Defining traceability in the food sector

1.1 What is traceability

Several definitions of food traceability have been given from single authors and international organizations. Is it evident that different definitions laid to several interpretation of its meaning. In general there is lack of coherence and agreement, determining dissimilar consequences on what a traceability system should include. This diversity and variety of traceability definitions is partly consequence of food products complexity and of the wide range of objectives that this tool can pursuit (Elise Golan et al., 2004). As consequence, several definition and classification from different authors, organizations and legislations can be identified. The aim of this paragraph is to give an overview on how traceability, in the context of the food sector, is defined in literature and among the main international organizations. To carry out the analysis has been performed a literature review, using as key word input "food + traceability". Due to the remarkable amount of definitions identified, only papers giving an original definition and published in peer review journal have been selected. Moreover, have been included the definitions given by the most cited international organizations, that is assumed to be the landmark for many published works. Considering that the contest of the analysis is the food sector, only the definitions provided in relation to food production and processing have been included.

Research has led to the identification of several original definitions of traceability. In order to understand the main similarities are adapted the schemes used by (Olsen and Borit, 2013), (Bosona and Gebresenbet 2013) and (Aung and Chang, 2014) to perform a structured comparison. To synthetically compare records four key elements in each definition are selected: Action (the verb used); Direct object (the components/elements target); Location (the stages of the supply chain involved); and Tools (the means to provide traceability).

According to the selected papers, several actions characterize a traceability system. The verbs used range from "to describe", "identify", "determine" "to collect and maintain" to "to follow", "to track" and4 "to trace", giving a wide heterogeneity to the definition. Terms widely used to characterize traceability are "tracking" and "tracing", some times used jointly and associated.

Table 1.1: List of selected food traceability definitions.

Author	Journal	Definition	Action	Direct object	Location	Tools
(Moe, 1998)	Trends in Food Science & Technology	Traceability is the ability to track a product batch and its history through the whole, or part, of a production chain from harvest through transport, storage, processing, distribution and sales (chain traceability) or internally in one of the steps in the chain for example the production step (internal traceability)	Track	Product batch and its history	Production chain from harvest through transport, storage, processing, distribution and sales	
(Wilson and Clark, 1998)	Supply Chain Management: An International Journal	The information necessary to describe the production history of a food crop, and any subsequent transformations or processes that the crop might be subject to on its journey from the grower to the consumer's plate	Describe	Production history of a food crop, and any subsequent transformations or processes that the crop might be subject	Journey from the grower to the consumer's plate	
(Opara and Mazaud, 2001)	Outlook on Agriculture	The collection, documentation, maintenance and application of information related to all processes in the supply chain in a manner that provides a guarantee to the consumer on the origin and life history of a product	Collection, documentation, maintenance and application	All processes	Supply Chain	
Liddell and Bailey 2001	International Food and Agribusiness	The ability to track inputs used to make food products backward through the supply chain to their source	Track	Input used	Backward through the supply chain to their source	
Opara 2003	Food, Agriculture & Environment	The ability to identify the farm where it was grown and sources of input materials, as well as the ability to conduct full backward and forward tracking to determine the specific location and life history in the supply chain by means of records	Identify. Conduct full backward and forward tracking. Determine.	Sources of Input materials. Specific location and life history.	Supply chain	Means of records
(Meuwissen et al., 2003)	Journal of Agribusiness	Provides a set of data about the location of food and food ingredients along the supply chain	Provide	Location of food and food ingredients	Supply chain	Set of data
(Bertolini et al., 2006)	Food Control	The documented identification of the operations which lead to the production and sale of a product.	Identification	Operations which lead to the		

				production and sale of a product		
(Regattieri et al., 2007)	Journal of Food Engineering	The history of a product in terms of the direct properties of that product and/or properties that are associated with that product once these products have been subject to particular value-adding processes using associated production means and in associated environmental conditions.		History of a product		
(van Rijswijk et al., 2008)	Food Quality and Preference	The ability to trace and track food, and food ingredients through the supply chain; thus traceability can be applied through all stages of production, processing and distribution	Trace and track	Food, and food ingredients	Supply chain (all stages of production, processing and distribution)	
(Tamayo et al., 2009)	Engineering Applications of Artificial Intelligence	The capability to trace goods along the distribution chain on a batch number or series number basis	Trace	Goods	Distribution chain	Batch number or series number
(Engelseth, 2009)	Journal of Business & Industrial marketing	The ability to trace and follow a food, feed, food-producing animal or substance through all stages of production and distribution	Trace and follow	Food, feed, food-producing animal or substance	All stages of production and distribution	
(Samarasinghe et al., 2009)	International Journal of Computer Science and Network Security	The combination of engineering metrology standards, and calibration in the context of requiring the nationally accepted tools and methods				
(Kher et al., 2010)	British food journal	Tracking the source and destination of food products and components	Track	Food products and components	Source and destination	
(Resende-Filho and Hurley, 2012)	International Journal of Production Economics	The probability of finding the source of a problem	Find	Problem source		

(Salampasis et al., 2012)	Journal of Systems and Information Technology	The ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed through all stages of production, processing and distribution	Trace and follow	food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed	All stages of production, processing and distribution	
(Olsen and Borit, 2013)	Trends in Food Science & Technology	The ability to Access any or all information relating to that which is under consideration, throughout its entire life cycle, by means of recorded identifications.	Access	Any or all information relating to that which is under consideration	Throughout its entire life cycle	By means of recorded identifications
(Bosona and Gebresenbet, 2013)	Food Control	Food traceability is part of logistics management that capture, store, and transmit adequate information about a food, feed, food-producing is correct animal or substance at all stages in the food supply chain so that the product can be checked for safety and quality control, traced upward, and tracked downward at any time required	Capture, store, and transmit. Traced upward. Tracked downward	Adequate information about a food, feed, food-producing is correct animal or substance	All stages in the food supply chain.	
(Comba et al., 2013a)	Journal Bio systems Engineering	The ability to determine for each portion of the intermediate or final product, at any time and in any part of the plant, its composition in terms of supply-lots fed into the system.	Determine	Composition of the intermediate or final product	In any part of the plant	Lots

Table 1.2 List of selected traceability definitions by International Organizations.

Organization	Reference Document	Definition	Action	Direct object	Location	Tools
(ISO, 1994)	ISO-8402:1994 Quality management and quality assurance and vocabulary	The Ability to trace the history, application or location of an entity by means of recorded identifications	Trace	History, application or location of an entity		By means of recorded identifications
(ISO, 2000)	ISO-9000:2000 Quality management systems e Fundamentals and vocabulary.	The ability to trace the history, application or location of that which is under consideration	Trace	History, application or location of that which is under consideration		
(Iso, 2007)	Traceability in the feed and food chain e General principles and basic requirements for system design and implementation	The ability to follow the movement of a feed or food through specified stage(s) of production, processing and distribution	Follow	The movement of a feed or food	Through specified stage(s) of production, processing and distribution	
(GS1, 2012)	GS1 Global Traceability Standard	The ability to track forward the movement through specified stage(s) of the extended supply chain and trace backward the history, application or location of that which is under consideration	Track forward. Trace backward.	The movement, the history, application or location of that which is under consideration	Through specified stage(s) of the extended supply chain	
(FAO and WHO, 2013)	Codex Alimentarius Commission Procedural Manual 21st Edition	The ability to follow the movement of a food through specified stage(s) of production, processing and distribution	Follow	The movement of a food	Through specified stage(s) of production, processing and distribution	

Considering the direct object of traceability (trace what?) some Authors give a broad explanation of what to trace as “all process”, “inputs”, “goods”, “history of products”, “information”, “composition of the intermediate or final product”. On the contrary, others give a more specific identification as “product batch”, “food crop”, “food and food ingredients”, “food, feed, food-producing animal or substance to be incorporated into a food or feed”.

On the area (“where”) that traceability should cover there is a general consensus that should be applied to the entire supply chain. Some Authors refer generically to “supply chain” or “all stage of supply chain”, while others describe the different stages of a supply chain in “production, processing and distribution”.

Finally, just few Authors indicate the means by which the traceability should be accomplished: (Opara and Mazaud, 2001) refer to “records”, (Meuwissen et al., 2003) to “set of data”, (Tamayo et al., 2009) to “batch number or series number” and (Olsen and Borit, 2013) to “recorded identifications”.

Schematizing these definitions traceability relates to the ability to identity position and movement of a product along the supply chain (Bosona and Gebresenbet, 2013). Another element to take into consideration is the presence of system that access to specific data or records (Olsen and Borit, 2013).

The analysis showed that the definition of traceability has been performed in a wide heterogeneity of scientific fields. Moreover, a single scientific area can include other fields or be strongly interrelated with a different one. (Karlsen et al., 2013) categorizes these fields in two main groups: social sciences and natural sciences. Economics, Marketing and Supply Chain Management compose the first. Whereas the latter consists of Quality Management and Engineering. As observed in Table 1.1 the sources of definitions are several Journals, covering various fields. As instance, if the purpose of the study is the consumers’ attitude towards food product with a certification, the target of the definition would be the consumer (Opara and Mazaud, 2001; Wilson and Clark, 1998).

Due to this heterogeneity it is crucial to consider the definitions provided by international organizations, which aim to give a generic description of traceability regardless to specific fields of research. The ISO gives definitions of traceability in three Standards. According to ISO 8402:1994 traceability is “*the ability to trace the history, application or location of an entity by means of recorded identifications*”(ISO, 1994); according to ISO 9001:2000 is “*the ability to trace the history, application or location of that which is under consideration*”(ISO, 2000); the ISO 22005:2005 refers expressly to

traceability in food and feed chains as "*the ability to follow the movement of a feed or food through specified stage(s) of production, processing and distribution*".

The definition given in the Codex Alimentarius is very similar to ISO 22005:2007, but it refers just to food, excluding feed (Iso, 2007).

The GS1 defines traceability as "the ability to track forward the movement through specified stage(s) of the extended supply chain and trace backward the history, application or location of that which is under consideration" (GS1, 2012).

Some Authors affirm the ISO 8402 is the most precise definition in terms of product traceability, because it describes the means (recorded identifications) by which is achieved (Karlsen et al., 2013; Olsen and Borit, 2013). Conversely, according to (Bosona and Gebresenbet, 2013) this definition lack of clearness on what the term *trace* indicates, if it indicates both forward or backward follow up. Furthermore, is not specified if traceability covers only a step of or the entire chain. The definition given by GS1, also if lacking of the explication of the means to achieve traceability, is probably more complete because it split the action in *track forward* and *trace backward,* solving possible equivocation on the usage of the term *trace.*

In conclusion, the clearer and more complete definitions are the one given by (Bosona and Gebresenbet, 2013) and by (Olsen and Borit, 2013). The first clearly refers to the two key functions of traceability (trace and track), while the latter underlines the necessity to implement a system of recorded identifications.

1.2 Key concepts in traceability: Track and Trace

According to the analysis performed key terms widely used to characterize traceability are *track* and *trace*, sometimes used jointly. These terms are often associated with the terms *backward*/*forward* and *upward/downward*. In this paragraph are analysed these key concepts, trying to explain their functions in relation to traceability.

Traceability has two main functions: tracking and tracing. Tracking is "the ability to follow the path of an item as it moves downstream through the supply chain from the beginning to the end", while tracing is "the ability to identify the origin of an item or group of items, through records, upstream in the supply chain" (Schwägele, 2005). Therefore tracking implies the ability to follow an item from point A (starting point along the chain) to point B (ending point), while tracing stands for the ability to identify an item in the opposite direction from B to A (Stefansson and Bernhard, 2001). According to Dupuy, Botta-Genoulaz, and Guinet (2005) tracking is "the ability, in every point of the supply chain, to find origin and characteristics of a product from one or several given criteria", linked to quality assurance criteria; while tracing is "the ability, in every point

of the supply chain, to find the localization of products from one or several given criteria", and is used in case of product recall.

EAN (2001) defines Top-down Traceability as "*the capacity for finding the origin and characteristics of a product, from any point of the supply chain, using one or more given criteria*" (quality assurance). Conversely, Bottom-up Traceability is "*the capacity for locating products, from any point of the supply chain, using one or more given criteria (recall or withdraw)*" (Gencod-EAN France, 2001).

Likewise Wang et al. (2011) associate the idea of tracking to product recall, as "*the ability to determine the current state of a product/part at any time*" (downward traceability); while tracing is "*the ability to determine the past "states" and the origin (raw materials, subparts) of the part*" (upward traceability)(Wang et al., 2011). Thompson, Sylvia, and Morrissey (2005) describe traceability as a system that keeps the product related information and as the main function of tracking and tracing a product. The first track the information from the top to the bottom of the chain (downward); the latter from the bottom to the top, tracing back the unit under consideration (upward) (Thompson et al., 2005).

Moreover, according to Jansen-Vullers, Dorp, and A.J.M Beulens (2003) tracking is "*a method of following an object through the supply chain and registering any data considered of any historic or monitoring relevance*". The Authors do not differentiate tracking and tracing but introduce the concept of forward traceability as "*the exploration of where-used relations between objects*", and backward traceability as "*the exploration of the where-from relation between objects*" (Jansen-Vullers et al., 2003).

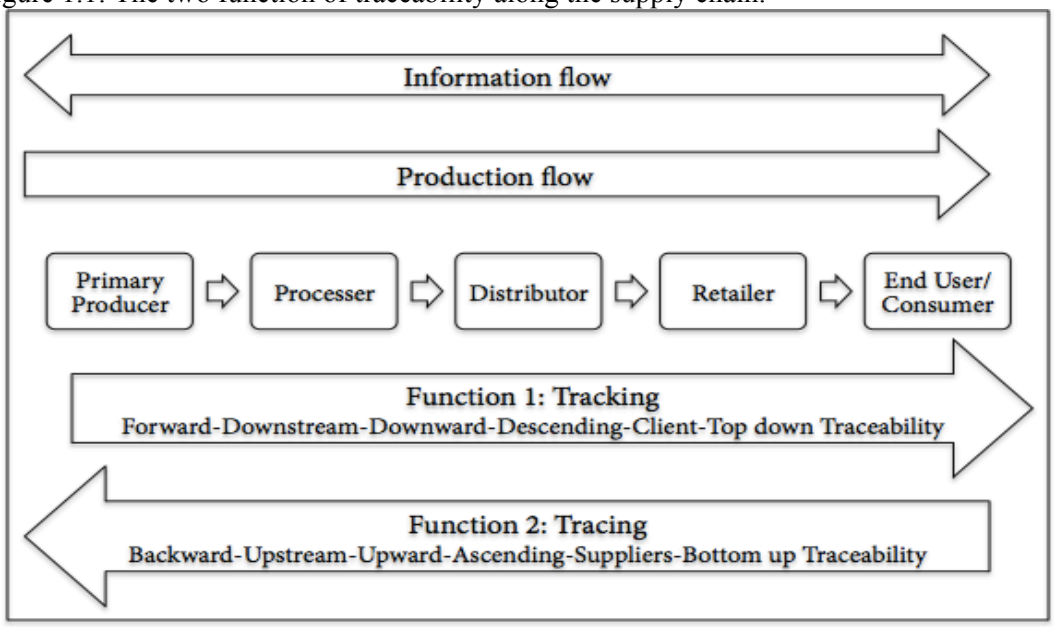
In relation to its objective and on how the information flow is recalled in the supply chain, Perez-Aloe et al. (2007) distinguish between back or suppliers' traceability and forward or client traceability (Perez-Aloe et al., 2007).

According to GS1 (2012) "Tracking is the capability to locate or follow the path of a particular traceable item downstream based on criteria determined at each point of the supply chain by reference to records held about it". "Tracing is the capability to identify the origin and characteristics or history of a particular traceable item upstream based on criteria determined at each point of the supply chain by reference to records held about it". It is proposed to use tracing backward or ascending traceability as a synonym of trace, while track forward or descending traceability as a synonym of tracking (GS1, 2012).

Due to the complexity of food supply chains, in 2014 Zhang and Bhatt prepared a guide on best practices in food traceability, providing a glossary on the nomenclature concerning traceability. Tracking is defined as "*the ability to follow the path of a traceable item through the supply chain as it moves between parties*", whereas tracing is

"*the ability to identify the origin attributes, or history of a particular traceable item located within the supply chain by reference to records held*". In contrast to GS1 they propose to use *tracking* as *tracking forward* and *tracing* as *tracking backward,* removing the differentiation between tracking and tracing (Zhang and Bhatt, 2014).

Figure 1.1: The two function of traceability along the supply chain.



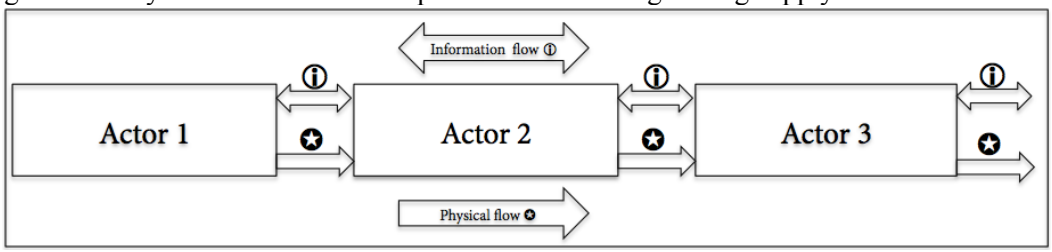
Source: Author's elaboration based on literature in Paragraph 1.2.

The analysis performed shows a wide range of terms associated with two main aspects related to traceability. Considering the different stages composing a food supply chain traceability is generally related to two main functions. Given the product flow along the supply chain one function performed by a traceability system is to carry information downstream, from the first agent (primary producer) to the end user. The second function performed is the system capability to find the information required in the opposite direction, upstream from the end user to the primary producer. Figure 1.1 systemizes how the information flow provided by a traceability system delivers information in both directions. Tracking is often associated with *forward*, while tracing is linked with *backward.* As illustrated in the Paragraph 1.1, many Authors agree in describing traceability as an information system and, depending on the direction of the information carried, use a different vocabulary to characterize it and to ensure that the action considered is clearly defined. Another aspect to be considered is that often while tracking is used to find the cause of a quality problem, tracing is used in the event of product recalls or withdrawals (Dupuy et al., 2005; Gencod-EAN France, 2001; Wang et al., 2011).

1.2.1 Key concepts in traceability: Physical and Information Flow

Supply chains are composed of several actors, carrying out different activities. To achieve an efficient supply chain traceability system is essential a linkage between information and physical product flow (Bosona and Gebresenbet, 2013). As shown in Figure 1.2 physical flow refers to the unidirectional material process from the primary producer to the end user. On the other hand information has a bidirectional flow, both downward and upward. Traceability management implicates the association of information and physical flow of traceable item, determining that each participant in the system should follow common basic rules of the traceability process (GS1, 2012). Given the complexity of current supply chain, a critical aspect is that the actor responsible for the information flow may be different from the actor responsible in the physical flow (Taillard, 2011).

Figure 1.2. Physical and information product flow sharing among supply chain actors.



Source: Author's elaboration based on literature in Paragraph 1.2.

1.3 Scope of traceability: Internal and External

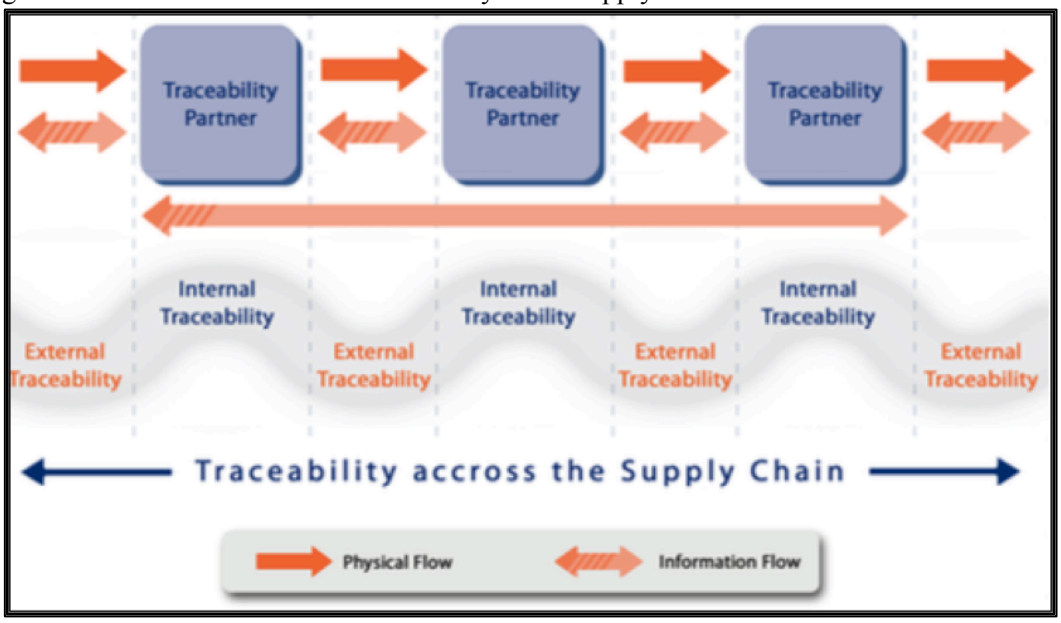
To achieve full chain traceability all agents involved shall implement both internal and external (chain) traceability (Arienzo et al., 2008; Aung and Chang, 2014; GS1, 2012; Hu et al., 2013; Porto et al., 2011; Taillard, 2011; Thakur et al., 2009). It implies that the output unit and the specific input unit are connected throughout the supply chain (Thakur et al., 2009). In general the two concepts are separately defined as different categories of traceability. The first differentiation in literature is made by Moe (1998), that defines internal traceability as "*the ability to track a product batch and its history internally in one of the steps in the chain*", while chain traceability as "*the ability to track a product batch and its history through the whole, or part, of a production chain from harvest through transport, storage, processing, distribution and sales*" (Moe, 1998). According to GS1 (2012) internal traceability "*takes place when a traceability partner receives one or several instances of traceable items as inputs that are subjected to internal processes, before one or several instances of traceable items are output*", whereas external traceability "*traceability takes place when instances of a traceable item are physically*

handed over from one traceability partner (traceable item source) to another traceability partner (traceable item recipient)" (GS1, 2012).

An internal traceability system is considered to be a necessary prerequisite to achieve full chain traceability (Senneset et al., 2007). It takes place within a single link of the chain, generally one company or company unit (Arienzo et al., 2008; Asioli, 2009); and is a process independent from a company's commercial partners (EAN France, 2003). The objective of internal traceability is to link all the units of output with specific unit of inputs, through an internal record keeping system that allows tracing backward all ingredients. Therefore is not necessary the connection among actors of the supply chain, but each should also maintain accurate records of their internal processes (Storøy et al., 2013).

Conversely, external traceability implies a connection among different links (usually companies) of the supply chain, by means of recorded identifications (Asioli, 2009; Olsen and Borit, 2013). The system should cover all stages from production, to distribution (Arienzo et al., 2008).

Figure 1.3: Internal and external traceability in the supply chain.



Source:GS1 (2012).

Generally external and internal traceability are considered to be the two key elements to achieve a fully traceable supply chain. However, according to Van Dorp (2002) the scope of traceability can be divided in four types, to describe with more accuracy the relationships among supply chain actors. The enterprise perspective refers usually to traceability in a single company production site. The Multi-site perspective is associated with manufacturing companies with multiple plants in different sites; in this case traceability is associated with multiple physical and information flows, increasing the

system complexity. The supply chain perspective relates to a network of two or more companies which manage information along the entire supply chain till the end user in order to meet specific traceability requirements. Lastly, the external environment perspective entails an external authoritative or official control to verify the compliance of traceability requirements. It can be a public authority to verify compliance with legislation (e.g. EU Regulations) or an external organization which validate the fulfillment of a private label (Dorp, 2002; Kelepouris et al., 2007).

1.4 Key elements of a traceability system

To be effective a traceability system generally includes four main elements that shall be clearly defined.

1.4.1 Traceable Units

In order to implement traceability system shall be defined which is the entity to trace. Kim, Fox, and Gruninger in 1995 introduced the concept of Traceable Resource Unit (TRU), considered one of the axioms of the TOVE traceability ontology. A TRU "*is a homogeneous collection of one resource class, that is used/consumed/produced/released by a primitive activity in a finite, non-zero quantity of that resource class*". Consequently, for batch processes TRU "*is an unique unit, meaning that no other unit can have exactly the same, or comparable, characteristics from the point of view of traceability*" (Kim et al., 1995). It represents the element that a traceability system must be able to trace, and it corresponds to an identified type of production batch (Dupuy et al., 2005). Moe (1998) stressed that in case of continuous processing the definition of TRU is more complex. The identification or the size of a TRU can change during the product route (Moe, 1998). Moreover, a TRU can be identified according to several attributes such as weight and volume (Karlsen et al., 2013).

According to Karlsen, Olsen, and Donnelly (2010) three types of TRU can be identified: batch is "*a quantity going through the same process*"; trade unit is "*a unit which is sent from one company to the next company in a supply chain*"; logistic unit is "*a trade unit created by a business before transportation or storage*" (e.g. pallet or container) (Karlsen et al., 2010). Buchanan and Emmett (2012) state that batch is related with internal traceability, while trade and logistic unit are associated with external traceability dealing with trading partners (Buchanan and Emmett, 2012).

The batch concept has been formalized in ISO 22005:2007 standard as "*set of units of a product which have been produced and/or processed or packaged under similar circumstances*" (Iso, 2007). According to GS1 "*a batch unites products/ items that have undergone the same transformation processes*", while a logistic unit is "*an item of any*

composition established for transport and/or storage that needs to be managed through the supply chain" (GS1 Global Office, 2006). In the definition of a batch the most critical criteria that would be most likely to alter the quality of the product should included. Generally the definition of a batch includes some main criteria: date/period of production or the transformation process; country; factory; production line; packaging line; team; raw material batches (EAN France, 2003).

In relation to the supply chain step considered a traceable unit will typically change, in relation to needs and business processes of each participant. For a single company the definition of a traceable unit can be function of specific business objectives, agreement with trading partners or standards/recommendations for business practices within an industry (Buchanan and Emmett, 2012).

Granularity

According to Opara and Mazaud (2001) a crucial issue regarding traceability is the identification of the unit to trace (Opara and Mazaud, 2001). In particular, the level of traceable units depends on stakeholders' need for traceable information; it can be compliance with legislation, certification schemes or to improve supply chain communication (Karlsen et al., 2012). As claimed by Bollen A. et Al. (2007) the size of a traceable unit defines the *granularity* of the traceable system (Bollen et al., 2007). Karlsen et al. (2012) defined granularity as "*determined by the size of a traceable unit and the number of the smallest traceable units necessary to make up the traceable unit at a specific granularity level*". Therefore granularity reflects not only the size but also the number of batches. The finer is the level of granularity the more is the detail of information provided about a product, giving more precision in case of a possible product recall (Dabbene et al., 2014).

1.4.2 Unique Identification of Traceable Units

Bollen, Ridena, and Cox (2007) introduced the concept of *Identifiable Unit* (IU), the entity that must be uniquely identified within a traceability system (Bollen et al., 2007). There are two main types of identification (ID) schemes: a unique string of characters and/or digits with no intrinsic meaning, and a unique "intelligent string" of characters and/or digits that contains information elements. Specifically, for internal traceable units a company can deploy a specific ID unique to the organization; concerning external traceable units for an effective traceability along the supply chain should be used a common standard to define the ID (Buchanan and Emmett, 2012).

1.4.3 Critical traceability Points/Events

The efficacy of traceability system is reduced whenever a systematic information loss occur (Dabbene et al., 2014). Within the supply chain a Critical Traceability Point (CTP)

is the location where information loss takes place. CTPs identification is necessary for the implementation of traceability, as certain recording are necessary to prevent information loss (Karlsen et al., 2010). It occurs when information on the composition or process conditions in not properly linked to the product and systematically recorded, determining a loss of traceability precision and of the granularity level of the system. As in the HACCP approach, the identification and mapping of CTPs is performed by qualitative methods as direct observation, structured interviews and document analysis, leading to a CTP analysis plan (Comba et al., 2013b).

The critical points are usually located wherever there is a change of partner or operation. The consequences of an inadequate data recording are brakes in supply chain traceability system, loss and/or imprecise information. Some of the main reasons for breakages are unrecorded links between successive production batches and logistic units, information not linked to batch numbers and logistic units, use of proprietary systems (no common standards), "Paper" archiving and procedures do not conform and/or are not precise enough, lack of awareness by staff or absence of training, and lack of automation and manual input (EAN France, 2003).

Mcentire et al. (2010) introduced the notion of *Critical Tracking Events* (CTEs) as "*points where product is moved between premises or is transformed, or is determined to be a point where data capture is necessary to maintain traceability*" (Mcentire et al., 2010). In order to follow the path through the entire supply chain these events need to be collected to enable full traceability. These CTEs may be internal (e.g. batching, mixing ingredients, transformations, aggregating) or external to an organization (e.g. receiving and shipping) (Elise Golan et al., 2004). Each supply chain is different and has its specifics CTEs. Generally the CTEs relate to product creation, product receipt, product shipping, product consumer sale (retail) and product depletion (retail and food service) (Welt and McEntire, 2011).

1.4.4 Key data elements

Once identified all relevant CTEs it is essential to associate them to those data necessary to follow a traceable unit. These data, recorded and stored, carrying relevant information on a traceable unit are called *Key Data Elements* (KDEs) (Sterling and Chiasson, 2014). The Institute of Food Technologists defines KDEs as "*those data required to successfully trace a product and/or its ingredients through all relevant CTEs*". To enable an efficient traceability system is so necessary associate the KDEs with all CTEs. Usually a KDEs include an Unique Item Identification, an Unique identifier for the location of the event and Date and Time Stamp (Welt and McEntire, 2011).

According to GS1 (2011) KDEs supports CTEs storing information regarding:

- What is traced: Unique Product Identifier (e.g. Global Trade Item Number, batch)
- When a CTE occurs (e.g. date and time).
- Where a CTE is located (e.g. Global Location Number).
- Description of a CTE (e.g. receiving, transformation).
- GS1 identifies four KDE categories:
- Master data: information about company, premises, products, which remain relatively static over time.
- Transactional (or event) data: information about the traceable entities associated with a CTE.
- Public information: information to share with external parties (authorities, trading partners, consumers, etc.)
- Private information: information used internally in an organization (GS1 US, 2011).

Traceability and HACCP

As the identification of CTEs and KDEs are the baseline to implement a traceability system, it can be identified some similarities with the HACCP methodology.

Table 1.3. Similarities in the HACCP and Traceability processes.

HACCP	Product traceability
Conduct a hazard analysis	Identify products and product inputs to be traced
Identify critical control points	Identify critical tracking events
Determine critical limits	Determine key data elements
Establish monitoring procedures	Establish data capture procedures
Establish corrective actions	Establish a system to detect "red flags
Establish verification procedures	Conduct mock trace back
Ensure record keeping	Maintain a written record

Source: IFT (2011) Developing a Product Tracing Plan Using Critical Tracking Events and Key Data Elements.

Even if traceability is applied among actors of the supply chain and HACCP in the single organization, as can be observed in Table there are some common points. In relation to CTEs in HACCP must be identified the Critical Control Points. Moreover, the qualitative procedure to identify these elements is similar (Comba et al., 2013b). Considering KDEs in HACCP must be determined the Critical Limits.

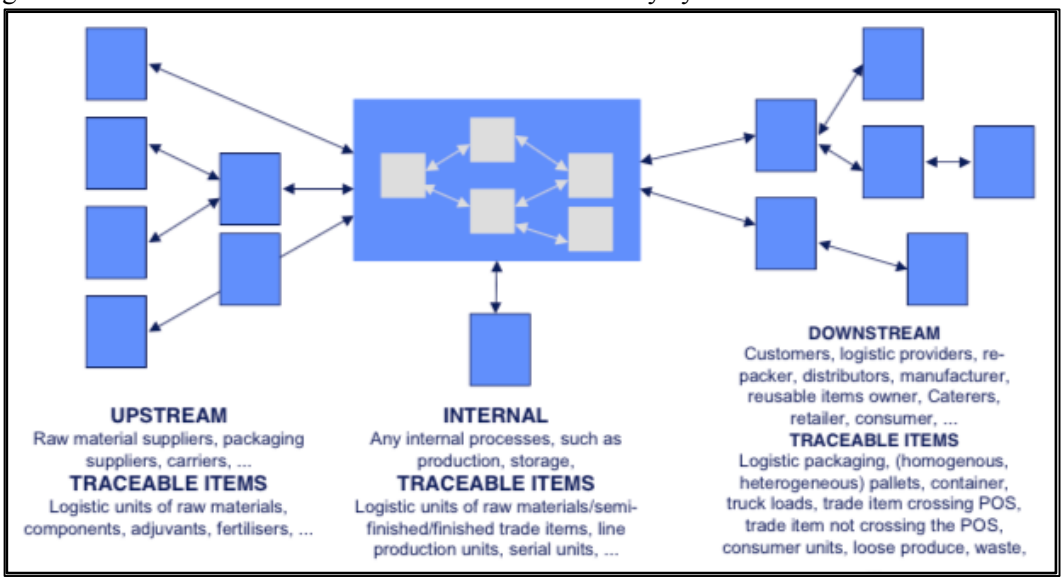
1.5 Key sub-processes for the implementation of traceability system

Traceability is based on the identification of operators and products in all links of the supply chain, and on the detection and recording of information to describe the process of product creation and transformation. On this baseline a traceability system shall be composed of four main sub-processes: Unique Identification, Data Capture and Recording, Traceability Links Management, Data Communication (EAN France, 2003; EAN International, 2004; ECR Europe, 2004; INDICOD, 2003).

1.5.1 Unique Identification

In order to facilitate tracking and tracing along the supply chain all the relevant traceable units must be uniquely and non-ambiguously identified. Every time that a unit is processed or transformed it should be assign a new identifier (considered the key to access all available and relevant information). This process of identification involvers all the units such as batches of row materials, trade and logistics units (EAN France, 2003). In addiction, the identification process should follow the path of the unit along all the supply chain, till the final consumer (INDICOD, 2003).

Figure 1.4. Scheme of items identification in a traceability system.



Source: EAN France (2003).

The EAN-UCC System

According to GS1 the EAN-UCC System well suits to provide globally unique identification to units to trace. The usage of a standard such as the EAN-UCC-128 provides a common business language which helps all actors in the supply chain to meet traceability requirements (EAN International, 2004). It is an identification system based on the allocation to each unit, at each stage of production and distribution, a unique identity number. The numbering system EAN / UCC means that each number is unique (INDICOD, 2003).

The standard provides the use of numbers to identify all traceable units that are globally unique. These numbers are defined as non-significant, as the information they provide may change in relation to supply chain partners. The Standard sets three main types of codes:

- Global Location Number (GLN)

It allows trade partners the unique identification of all location involved in the creation of a product, such as warehouses, delivery/loading ramps and departments.

- Global Trade Item Number (GTIN)

The consumer and packaging units are identified as trade items, which information can be retrieved at any point of the supply chain. The term refers both to single product and their different configurations, which is assign a unique code (EAN France, 2003; EAN International, 2004; INDICOD, 2003; Sterling and Chiasson, 2014) The code can store different information such as description, supplier, brand owner, composition, characteristics, manufacturing process, dimensions, weight, 3rd party certifications (EAN France, 2003).

The GTIN is combined with a Batch or Serial Number to allow the identification of a particular item. The serial number permits the possibility to detect an individual item (e.g. a single television). The information carried can be the date/ time of production and packaging, production line, sample number, temperature at the time of the transformation process, minimum and maximum durability. The Batch number identifies trade items that undergone the same production process (e.g. yogurts). The information conveyed can be date/ time of production and packaging, production line, sample number, temperature at the time of the transformation process, expiry date, results of analysis (EAN France, 2003).

- Serial Shipping Container Code (SSCC)

The SSCC identifies the logistic units (pallets): "*an item of any composition established for transport and/or storage which needs to be managed through the supply chain*" (GS1). The information of the code can relate to content, type of logistic entity (gtin), supplier, transport company, delivery date, storage location and temperature, quantity of cartons removed from or added to the pallet (picking, replacement of a carton on a pallet, transportation conditions, movements (dates and times of removal from stocks, loading, etc.), shipping advice number, delivery note number (EAN France, 2003; EAN International, 2004).

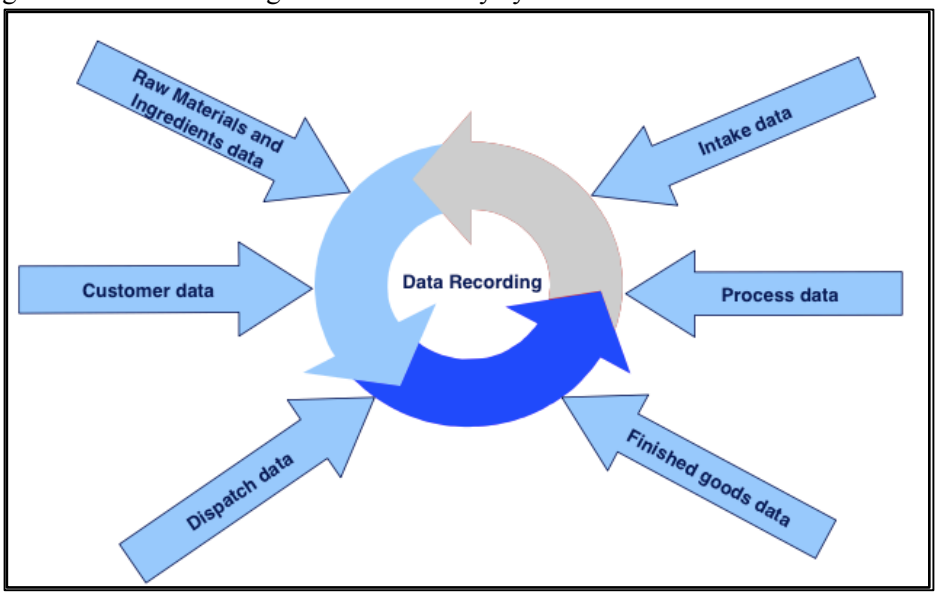
Other information that shall be collected regards to the traceability legislative requirements for each type of product handled (Asioli, 2009).

1.5.2 Data Capturing and Recording

Traceability is based on detection and recording of information describing the process of product creation and transformation. Managing traceability means defining what information to record during the production and processing of the product throughout the

supply chain. The traceability system requires registration updated, archived and available to all information relating production process activities and flows. The recording means may resort to manual documentation on bases paper or the use of technologies (INDICOD, 2003).

Figure 1.5 Data recording in the traceability system.



Source: EAN France (2003).

The EAN-UCC System

According to the EAN-UCC Standard data capture and recording shall be carried out with the support of Barcodes or Radio Frequency Identification (RFID).

Within supply chains the UCC/EAN-128 bar code is used to encode primary identification such as GTIN, SSCC and additional data such as batch number. Using UCC/EAN-128 bar code to comply with the Standard is mandatory the Application Identifiers (AI's), which ensure that data are universally recognized (EAN France, 2003). GS1 developed the standard Electronic Product Code to support the usage of RFID technology (GS1, 2014).

1.5.3 Traceability Links Management

Once data are recorded they must be managed to allow downstream and upstream traceability. In the majority of supply chains products are tracked and traced through production batches and through their process of distribution (transport and storage) (ECR Europe, 2004). It is so necessary to manage data to link units from raw materials to consumers. There are three types of links to manage along the supply chain:

- Links among batches: links among raw materials, packaging, final products and all intermediate batches.
- Links among batches and logistic units.

- Links among logistic units: links among received and sent logistic units (INDICOD, 2003).

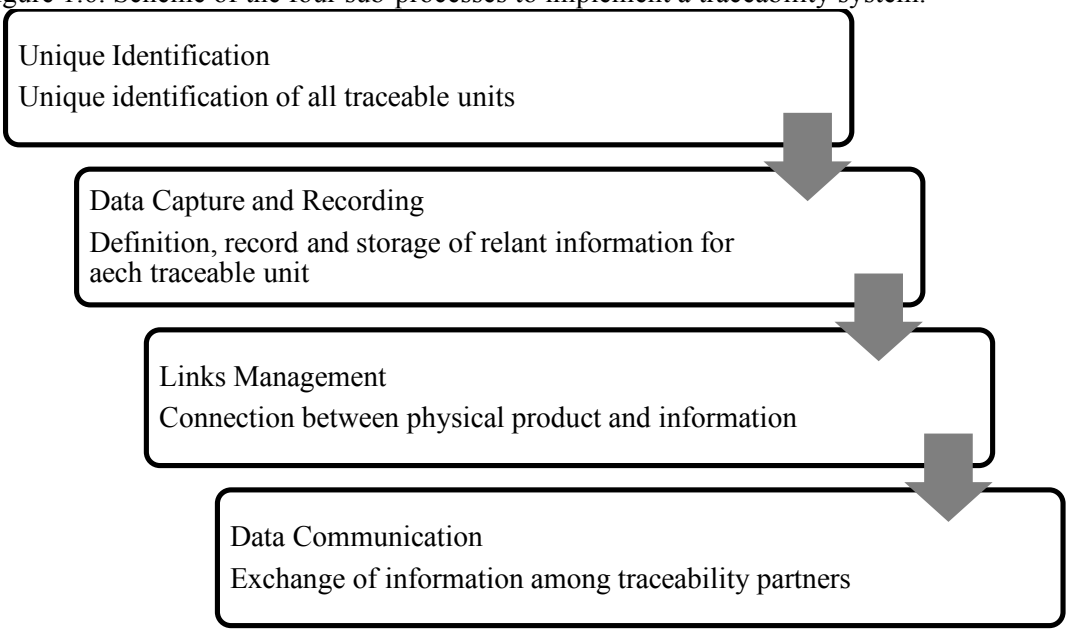
1.5.4 Data Communication

One of the key features of a traceability system is the information exchange among supply chain partners. It is required to link the products' physical flow with data information flow referred to them. Each participant shall communicate with predefined traceability data to the next (EAN France, 2003). This activity can be implemented with traditional tools (e.g. delivery notes) jointly with identification codes (e.g. ENA-UCC-128) (ECR Europe, 2004).

The EAN-UCC System

The enabling technology recommended is the Electronic Data Interchange (EDI). EDI "is the exchange of structured data in standardized message formats via electronic means between computer applications of trading partners" (EAN France, 2003).

Figure 1.6. Scheme of the four sub-processes to implement a traceability system.



Source: Author's elaboration based on literature in Paragraph 1.5

1.6 Traceability Performance Assessment

In order to figure out how a traceability system achieves the goals assigned, is necessary to clarify how its performances should be assessed. A system that enables to measure performances can be defined as "*a system that enables a firm to monitor the relevant performance indicators of products, services and production process in appropriate time frame*". Generally these indicators try to determine the effectiveness, the efficiency and the competency of a system. Aramyan et Al. (2007) developed a conceptual framework to capture the characteristics of agri-food supply chain consisting of four categories: efficiency, flexibility, responsiveness and food quality. Traceability is allocated in food quality category, and considered as medium importance element but often not measured and considered hard to maintain till final consumer (Aramyan et al., 2007). According to Bosona and Gebresenbet (2013) a traceability system should be evaluated in accordance to its overall goals, which enclose more punctual goals: compliance with rules and legislation; food safety and quality; social and stakeholders' satisfaction; economic benefits; technological ad scientific benefits. The system as a whole should be evaluated on the efficiency and effectiveness of all listed goals (Bosona and Gebresenbet, 2013).

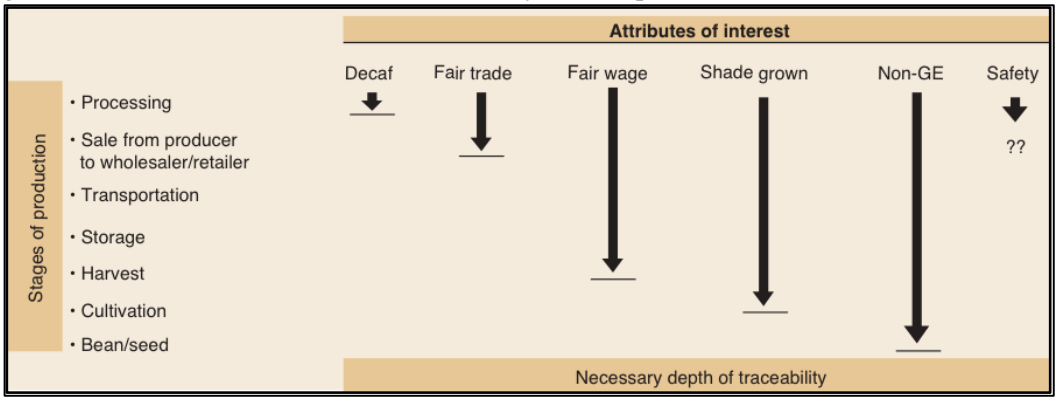
Van der Vorst (2004) states that traceability system performance can be assessed on three strategic levels. The first is the *compliance-oriented performance level*, focused on the compliance of regulatory issues. The second *is the process-oriented level*, aimed at controlling the process through local ITC system to get a performance improvement from traceability. The latter is the *market-oriented performance level*, establishing a full

traceability system within the entire supply chain. In this case all the chain is involved in traceability in order to achieve competitive advantage on the market place (Vorst, 2006).

In complex food chains, such as meet production, are present hundred of inputs. This makes virtually impossible to trace all inputs and processes for all possible objectives. In accordance with Golan et Al. (2004) the characteristic of traceability implemented by a firm differs in relation to the objective set. Moreover, it relates to cost and benefits achieved. Cost and benefits perceived by a company determine the level of *Breadth*, *Depth*, and *Precision* of traceability systems, through which the system can be evaluated. The firms will implement different level of traceability trying to maximise net benefits, to ensure that benefits minus costs are positive (Elise Golan et al., 2004).

- Breadth: "*describe the amount of information the traceability system records*". The Breadth relates to the information that firms considered as valuable and to the traceability system objectives. A complete food attributes recordkeeping is not possible, expensive and not necessary. In relation to firms objective are selected the attributes to store. As instance if the traceability system is implemented to inform consumers on food origin, it will be necessary to record information just on the country where the food is from (Golan et al., 2003).
- Depth: "*is how far back or forward the system tracks*". This traceability attribute determines till which point of the supply chain the system is able to track and trace. It is determined by quality or safety control points (critical traceability points/events). Generally is linked to the Breadth of the system: the traced attributes determine how deep is the traceability system.
- Precision: "reflects the degree of assurance with which the tracing system can pinpoint a particular food product's movement or characteristics". The key element to determine the precision the unit of analysis used and the acceptable error rate. A unit of analysis can widely varies from a container, a silos, a batch, a day of production etc. It is the tracking unit of the traceability system. The smaller is the unit the greater will be the system precision (Elise Golan et al., 2004).

Figure 1.7. The ration between attributes and system Depth.



Source: Golan et Al. (2003).

Given the importance of an efficient and effective traceability system in case of foodborne crisis McEntire et Al. (2010) suggest to integrate the three characteristics set by Golan et Al. (2004) with a new one: Access. According to the Authors Access is "*the speed with which track and trace information can be communicated to supply chain members and the speed with which requested information could be disseminated to public health officials during food related emergencies*" (Mcentire et al., 2010)

Chapter II. Drivers, barriers, costs and benefits of traceability in the agri-food sector

Several aspects drive the implementation of traceability system within a food supply chain and, conversely, several barriers slow down its application. Drivers and barriers are associated with benefits and costs that firms have to deal with to track and trace products or processes. First, the Chapter explores the possible classification of traceability benefits. Then, each category is examined in Depth. In the second part are discussed costs and barriers linked to traceability application.

While the analysis showed a general agreement on negative and positive aspects related to traceability, in literature no common accordance is found on the way these aspects should be classified. Moreover, it is not clear the border between drivers and benefits, and between barriers and costs. Generally, a driver corresponds to an expected benefit, while to a barrier is associated a cost.

2.1 Benefits of implementing traceability

Authors classify the benefits of traceability in several ways. Prior to the detailed analysis of these benefits the following paragraph intend to systematize the previous literature that focuses on the identification of benefits categories. The aim is to propose a classification that synthetically could help to group effectively the positive effects of traceability in food supply chains.

2.1.1 How to classify food traceability benefits

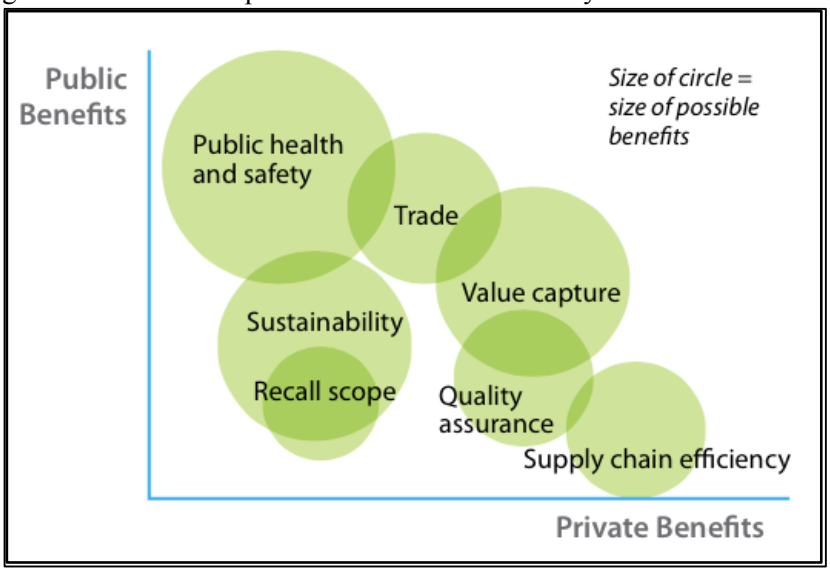
In 1998 Moe distinguished in chain and internal traceability advantages, stressing that from its implementation benefit both the entire supply chain and the single process within a firm. Specifically, chain traceability benefits are linked to compliance to regulatory requirements, efficient recall procedures, better control of raw material quality, avoidance of measurements repetitions, and possibility to implement marketing activities on specific raw materials. On the other hand, internal befits are: improved process control, better planning to optimize use of resources, correlation of product data with data on characteristics and processes, cause-and-effect-indicators to satisfy product standards, avoiding mixing high and low quality materials, ease of information retrieval in quality management audits, and better foundations for implementing information technology solutions in control and management systems (Moe, 1998).

When considering traceability, it should be pointed who is benefiting from it. Along the supply chain different stakeholders are potentially positively affected by traceability. Van der Vorst (2004) sets three categories of stakeholders that benefit from chain

traceability: Consumer, Business and Government. All the three categories benefit from the implementation of traceability in different ways. Consumer with a safe food and information on food characteristics; business with a more controlled production system; and government with a prompter action in case of product recall (Van der Vorst, 2004).

Traceability has positive return both on the private and public sphere, but varying intensity in relation to the benefit considered. Figure 2.1 shows that the most valuable public benefit is related to public health and safety, while for private benefits is the enhancement of supply chain efficiency (Mcentire and Bhatt, 2012; Sparling et al., 2011).

Figure 2.1. Public and private benefits of traceability.



Source: Sparling, Laughland, and Sterling (2011).

Understanding the effects of food traceability is therefore a broad task, that necessity to that into consideration several viewpoints and stakeholders in the supply chain. As instance, the benefits of full traceability are different in relation to the actor of the chain contemplated. Therefore, to clearly estimate benefits, it is necessary to classify them within homogeneous categories.

For firms is crucial to assess the potential benefits of traceability. In relation to expected improvements firms will be set the proper level of traceability (Breadth, Depth, Precision and Access). According to Golan et al. (2003) food suppliers have three main reasons to develop, implement and maintain traceability systems, which led to several benefits allowing net revenues for firms (Golan et al., 2003). The first is *Traceability for Supply Management*: firms have an incentive to establish product-tracing systems to manage production flows and track retail activity. Traceability allows reducing expensive overstocks, coordinating orders and shipments, and managing inventories. The second is

Traceability for food safety and Quality Control: it helps to enhance good safety and quality control systems, isolating the source of food safety and quality problem. The latter is *Traceability to Differentiate and Market Foods with Credence Attributes*: it allows firms to differentiate and prove on the market that a product has specific attributes, especially those that are costly or difficult to measure for consumers (Elise Golan et al., 2004).

Similarly Sykuta (2005) states that traceability has three main applications and consequence benefits. The first is the implementation of an inventory tracking and information system, which led to improve supply chain management. The second relates to the improved capacity to identifying and correcting quality failures. The third focuses on product characteristics, which can be easily delivered to consumers (credence attributes) (Sykuta, 2005).

Another category of benefits that is a main motivator for adopting traceability is complying with regulations. D. H. Sparling and Sterling (2004) classify traceability benefits in four groups. Meet legal requirements (*Regulatory benefits*), not only a benefit but also an essential condition for market entry. Then, *Market and Customer Response Benefits*, related to credence attributes. Third *Recall and Risk Management Benefits:* traceability helps reduce the potential scope of a food recall, the volume of product that must be withdrawn in order to capture all compromised product. Lastly *Supply Chain Benefits*, pointing that traceability increase the efficiency and effectiveness of supply chain management, determining an increased product quality and cost reduction (Sparling and Sterling, 2004).

Samarasinghe et al. (2009) indicate four areas of benefits: *Market Benefits*, stressing the increasing demand from consumers and distribution firms. *Quality and Safety Management* and *Products Recalls*. Finally, *Reduced costs of Production,* linked to potential supply chain benefits(Gooch and Sterling, 2013; Samarasinghe et al., 2009).

Mai et al. (2010) consider traceability benefits both from social and industrial perspectives. From social viewpoint it reduces risks and costs associated with outbreaks of food borne diseases and reduces costs for consumers in acquiring information associated with food characteristics. Otherwise, from an industrial perspective, it led to four groups of benefits: Market Benefits; Benefits from Recall Savings; Benefits from Reduction of Liability Claims and Lawsuits; Benefits from Process Improvements (Mai, 2010; Mai et al., 2010).

More recently, in 2013, Bosona and Gebresenbet performed a literature review on traceability, affirming that traceability benefits can be grouped in Social, Authorities' and Food Companies' benefits. Nevertheless, given the breadth of these three groups they

have identified six categories of benefits: *Increase in Consumers' Satisfaction, Improvement in Food Crisis Management, Improvement in Food Supply Chain Management, Competence Development, Technological and Scientific Contribution, and Contribution to Agricultural Sustainability* (Bosona and Gebresenbet, 2013).

The United Nations Global Compact in 2014 proposed to group drivers and benefits of traceability into four groups. *Value and Efficiencies* consist in the reduction of supply chain risk, operational and process consistency, securing supply, supplier selection and suppliers relationships, and reputational benefits. *Stakeholder pressure* is the capability to meet stakeholder demand for product information and the possibility to verify sustainability claims. *Regulation* relates to regulatory requirements. Finally *Global Alignment* which determines a standardization of approach across an industry (United Nations, 2014).

From the literature analysis performed four main groups of traceability benefits are widely recognized that relate to: process improvement, food safety management, product differentiation for market and consumers, regulation compliance. On this baseline in the next paragraph these four categories are explored in deep.

2.1.2 Process improvement

Traceability system enables several benefits distributed on supply chain actors and single firms (Mai, 2010). It reinforces the level of coordination between partners of food supply network and the effectiveness of process within a single organization (Rábade and Alfaro, 2006).

At the supply chain level traceability enhances vertical integration, increasing the quantity of information shared and monitored among partners. The vertical integration improves the ability to access relevant information determining a better decision planning and facilitate contracting relationship in the supply chain (Buhr, 2003). Especially voluntary traceability leads to a redistribution of liability among chain agents (Banterle and Stranieri, 2008b). The contraction of uncertainty level throughout supply favourites new forms of governance, increases liability among agents and enforces of production rules, leading in general to an increase in vertical coordination (Banterle and Stranieri, 2008a).

Traceability practices entails a decrease of transaction costs especially in the case of private labels, reducing the signalling costs of quality resulting an higher market share, a reduction of cost for quality control and enhanced process innovation for vertical differentiation strategies (Asioli, 2009; Canavari et al., 2010; Sodano and Verneau, 2003).

The information trials provided by traceability systems provide the foundation for a good supply management thanks to an higher coordination of supply chain, allowing efficient ways to produce, assemble, manage warehouse, and distribute products (Elise Golan et al., 2004; Meuwissen et al., 2003).

Traceability is proved to be an efficient tool to advance the distribution system. Especially on-line traceability system can significantly reduce cost of distribution with less delivery errors, a reduced transportation time, less refunds and less devolution of lots (Alfaro and Rábade, 2009; Elise Golan et al., 2004; Rábade and Alfaro, 2006).

Also firms' inventory management benefit thanks to traceability, through a better use of warehousing space, reduced handling costs, decreased inventory level, and minimization of production and logistics processes errors (Alfaro and Rábade, 2009; Can-Trace, 2004). Golan et al. (2004) analysing US national inventory-to-sales ratio statistics showed that keeping a better track of inputs and outputs reduces control inventory costs (Elise Golan et al., 2004; Samarasinghe et al., 2009). Moreover, R-fid technology allows a significant depot inventory control (Kärkkäinen, 2003; Samarasinghe et al., 2009).

The strengthened inventory control gives to firms several indirect advantages reflecting higher efficiency in process management. Notably electronic traceability could determine yield improvements, as instance increasing the quantity of meat produced in a slaughtering plant (Buhr, 2003; Mai et al., 2010). The improved inventory accuracy reduce also product wastage, diminishing the spoilage-out of data and the stock loss (Kärkkäinen, 2003; Mai et al., 2010).

The enhanced information and control of production (Buhr, 2003), determine a reduction in the time needed for product history investigation and prevention of production errors (FoodLinks Project, 2003), with a general operational time saving (Donnelly et al., 2013).

Another element to consider is that traceability systems determine saving in labour cost (Buhr, 2003; Elise Golan et al., 2004; Kärkkäinen, 2003; Meja et al., 2010; Resende-Filho and Buhr, 2007). In particular, Rfid can decrease the labour necessary to perform inventory counts (Kärkkäinen, 2003).

Implementation on traceability along the supply chian reduce the risk of liability claims. Indeed, it is a valuable tool for firms to counterattack liability claims and to recoup claims from other participants in the supply chain (Meuwissen et al., 2003). Firms can establish the extent of their liability in case of food safety accidens, allocating accurate responsabilities among supply chian partenrs. It is so a tool throught which fimrs can avoid negative consequences of a foodborn desease and an incentive to provide safe food (Bevilacqua et al., 2009; Elise Golan et al., 2004; Hatanaka et al., 2005; Pouliot and

Sumner, 2008). Through the coordination among supply chain agents is performed an accurate identification of the responsibility associated with the reduction in product recalls (Banterle and Stranieri, 2008a). From the firm viewpoint traceability is an effective mean of reducing risk exposure especially in a recall situation. It reduces liability claims costs and allows potential reduction in insurance premiums (Can-Trace, 2004; Jill E Hobbs, 2004; Jill E. Hobbs, 2004). Moreover, the improvement in recall through reductions in frequency, scope and severity reduced drastically its cost. The precision in recall reduces the number of locations and firms experiencing the recall, compromising just the supply chain agents effectively involved in the foodborne crisis (Bhatt et al., 2013; Elise Golan et al., 2004; Jill E. Hobbs, 2004; Mcentire and Bhatt, 2012; Mcentire et al., 2010; McEvoy and Suoza-Monteiro, 2008; Meuwissen et al., 2003; Sanderson et al., 2006). Furthermore, traceability benefits resulting from reduced losses are maximised when all actors of the supply chain are involved (Saltini and Akkerman, 2012).

2.1.3 Food safety management

Traceability itself is not enough to guarantee food safety and quality, but enables to keep record of information of products during all stages of the production, processing and distribution. Nevertheless it effectively reduces risk exposure by enabling food producers to identify, isolate and correct the problem quickly and efficiently, protecting public health (Samarasinghe et al., 2009).

Traceability systems have a significant role in resolving information asymmetry. One of the economic functions played is to reduce societal costs in case of a foodborne illness (Jill E. Hobbs, 2004). An efficient system can minimise the scope of a food borne illness, cutting public costs by reducing the number of people exposed to unsafe food (Jill E Hobbs, 2004). Therefore, it reduces ex post damages of a food safety incident (Jill E. Hobbs, 2004; Monteiro et al., 2008). Indeed it is an advantage both for authorities and other stakeholders, in order to improve precision and time needed for food recall (Banterle and Stranieri, 2008a; Dabbene et al., 2014; Donnelly et al., 2013, 2012; Dupuy et al., 2005; FoodLinks Project, 2003; Elise Golan et al., 2004; Poghosyan et al., 2004; Sparling et al., 2006).

2.1.4 Product differentiation for market and consumers

Traceability allows firms to take market advantages from enhanced food safety (being able to avoid being implicated in an outbreak), protecting brand name, assuring product claims, and maintaining consumer confidence (Meja et al., 2010).

Conversely, the lack of traceability systems determine market failure as a result of asymmetric or missing information for consumers (Elise Golan et al., 2004). Without

traceability consumers are not aware of products quality, determining increased costs arising from quality verification (Jill E. Hobbs, 2004). Traceability supports the assurance of quality attributes, especially those that are not visible, called credence attributes. These attributes have characteristics that consumers (and markets) cannot discern even after consumption (Darby and Karni, 1973). Credence attributes are composed of two broad categories. Non-visible process attributes are tracked because products are made using specific processes, and the process matters to selected customers, as organic food (Can-Trace, 2004). Whereas, content attributes affect the physical properties of food traceability, playing a determinant role in markets where credence attributes matter for consumers or producers. The higher is the value given by consumers and producers to these attributes the higher are the benefits of traceability implementation (Elise Golan et al., 2004). Consequently for producers is determinant in deciding the investment in traceability systems to understand how consumers are willing to pay a premium price for traced quality attributes of products.

Many studies have been conducted to elicit the value of traceability from consumers' perspective. Many authors found that traceability coupled with quality assurance determine an higher consumers willingness to pay (Cicia and Colantuoni, 2010; Henson, 1996; Hobbs, 2002; Ubilava and Foster, 2009). Traceability-related food attributes enhance benefits for consumers that consider traceability as valuable quality and safety assurance (Van Rijswijk and Frewer, 2012, 2006; van Rijswijk et al., 2008). Chen and Huang (2013) find out that traceable food has the effect to reduce consumers perceived information asymmetry, strengthening their purchase intentions (Chen and Huang, 2013). Is to consider that traceability by itself is not a sufficient attribute that guarantee consumers increased willingness to pay. It should be linked to quality assurance labels (Catarinucci et al., 2012; Elise Golan et al., 2004; Hobbs, 2002; Mora et al., 2007).

Consequently traceability helps firms to meet market and consumers requirements, assuring a faster responsiveness to changing customer demand always more demanding of quality, control and information (Banterle and Stranieri, 2008a; Can-Trace, 2004; Donnelly et al., 2013; FoodLinks Project, 2003; Sparling et al., 2006). Traceability gives firms the opportunity increase products' transparency, offering more detailed information to consumers and buyers, and contributing to the social dimension of sustainability (Donnelly et al., 2013; Meuwissen et al., 2003; Trienekens et al., 2012; Wognum et al., 2011). Transparency has the positive effect of improving the firms' image and reputation, reinforcing brand positioning in the market thanks to product differentiation (Banterle and Stranieri, 2008a; Can-Trace, 2004; Donnelly et al., 2013; FoodLinks Project, 2003; Elise Golan et al., 2004).

Given the difficulties in verifying credence attributes, traceability can be crucial in order to reduce anti-counterfeit, frauds and unfair competition among firms (Elise Golan et al., 2004). It is clear for high-end products, such as wine and ham. Thanks to traceability systems and technologies for product authentication it is possible to ensure consumers on the accuracy of information given (Dabbene et al., 2014; Myae and Goddard, 2012; Sun et al., 2014). Especially if product information is provided through electronic system (barcode or R-fid) consumers are more trusting on information reliability (Chrysochou et al., 2009).

2.1.5 Regulatory benefits

Given the importance of recent food crises, which have affected the international community, several countries have implemented regulations to ensure food safety.

In Europe in 2005 the General Food Law Regulation (EC Reg. No. 178/2002) and the so-called *EU Hygiene Package* (EC Reg. No. 852/2004; 853/2004 and 854/2004) introduced mandatory traceability requirements for all food business operators. A general regulatory framework, crossing all food sectors, was introduced, determining major changes in the European food supply chain (Dabbene et al., 2014; Heyder et al., 2010; Preziosi et al., 2014; Souza-monteiro et al., 2010). These mandatory laws have strongly contributed to a much more intensive regulation of food production. Regarding traceability in the art. 18 of EC Reg. No. 178/2002 was introduced the obligation to secure "*traceability of food at all stages of production, processing and distribution*" (EC Reg. No. 178/2002). By reason of this increased regulation, especially European firms in the supply chain are obliged and stimulated to implement traceability systems, in order to reduce the cost of non-compliance, ensuring the commitment with mandatory legislation (Asioli, 2009; Banterle and Stranieri, 2008a; Bertolini et al., 2006; Bosona and Gebresenbet, 2013; Elise Golan et al., 2004; Hammoudi et al., 2010; Heyder et al., 2010; Resende-Filho and Hurley, 2012; Schwägele, 2005; Souza-monteiro et al., 2010). Indeed traceability in Europe is necessary, consisting of mandatory tool to access and operate in the market (Asioli et al., 2012; Jill E. Hobbs, 2004; Sparling and Sterling, 2004). From firms viewpoint industry-wide traceability systems can assist the establishment of legal liability, reducing liability claims and lawsuits (Jill E Hobbs, 2004; Karlsen et al., 2013; Mai et al., 2010).

Table 2.1. Potential groups of benefits traceability implementation.

Process improvements	**Food safety management**	**Product differentiation for market and consumers**	**Regulatory benefits**
Inventory turnover improvement (Alfaro and Rábade, 2009; Can-Trace, 2004; Elise Golan et al., 2004; Kärkkäinen, 2003; Mai et al., 2010; Samarasinghe et al., 2009; Sparling et al., 2006)	Less frequent recalls (Mai et al., 2010; Sparling et al., 2006)	Increasing consumers trust (Asioli et al., 2012; Mai et al., 2010; Sparling et al., 2006)	Regulatory and legislative compliance (Asioli et al., 2012; Mai et al., 2010; Sparling et al., 2006)
Reduce Spoilage/out of date cost reduction (Kärkkäinen, 2003; Mai et al., 2010; Sparling et al., 2006)	Less severe recalls. Reduced scope of recall (Precision) (Jill E. Hobbs, 2004; Mai et al., 2010)(Banterle and Stranieri, 2008a; Dabbene et al., 2014; Donnelly et al., 2013, 2012; Dupuy et al., 2005; FoodLinks Project, 2003; Elise Golan et al., 2004; Poghosyan et al., 2004; Sparling et al., 2006).	Meeting customer's requirement (Asioli et al., 2012; Sparling et al., 2006) (Mai et al., 2010; Van Rijswijk and Frewer, 2012, 2006; van Rijswijk et al., 2008)	
Yield improvements (Buhr, 2003; Mai et al., 2010; Sparling et al., 2006)	Better management of recalls (Mai et al., 2010)	Increase market share (Asioli et al., 2012; Sparling et al., 2006)	
Labour cost savings (Buhr, 2003; Elise Golan et al., 2004; Kärkkäinen, 2003; Mai et al., 2010; Meja et al., 2010; Resende-Filho and Buhr, 2007)	Reduced time needed for food recall (Banterle and Stranieri, 2008a; Dabbene et al., 2014; Donnelly et al., 2013, 2012; Dupuy et al., 2005; FoodLinks Project, 2003; Elise Golan et al., 2004; Poghosyan et al., 2004; Sparling et al., 2006)	Obtain premium price (Asioli, Boecker, and Canavari 2012; D. Sparling et al. 2006; Hobbs 2002; Ubilava and Foster 2009; Cicia and Colantuoni 2010; Henson 1996)	
Reduce cost of production (Sparling et al., 2006)		Access to new markets (Asioli et al., 2012; Jill E. Hobbs, 2004; Sparling and Sterling, 2004)	
Reduce the possibility of errors for data inputs and data management (Asioli et al., 2012)		Enhancing brand image and reputation (D. Sparling et al. 2006; Donnelly, Thakur, and Sakai 2013; Banterle and Stranieri 2008a; Can-Trace 2004; Golan et al. 2004; FoodLinks Project 2003)	

Improve supply chain coordination (Banterle and Stranieri, 2008b; Buhr, 2003; Elise Golan et al., 2004; Meuwissen et al., 2003; Rábade and Alfaro, 2006; Sparling et al., 2006)	Anti-counterfeiting (Dabbene et al., 2014; Myae and Goddard, 2012; Sun et al., 2014)
Reduced distribution costs (Alfaro and Rábade, 2009; Elise Golan et al., 2004; Rábade and Alfaro, 2006)	
Reduced risk of liability claims, lawsuits and costs of recall (Bevilacqua et al., 2009; Bhatt et al., 2013; Can-Trace, 2004; Elise Golan et al., 2004; Hatanaka et al., 2005; Jill E Hobbs, 2004; Jill E. Hobbs, 2004; Mcentire and Bhatt, 2012; McEvoy and Suoza-Monteiro, 2008; Meuwissen et al., 2003; Pouliot and Sumner, 2008; Sanderson et al., 2006)	

2.2 The costs of traceability

As described before, implementing traceability systems will result in benefits both for firms and society. Concurrently, firms will incur the cost of having a new system to implement, which allows to identify the production inputs, to track product in the facility, and to identify the location and time for each product unit. A firm has to collect Key Data Elements and Critical Data Events to ensure the reliability of the system. These activities require firms to invest recourses necessary to acquire or maintain equipment as well as employees training and consultancy costs (Meja et al., 2010). However these costs may widely vary in relation to several factors such as the nature of firm, products and activities, and its role and position in the supply chain (Can-Trace, 2004; Gooch and Sterling, 2013; McEntire et al., 2010). When the complexity of production and distribution system is high the cost of traceability tends to grow. Products undergoing a large number of transformations require a larger number of information to be collected, increasing the difficulty of tracking and tracing. Also for products that are bought and sold numerous times the cost of traceability will rise (Elise Golan et al., 2004). The size of firms tends to influence the cost of traceability as well. Especially for small sized firms the implementation of new technological solutions for traceability can be considerably expensive. Moreover, costs will change significantly in relation to the adaptability of previous existing record keeping and tracking system (Meja et al., 2010).

The implementation of traceability systems do not generate cost just for single firms, but for all supply chain firms involved, setting extra costs associated with administrative and monitoring functions that are not accounted at single firm level (Meja et al., 2010). The cost of coordinating firms along the supply chain can be reduced through software technologies that enhance vertical coordination and supply chain management (Elise Golan et al., 2004).

Another element to evaluate when considering costs is the desired level of traceability. As traceability benefits also its costs increase in relation to system Breadth, Depth, Precision, and Access. The more the system is Depth higher the number of transactions and thus the cost. Increasing the system Breadth grows also the amount of information to record and its associated costs. Finally, a high level of Precision requires a system capable to record smaller and exact units resulting higher costs (Elise Golan et al., 2004).

In order to classify traceability system costs Golan et Al. (2004) separate them in recordkeeping and product differentiation. The first are related to collection and maintenance of information on product attributes along the supply chain. The second group of costs are those incurred in keeping products or product attributes separate from

one another through discrete unit (usually lots) defined over a set of common processes or content attributes (Elise Golan et al., 2004). Two separate approaches to separate product's attributes are possible: segregation and identity preservation. Segregation system separates one crop or batch of food ingredients from others, while identity preservation identify the specific product nature and origin. The latter implies a higher level of Precision, with higher costs (Elise Golan et al., 2004; United Nations, 2014).

Costs of realizing traceability can be split into two main categories: costs that incur during implementation and on-going costs. The implementation costs are generally fixed costs that occur for the first developing and implementation of system. Conversely, on-going costs are variable expenses that change in proportion to the activity of a business, such as labour, materials, and licensing fees (Asioli et al., 2012; Can-Trace, 2004; Henson et al., 2005; Meja et al., 2010; Sparling et al., 2006).

According to (Meuwissen et al., 2003) the main implementation costs relate to the necessity to transform processes, less flexibility, automation, and extra storage, production materials, personnel, and documentation. While maintenance costs relate to audits to be performed (Meuwissen et al., 2003).

(Asioli, 2009) considers implementation costs: "*Production line, supervisory staff, managerial/ administrative staff time and disruption of production; Purchase of new equipment and software; Training courses; External consultants; Materials; and Certification and Audits. Maintenance costs are: Production line, supervisory staff, managerial/ administrative staff time and disruption of production; Upgrading equipment and software; Training courses; External consultants; Materials; and Audits*" (Asioli, 2009).

Some cost categories such *"Production line, supervisory staff, managerial/ administrative staff time", "Audits", "Training" and "External Consultants*" are common for both implementation and on-going phases (Asioli, 2009; Meuwissen et al., 2003; Mora and Menozzi, 2002).

Sparling and Sterling (2004) set four costs categories: "Technology – software, services and hardware; Database changes and systems integration; Implementation & training; and On-going maintenance & support" (Sparling and Sterling, 2004).

Can-Trace Project (2004) suggests to group costs in ten categories: "*Hardware - Computer & Tracking Hardware; Hardware & other Capital Expenses; Software; Consulting Services ñ Integration & Support; Education & Training; Other Personnel Costs; On-going maintenance & support; Label Supplies; Policy Development, Compliance & Auditing; Other Costs*" (Can-Trace, 2004).

More recently in 2010 Mejia et al. categorize traceability system cost into six groups, clarifying that each cost component can be present in both the implementation and maintenance phase: "*Capital equipment and software; External consultant costs for identifying, designing, or implementing the system; Training cost associated with the system; Labour costs for operating the system, including labour for record keeping requirements; Additional material for operating system; and Effects of the system on line speed or efficiency of operations*" (McEntire et al., 2010; Meja et al., 2010).

Finally (Donnelly et al., 2013) studying the potential costs and benefits of advanced traceability in the supply chain between Japan and Norway divide costs in: "*System cost; implementation, Training; Consultant; Labour; and Equipment*" (Donnelly et al., 2013).

The literature review performed indicates that Authors commonly agree in splitting traceability costs into start up and maintenance costs. More or less detailed cost components are generally common in several studies performed.

2.3 Barriers to traceability systems implementation

Although costs are considered as a main obstacol to traceability system adoption, other factors affect its diffusion in food supply chains (Mcentire et al., 2010). Van der Vorst (2004) conductiong an international benckmark study on traceability systemes identifies five mayor bottlenecks. Concerning supply chain the main barriers are: defined and different traceability performance level among members, lack of organisation and transparency, and lack of shared standars. Furthermore, firms have no clear understandign of benefits and are not willing to invest in traceability infrastructures, due to high cost of meterials flow separation (Van der Vorst, 2004).

F. Wang et al. (2009) analysing the adoption of traceability system in Chinese fishery process enterprises oberved that the main constraints is the inconsistence of standard and implemementation criterion. Also in this case other main barriers are the high cost of adoption, the uncertainity of future benefits. Companies perceive as a barrier the occurrence of hidden costs as the change in the internal management and relations with other members of the supply chain. Finally, lack of skills and lack of policy support from local and national authorities are an obstacle to investment in traceability systems (Wang et al., 2009).

Mc Entire et al. (2010) interviewing US firms point out that, beside the monetary cost of investment, one of the most critical factors is the necessity of restructuring the IT infrastructure (especially for installations located in remote places). Another problem recognized concerns relations with suppliers, that often are not interested in product

tracing, providing insufficient and not standardized information. Many of the respondents believe that they can lose customers to competitors due to increased costs that traceability generates. In some cases it is found that firms believe that smaller suppliers would not be able to meet the new standards, resulting reduced competition. Especially for small companies a critical factor concerns the training of staff. Finally, incresed product tracing results increased responsibility and loss of anonimity in case of a problem foodborn (McEntire et al., 2010).

Kher et al. (2010) adopted Delphi methodology to investigate the impact of traceability regulations in EC and summarized the barriers of adopting traceability system. According to participants main barriers are the "intensiveness" of resources required especially for small producers, increased administration costs and paper works, errors in entry data. Another constraint relates to the definition of batch size and IT system connections among different firms. Common agreement is identified regarding different level of accuracy of traceability among supply chain links (Kher et al., 2010).

Conducting a comprehensive literature review on food traceability issues Bosona and Gebresenbet (2013) categorizied five groups of barriers in the implementation of effective traceability systems. First *resource limitation*, linked to the expendidure needed to implement traceability and the allocation of costs among supply chain partners. *Information limitation* relates to difficulties in adquiring complete, accurate, timely, and easily accessible data among firms. Another factor is the *standard limitation*: firms tend to use different standard and traceability systems, resulting a lack of data uniformity and different traceability leveles. *Capacity Information* is the necessity of skilled workers and managers, calling for training courses. Moreover, traceability sysyems require addictional administration work, considered a barrier especially for small firms. Lastly, *awareness limitation* relates to a lack of clearness regarding real benefits and an inconstant willingness to pay for traceability among supply chain partenrs (Bosona and Gebresenbet, 2013).

Accoridng to Aung and Chang (2014) there are two categories of hurdles to overcome to effectively implement traceability along the supply chain: *organizational* and *technological*. The first relates the innovation in the organization of both internal processes and integration among supply chian partenrs. The latter refers to technological investements necessary to enhance traceability performances such as the usage of specific software, Electronic Data Interchange (EDI) technolgies, BarCodes, and Rfid (Aung and Chang, 2014).

Chapter III. Research process and methodology

In this Chapter the research process and the methodologies implemented in this thesis are discussed. Starting from a critical analysis of existing literature, are explained the research problem and the process of formulation of research questions. The Chapter describes the context of research and the Italian poultry meant supply chain, chosen to carry out the survey. Then, the process of selection of the target population is described and how the questionnaire is constructed. Chapter VI gives a more detailed explanation of questionnaire structure.

3.1 Research process

This research starts with an extensive analysis of existing literature on traceability implementation in the agri-food sector. The first goal is to determine a common definition of the issue among both international scholars and international organizations. Then, the key elements in the implementation of traceability along food supply chain are described.

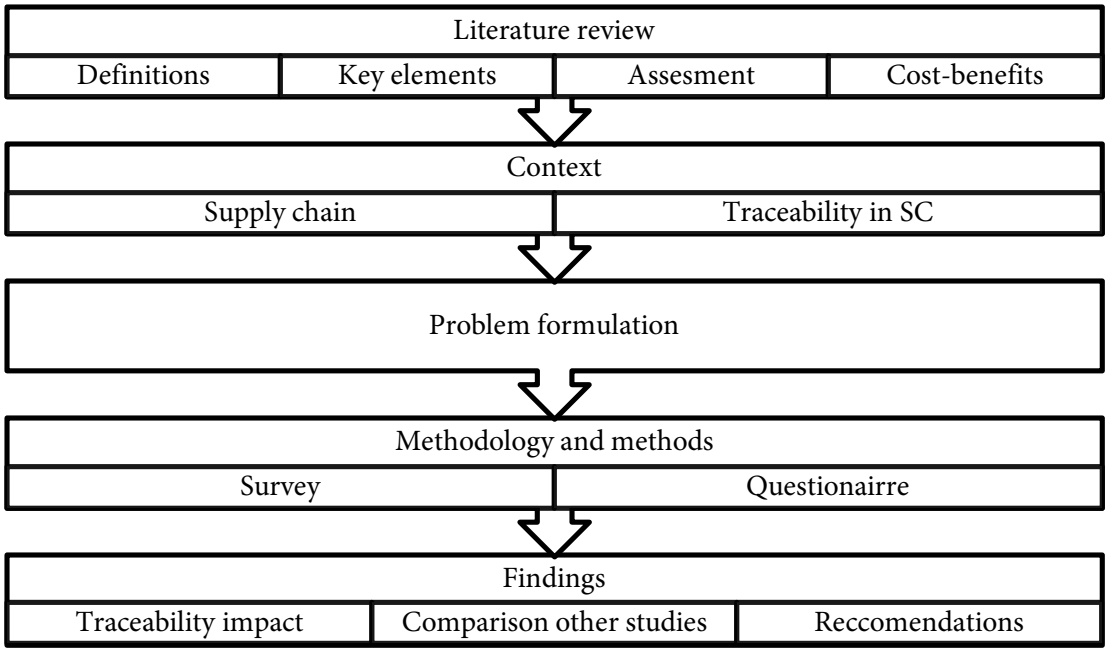
The second step is the analysis of previous works that investigated the impact of traceability on agri-food firms. Specifically, were selected works that studied its impact in terms of cost, benefits and difficulties for firms.

Given the critical analysis of literature, the main gaps of this research topic are identified. On this baseline, a food supply chain in which have not been performed the analysis of traceability impact is selected. The goal is twofold. The first is to assess the level of traceability implemented and verify main benefits and barriers for firms operating in the supply chain. The second is to determine if the level of traceability influences firms' perception in terms of its cost and benefits. Finally, it is conducted a comparison among the present work findings and other scholars' findings.

The methodology is a survey implemented through a questionnaire handed out to the selected supply chain operators.

The work has a potential positive impact both for academic research, expanding the scope of the analysis on an unexplored industry and, for food industries, to figure out how other firms of the industry perceive traceability in relation to the level of its implementation. Furthermore, industry associations and regulators may in deep their knowledge on traceability mandatory and voluntary regulations.

Figure 3.1. The research framework.



Source: Author's elaboration.

3.2 Critical analysis of existing literature on food traceability

The analysis of the literature has focused on various aspects of traceability implementation in the food industry.

The starting point is the definition of traceability. In many cases it was not found univocal definition and it was found the use of various terminologies. However, the meaning of traceability is very similar to the majority of authors. It allowed to identify some concepts commonly shared by authors. The key concepts are the actions of track and trace, and the identification of traceable units and critical traceability events.

Only a few works are devoted to the identification of traceability performance assessment. In particular (Elise Golan et al., 2004; McEntire et al., 2010) propose four elements that facilitate the evaluation of a traceability system: Breadth, Depth, Precision, and Access.

The third part of the literature explored previous works devoted to traceability impact on firms. Despite diversified points of view, process improvements, food safety management, product differentiation, and regulatory aspects are the main areas in which the introduction of traceability systems has a positive outcome.

In addition to benefits, the analysis focused on costs and difficulties encountered by firms implementing traceability in the agri-food sector. Concerning costs, many authors underline that costs may widely vary in relation to several factors such as the nature of firm, products and activities, and its role and position in the supply chain (Can-Trace,

2004; Gooch and Sterling, 2013; McEntire et al., 2010). Generally two categories of cost existes: start-up and maintainance costs.

Regarding the barriers to traceability implementation, are divided into organizational and technological (Aung and Chang, 2014; McEntire et al., 2010). Other authors point out that another aspect to consider is the uncertainty of future benefits achievable (Aung and Chang, 2014; McEntire et al., 2010), also in relation the consumer response (Elise Golan et al., 2004).

From the analysis it is clear that even today there is no consistency in the scientific world in the definition and evaluation of traceability systems. This probably is due to the fact that the topic cuts across different scientific disciplines. Therefore, often researchers viewpoints and objectives are different. In fact, traceability in the food chain relates to several scientific fields such as economics, marketing, supply chain managment, and engineering. In addition, in the studies analysed, heterogeneous research methodologies such as interwies, focus groups, surveys, modeling, simulations, and case studies are adopted. This heterogeneity shows that to date there is no common theoretical framework relating to food traceability sysyems (Karlsen et al., 2013).

Another aspect is the array of contexts in which the studies were carried out. National contexts are very different, and this causes some challengies in comparing the results of investigations. In addition, existing legislation may vary considerably. Charlebois et Al. (2014), performed a benchmarking of food traceability regulations in several countries. The result is that European countries scored "Superior", others like Canada, US Scored "Average", and China scored "Poor". Inevitably, this heterogeneity affect the results of the investigations studied, because the perception of consumers and businesses on benefits and costs of traceability will be different (Charlebois et al., 2014) .

3.3 Contribution and novelty of the research

Despite the limitations of the analysis, this has provided the foundations to draw the empirical analysis object of this work. The key points of traceability implementation were highlighted, and it has been possible to set a fail level of conceptualization that allowed to build the case study object of the survey.

In the literature analysis carried out, only in two cases (Asioli, 2009; Asioli et al., 2012; Banterle and Stranieri, 2008a; Stranieri and Banterle, 2015) was attempted to establish the level of traceability in a food supply chain (Breadth, Precision, Depth). In the present work, the first step is to assess traceability performance in terms of Breadth, Precision, Depth. To these three components will be added two dimension not yet investigated: Access and Technology.

Subsequently, based on the classification proposed in Chapter II, will evaluated the benefits, costs and challenges of implementing traceability.

As well as to link traceability assessment and its impact on firms, the contribution of the research will add up with other empirical studies carried out helping to increase the the knowledge on the effect of traceability in different agro-food supply chains. It will be a valuable contribution that will help to create a more solid basis for the formulation of a theoretical framework on the topic.

From the policy maker point of view, the case study will contribute to test the impact of new EU legislation (EC Reg. No.1169/2011) on meat production firms. In addition, the supply chain examined share a voluntary regulation on traceability, previously to the entry into force of the recent EU requirement on traceability. The assessment of such voluntary regulation provides useful information to the decision makers in assessing the possibility to promote voluntary traceability in other supply chains.

Moreover, the work will be a useful to address future decisions of the producers' association of the supply chain under investigation, who is responsible for the voluntary traceability production specification. Finally, the output will be suitable for other supply chains operators who wish to implement a voluntary production specification to increase the level of traceability.

3.4 Research goals

The research is focused on the implementation of traceability practices in the Italian poultry supply chain. First, is presented the assessment of the traceability level in terms of Breadth, Depth, Precision, Access, and Technology. The breath is the amount of information the traceability system records. It gives information not only on food safety issues, but it considers also information on products' quality such as animal welfare and sustainable production. Depth is how far back or forwards the system tracks, and determines if the producer is able to track and trace information over the direct suppliers and costumers. Precision determines the dimension and the unit of the traceability system. Finally, Access is the speed with which track and trace information can be communicated to supply chain members and the speed with which requested information could be disseminated to public health officials during food related emergencies. Access is closely linked to the capacity of the supply chain to communicate in real time any relevant information that can weak the information flow among commercial partners. The objective is to verify the degree of traceability penetration in Italian poultry supply chain, which constitutes the baseline to better understand the results of the next part of the

survey. To link these four characteristics of a traceability system, it is proposed an index that synthetically explain the level of traceability applied (see Chapter VI).

Then, given the level of traceability, is evaluated the positive outcome of traceability for supply chain's firms. Three main areas of potential benefits are assessed. The first is the enhanced food safety both for regulation requirements and recall and withdraws management. The second is a better internal management in terms of costs and staff organization. The latter relates to potential improvements in the external sphere of firms' relationships with other supply chain members and consumers.

Costs are often cited as a main barrier to traceability implementation. Given the level of traceability, firms face the costs of its implementation. This part of the investigation explores internal and external cost incurred by firms.

Lastly, the goal of the investigation is to point out firms' perception on difficulties faced in the implementation of the system.

Beyond the analysis of traceability practices in an unexplored industry sector, the novelty of the research is linkage identification between different levels of traceability and firm's positive and negative output of its implementation.

3.5 Research questions

As described in Chapter II, several stakeholders' categories potentially benefit from the implementation of a traceability system within a food supply chain. Considering consumers, traceability increases the amount of information, reducing the information asymmetry with producers. From public institution perspective, public health is reinforced, determining a reduction of expenditures for food borne related crisis. This research investigates the firms' viewpoint, to figure out their perceptions on food traceability system.

As explained in Research Goals, the investigation assesses the impact of traceability in the Italian poultry supply chain. Thus, the main research question is "Which is the impact of traceability in the Italian poultry supply chain?". From this generic questions arise other more detailed, which take into account also the level of traceability implemented by firms:

- Traceability level influences traceability benefits?
- Traceability level influences traceability costs?
- Traceability level influences difficulties in traceability implementation?
- Traceability level influences the difficulty in implementing EC Reg. No. 1169/2011?

Thus, the objective is not only to assess main benefits, costs, and difficulties, but also to figure out how these vary in relation to different levels of Breadth, Depth, Precision, Access, and Technology.

3.6 Context and scope of research

Benefits as well as constraints in the implementation of food traceability may vary considerably in relation to the context of the analysis. The geographical location and the time in which the analysis is carried out determine changes in firms' perceptions of traceability. One critical aspect that influences the level of traceability is the regulatory framework in which supply chain actors operate. Since 2005 in the EU is in force the EC Reg. No. 178/2002, that introduced general traceability requirements for all food operators. Moreover, many sectorial directives influence specific food-related industries. Today, in the European countries are in force the stricter rules concerning food traceability (Charlebois et al., 2014). Italy has been selected as target country of the investigation.

Even though a general regulatory framework for traceability was introduced in 2005, since the 1990s vertical regulations had covered specific sectors. The meat supply chain has been one of the most regulated sector, and the last regulation concern food labelling and traceability (EC Reg. No. 1169/2011 and EC Reg. No. 1337/2013). In this investigation is considered the Italian poultry supply chain. The reasons for this choice relate to the peculiar characteristics of the supply chain, the recent mandatory regulations, and the marked industry proactivity in terms of traceability.

The poultry production in Italy is characterized by a high vertical integration, where the the processing companies are the leaders of the supply chain. There is a high concentration in the processing phase, determining that meat and eggs consumed arrive from few producers. In 2015, with the entry into force of the EC Reg. No. 1169/2011, the legal traceability requirements for firms in this sector have grown considerably. On the other hand, already in 2005 the major firms that control the market have implemented a shared and voluntary traceability system. Therefore, from a traceability viewpoint the Italian poultry supply chain is a mature industry. This might make easier to observe and evaluate potential positive or negative effects of traceability systems.

In Italy UNAITALIA represents more than 90% of the national poultry meat production. UNAITALIA is a trade association that protects and promotes the food chain Italian meat and eggs. In 2005, the association was the fist to obtain the authorization for a voluntary labelling of poultry meat released by the Italian Minister of Agriculture Today the association promotes a voluntary labelling for poultry industry. These label, allow

consumers to have additional information on the product and require participant industries to implement traceability procedures that go further than regulation mandatory prescriptions. Therefore, UNAITALIA plays a remarkable role in addressing industry's choices, especially orientating traceability practices.

The scope of this research is the impact of traceability systems in the Italian poultry meat supply chain. The investigation has been carried out with the collaboration of UNAITALIA. The Association's contribution has been determinant in the research design. Specifically, the association supported the identification of the target population of the survey, the definition of the data collection method (questionnaire).

3.7 Research methodology and methods

Through the literature review were identified the main issues related to food traceability implementation and its impact on firms. Scholars use different approaches to investigate how firms perceive traceability practices, both from a positive and negative perspective. Methodologies are generally divided into ideographic and nomothetic. The first approach to social science "*is based on the view that one can only understand the social world by obtaining first- hand knowledge of the subject under investigation*". This approach is more linked to qualitative research methods in data collection to obtain findings. On the other hand, the nomothetic methodological approach "*emphasis on the importance of basing research upon systematic protocol and technique*". This approach is characterised by the use of quantitative techniques for data analysis (Burrell and Morgan, 1979). In the specific field of this analysis the literature review performed shows that both methodology are applied. Some Authors uses a more qualitative approach while other a quantitative one. Finally in some cases both qualitative and quantitative methods were implemented.

This research implements a nomothetic approach, with the adoption of quantitative methods. Given the context of the analysis described previously and in order to set replicable results, the survey is considered as the methodology that best suits with the goals of the analysis.

Once performed the analysis of the research context with UNAITALIA association, and defined the research questions, the next step is the definition of the data collection method (Bryman, 2012). The analysis of traceability impact on the Italian poultry supply chain is an unexplored topic. Thus, it is necessary to collect original data, involving a primary data collection method. The questionnaire is chosen as the proper way to gather information and answer research questions. Through a cross sectional questionnaire, it is possible to evaluate in a defined moment the impact of traceability practices on the main

Italian poultry meat producers. The structure of the questionnaire as well as the traceability level index will be in deep discussed in Chapter VI.

Target population

In Italy many firms are involved in the poultry meat production. Nevertheless, over 90% of poultry meat is produced with a vertically integrated system (Giacomini et al., 2004; Sanfrancesco, 2015; UNAITALIA, 2005, 2004). As Chapter IV will discuss, few firms control through the property or agistment contracts all actors involved in the supply chain. Moreover, the majority of production is regulated with production specifications set by those few leaders of the chain. Thus, traceability related aspects are affected by this peculiar supply chain shape.

In agreement with UNAITALIA has been decided that the head of the supply chain (from Chapter V called Group Operators) would be the more appropriate actor in poultry meat production in terms of capacity to evaluate how traceability practices affect positively or negatively supply chain operators. Moreover, they hold and are aware of all traceability information shared by the supply chain actors, allowing to correctly describing traceability level in terms of Precision, Breadth, Depth, Access, and Technology. Therefore the target population are the main Group operators of the Italian poultry meat industry. With UNAITALIA were selected 9 Group operators, which are responsible for roughly 90% of the poultry meat production.

Chapter IV. The poultry supply chain: global and Italian overview

Since the 30s, research and technological innovation in the breeding and feeding poultry sectors have rapidly grown in developed countries. The current industrial system has significantly developed. From many small, independent farms in the 40s it has turned into a system of highly integrated supply chain. Globally, chicken meat and eggs are an important source of protein, representing more than 30% of the meat consumed (FAO, 2010). Thanks to introduction of modern intensive production methods, genetic improvements, improved preventive disease control and biosecurity measures, increasing income and human population, and urbanization this growth process now also includes countries in the developing world. The industry has greatly increased productivity through technological innovation (FAO, 2009).

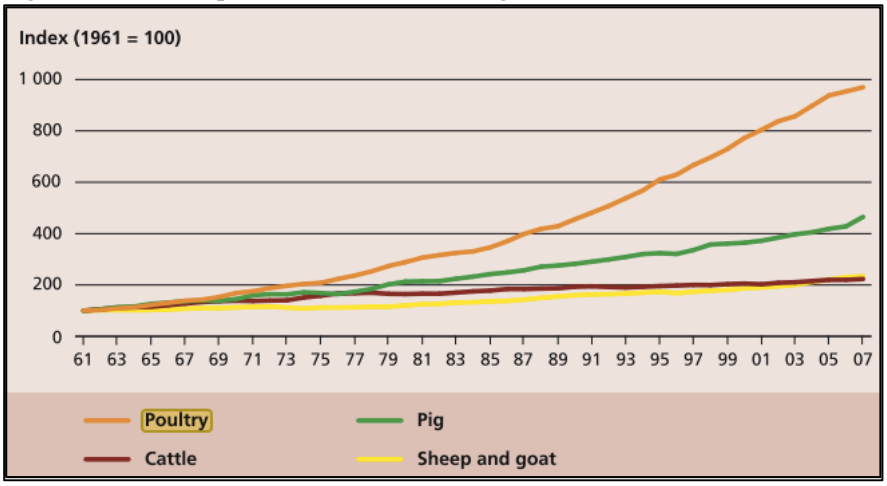
Globally, the commercial poultry industry is characterized by large-scale vertically integrated processing industries that contract grow-out operations to smaller farmers. The industry is characterized by a high level of vertical control (ownership) or, alternatively, by a high level of coordination among production inputs suppliers, poultry growers, poultry processors and marketers. However, there is still a different level of integration among countries and firms. In some cases, the integrated system covers all stages of production. In other cases, food-processing mills and further top segments are not included in the integration (Narrod et al., 2012).

4.1 Global poultry market

Globally the poultry industry is the livestock sector with the higher growth rate. The industry is developing, matching the growth of human population. This positive trend is predicted to increase in next years, especially thanks to the contribution of developing countries as a result of population growth, urbanization, and rising incomes (Augustine and Shukla, 2015).

Comparing poultry industry with other sectors, it has experimented a regular and considerable growth since the early 60's, thanks to the spread of industrialised production models (Figure 4.1).

Figure 4.1. World production of main categories of meat, 1961–2007.

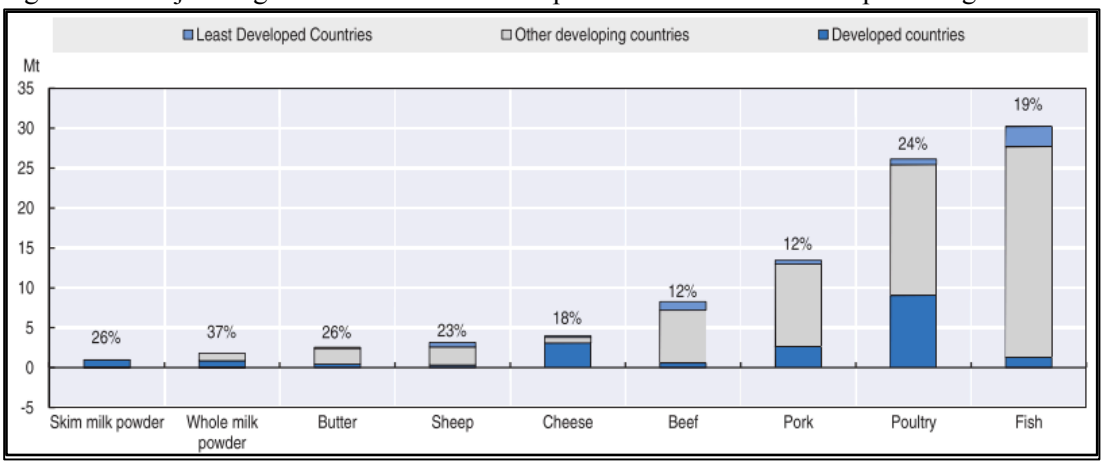


Source: FAO (2009).

Between 1961 and 2007, production increased from 35.9 to 86.8 million tonnes. Developing contributed the most with a growth of 73%, while developed countries with a production increase of 38% (FAO, 2009).

Today poultry industry accounts for over 30% of world meat production (108.7 million tonnes), with a volume second only to the production of pork (115.5 million tonnes) (FAO, 2014). Figure 4.2 shows that poultry production will grow 24% by 2024. Least developed countries will account a slight share of additional output, while both developing and developed countries will growth considerably (FAO and OECD, 2015). Moreover, is estimated that among livestock industries, poultry consumption will increase 47% by 2022 (FAO and OECD, 2015).

Figure 4.2. Projected growth 2024 in livestock production in volume and percentage.



Source: FAO and OECD (2015).

Poultry industry experimented a great growth, and this positive trend is expected to advance in the next years, with an annual growth rate of 2% (Association of Poultry Processors and Poultry Trade in the EU Countries - ASBL, 2015). Poultry meat will

dominate in next years the meat consumption, and by 2024 will account for the half of total meat consumed (FAO and OECD, 2015).

4.2 The poultry supply chain in Europe

Also in Europe, the organizational structure of the poultry industry is highly concentrated, with industry operators closely linked with each other.

Mainly there are two organizational models. The first is characterized by a greater independence of the operators. In fact, hatchery, the feed mill and the processing plant are independent firms that operate in an open market. In this model the farmer is the owner of the animals.

The other model is the integrated production. Through a strong vertical integration of the different stages, few operators control the supply chain. In this model the hatchery, feed mill and processing plant are owned and controlled by the integrating firm. In addition, the integrator firm also owns animals and breeder farms. However very often integrator firms have contracts with the breeder farms, providing them chicks and the feed, owning the animals at any time. In this case the former are paid for their contribution in terms of work, plants, and other variable costs.

While in Germany, both models are used, in other European countries like Italy, France, Spain, the integration model is more developed (Horne, 2007).

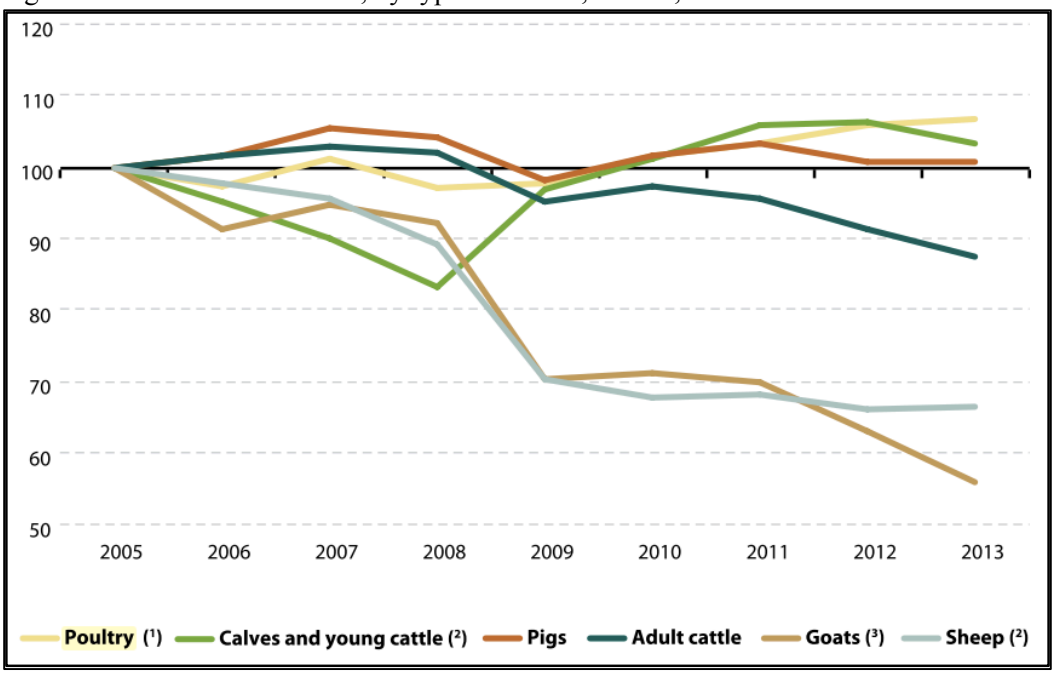
4.3 The European poultry market

Even if the poultry industry has high perspectives of growth, market opportunities are located mainly in developing countries. Firms operating in the European area are facing difficulties in expanding their market both for strict regulations and consumers demand. This determines higher costs of production if compared to extra-EU operating firms. The challenge is to find a way to leverage on the higher quality supplied to compete and expand in the dynamic external market linking higher quality (Association of Poultry Processors and Poultry Trade in the EU Countries - ASBL, 2015).

Shifting to internal market, also if the European institutions set homogeneous quality standards, there are many differences among Member States. Poultry consumption is 26,8 kg/capita for the EU, varying from the 11,3 kg per capita in Sweden to 39 kg/capita in Portugal. Also the production methods vary significantly across Europe. In the majority of countries conventional poultry meat accounts for over 90%, in France 25% of chicken are raised under an extensive rearing scheme (Association of Poultry Processors and Poultry Trade in the EU Countries - ASBL, 2015).

Figure 4.3 shows that poultry production from 2008 steadily growth till 2013. Between 2012 and 2013 only goat and poultry production rose respectively of 0.7 and 0.8%. The European production of poultry in 2013 was over 12 million tonnes (carcass weight) (Eurostat, 2015). Analysing the composition by member state, in 2014 six countries accounted for 70% of total production. The slight improvement in 2013 for the EU-28 was due to a great expansion of Poland (+11.8% on 2012) and to a smaller extent to UK and Italy with a 3.2% growth (European Commission, 2015).

Figure 4.3. Production of meat, by type of animal, EU-28, 2005–13.



Source: Eurostat (2015).

Europe kept the self-sufficiency in terms of poultry consumption. According to European Commission, in 2014 the self-sufficiency level in European Union was almost 104%. Moreover, this rate is steadily increasing in the last years, due to decreased imports (European Commission, 2015; Horne, 2007). In addition to a mature industrial system, the internal food safety regulation in the EU, determine for external countries strong obstacles in exporting. As instance, import of poultry meat from the USA into the EU is not allowed due to anti-microbial treatments for sanitizing poultry carcasses used in US processing plants (Horne, 2007).

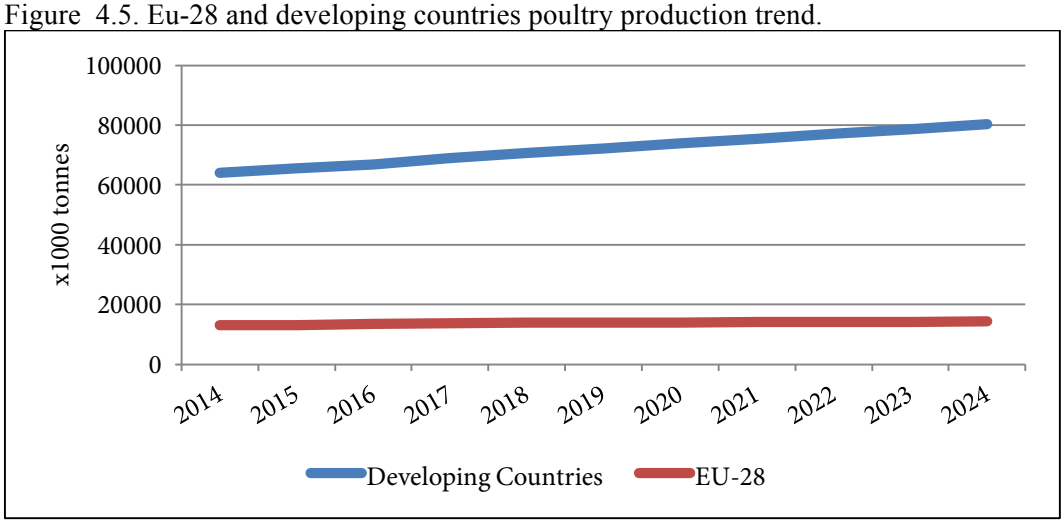
Figure 4.4. EU-28 balance import export for poultry meat (x 1,000 tons).

	2009	2010	2011	2012	2013	2014
Gross indigenous production	12.543	12.953	13.215	13.484	13.731	14.091
Export meat	928	1.149	1.204	1.234	1.223	1.265
Import of meat	848	782	796	795	750	753
Consumption	12.454	12.578	12.797	13.034	13.245	13.566
Consumption per capita, kg	25,1	25,3	25,7	26,1	26,3	26,8
Self-sufficiency %	100,7	103,0	103,3	103,4	103,7	103,9

Source: Association of Poultry Processors and Poultry Trade in the EU Countries - ASBL (2015)

The production of poultry meat in next decade is expected to increase. The production from 13.04 million tonnes will rise to 14.35 million tonnes, with a growth of roughly 10%. Figure 4.5 illustrates that even though there is a positive trend in the EU, in developing countries the production will growth mainly (+20.25%) (FAO and OECD, 2015).

Figure 4.5. Eu-28 and developing countries poultry production trend.



Source: Author's elaboration based on OECD-FAO Agricultural Outlook 2015-2024.

4.4 The Italian poultry supply chain

In Italy the sector is structured generally as industrial supply chain, characterized by a high dimensional concentration of the processing operators and a strong vertical integration between the different links of the supply chain (Boatto et al., 2008; Osservatorio Agroalimentare del Piemonte, 2012). The leaders (integrators) are processing firms, that are usually the owner of the production facilities by providing the necessary manpower for the conduction of breeding (Aleandri et al., 2015).

UNAITALIA estimates that over 90% of poultry meat and 70% of eggs for consumption, in our country are produced with this vertically integrated system (Sanfrancesco, 2015; UNAITALIA, 2004). In this context, the rearing phase, also quite

concentrated, is essentially directed by the downstream stages, and has reduced its strategic edge and owns a modest bargaining power. With regard to meat production, the ratio of integration is generally handled through agistment contracts, which bind strongly to rearing phase to those downstream, not only in relation to commercial outlets, but often also in terms of procurement of inputs and business decisions. Thus, only a small part is managed directly by rearing operators, that offer the animals to market (Aleandri et al., 2015). Vertical integration developed in Italy, determines that the market tends to disappear and be replaced by the so-called "contract economy" founded with the integration contract, implemented in the Italian law by the agistment contracts. This type of contract experience a great success in the 90s among both rearing operators, to minimise market risk, and, among industry operators, to receive guarantees of supply to better plan the production (Giacomini et al., 2004). This situation creates a high degree of dependence of farmers towards integrator firms. Rearing operators then operate with a highly concentrated market managed by a few large size firms (integrators). This determines a contractual weakness and a decline in prices of their products. On the other hand, the small farmer is protected by the continuous changes in prices on market, thanks to stable costs and a reliable price reference (INEA, 2004). To efficient the bargaining phase between the different operators of the supply chain, the Ministry of Agriculture set up a chance to formalize supply chain contracts. These contracts are intended to promote the integration of the supply chain system of agricultural and agro (art. 22 comma 2, legge 27 Dicembre n. 289 – legge finanziaria 2003) (INEA, 2004).

Processing firms to provide inputs to farmers, realise with upstream operators (feed mills, suppliers of chicks), supply or integration contracts, establishing a holding company, in which processing firm is the leader. Usually, the leader performs a process of internalization involving the feed mill. Instead, a step often outsourced are chicks for reproduction (grand-parents). The multiplication and incubation of the eggs can be integrated in the leader firm or managed with agistment contracts. More rarely are use free market contracts. (INEA, 2004).

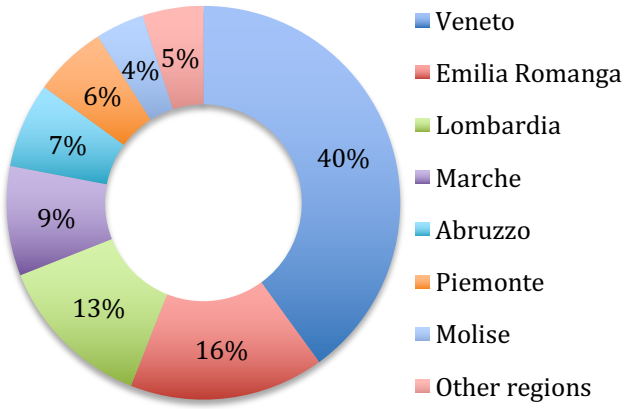
Since the 60s, the processes of restructuring and acquisition involving key players in the animal feed and processing sector, on the one hand, and the processes of concentration and polarization of regional farms, on the other, have fundamentally changed the structure of production. Currently the industry of slaughtering and meat processing is on oligopoly dominated by two major industrial groups (group Veronesi and Amadori Group) operating at national level and which together control over a half of the market, followed 5/6 companies that operate regionally or locally (Boatto et al., 2008). In 2012, the fist three players (Veronesi, Amadori, and Fileni) control 72.7% of supply chain value and

74.3% of production volume (Zinola, 2012). According to UNAITALIA the first three players hold over 85% of market share (Sanfrancesco, 2015).

At farm level, the production is carried out at a small number of large structures that focus mainly in the regions of northern Italy (Veneto, Emilia Romagna and Lombardia). In the case of chicken meat, firms rearing more than 10,000 animals represent 2.6% of the total (about 1,100 units), but account for over 97% of the animals (about 88 million) (Boatto et al., 2008).

The territorial concentration is a feature that distinguishes the poultry meat production and its industrial turnover, not only in Italy, but also of most industrialized countries. It is justified by the research of the cost savings related to size (economies of scale) and location (economies of scope) for logistical and organizational advantages (Giacomini et al., 2004).

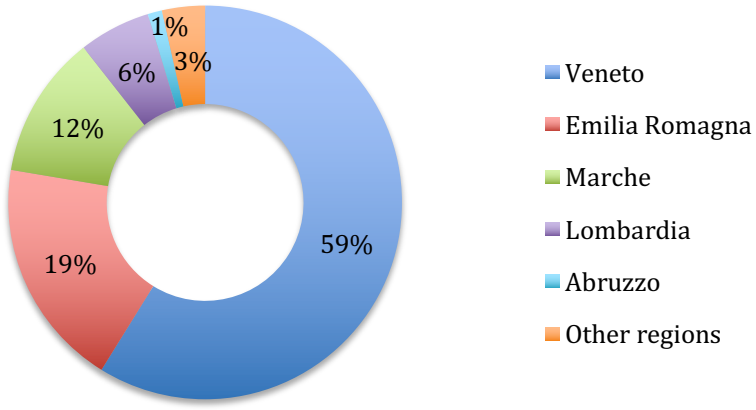
Figure 4.6. Poultry meat production by Region, 2015.



Source: Author's elaboration based on Aleandri et Al. (2015).

Poultry production is practiced throughout the country, but is particularly common in Veneto, Emilia Romagna, and Lombardia, which concentrate more than half of the Italian poultry population (Figure 6). Veneto owns almost 60% of industry turnover, followed by Emilia Romagna and Marche (Figure 7) (Aleandri et al., 2015). In Italy, 83% of animals are located in northern regions, which account for 66% of active firms in the sector. This figures explain the high rate of geographical concentration and the greater dimension of firms located in this area (ISMEA, 2013).

Figure 4.7. Poultry industry turnover by Region, 2015.



Source: Author's elaboration based on Aleandri et Al. (2015).

In quantitative terms UNAITALIA estimated that the industry is made up of about 359 breeder farms, sent to 114 hatcheries produce about 600 million chicks. Out of the 4,193 national growing farms, 45% produces animals for meat production and 26% eggs for consumption. The remaining percentage is divided between the turkey farms (15%) and other avian species (14%). At the end of cycle poultry are conveyed in 174 slaughterhouses and 467 cutting plants. Upstream of the production process there are 400 feed mills, whose produce 5.6 million tonnes of fodder (Sanfrancesco, 2015).

The Italian poultry sector generated in 2015 a turnover of €5,700 million, and employ 55,000 workers. In 2015 were produced roughly 1,261,200 tons of meat and 12,543 billion eggs (Sanfrancesco, 2015).

4.4.1 Italian poultry market

In 2014, Italy was the sixth European producer of poultry meat with a production of 1.26 million tonnes (650 million animals), with a moderate production increase of 0.2% in 2013 and an increase in consumption of 0.7%. The long-term analysis shows that in the decade 2002-2013 the production has increased by 3%. This growth was mainly due to chicken meat (+ 16%), while the production of other avian species decreased. Forecasts for 2015 predict a 3% increase in production. In 2013 the pro-capita consumption was 19.45 Kg, in the average of European consumption. As for EU-28 as a whole, Italy is self-sufficient, producing more meat respect to national consumption. Export were 170,000 tonnes, while imports 94,500 tonnes (Unaitalia, 2015a).

The poultry industry plays a very important role in the Italian agri-food industry, both in strictly economic terms, and for spill-overs effects. Restricting the comparison to the entire chain of animal meat (cattle, pigs, poultry, horses and sheep and goats), based on

2011 data, more than a quarter of the value of production of livestock derived from poultry. The poultry industry produces 18% of sales and 22% of exports of the entire meat industry; 28% of employment, is linked to the poultry sector (Aleandri et al., 2015). According to ISMEA in 2013 the value of the poultry sector was 10.563 billion euro, of which 4.813 million arising from the agricultural phase and 5.75 million from the transformation firms (ISMEA, 2013).

Table 4.1. Poultry supply chain plants in Italy.

Supply chain actors	Number of plants
Feed Mills	400
Primary breeding farms	379
Hatcheries	114
Growing farms	5,721 (Meat 4,193) (1,528 Laying hens)
Slaughterhouses	174
Meat cutting plants	467
Further processing plants	78

Source: Sanfrancesco (2015).

4.5 The configuration of the poultry meat supply chain

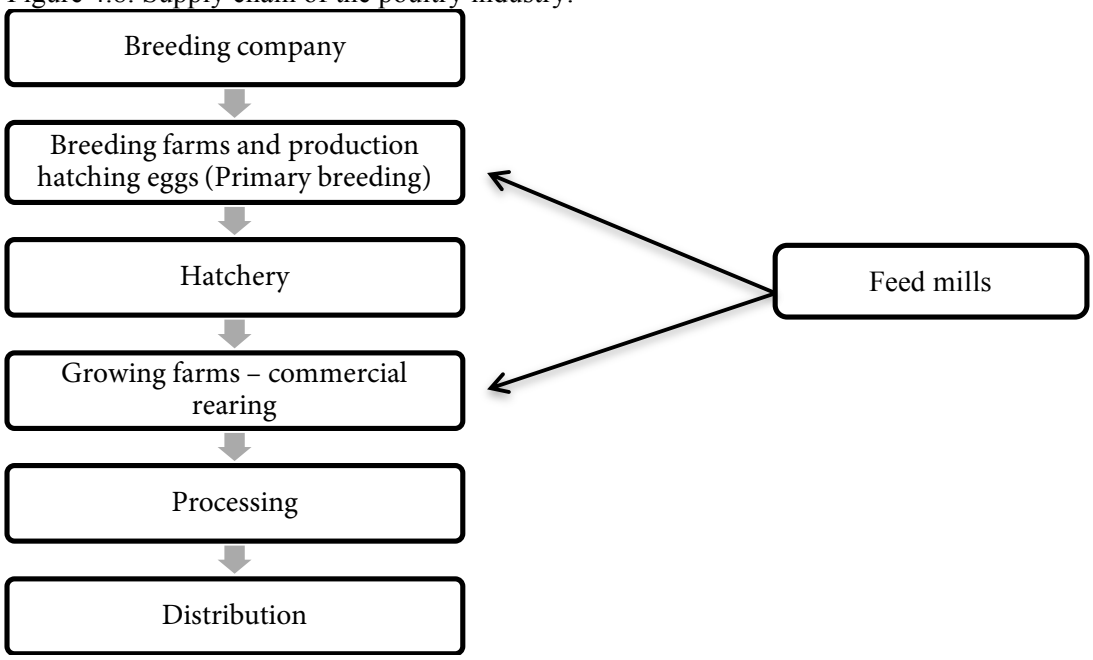
Figure 4.8 presents the general structure of the industrial poultry supply chain. As stated in Paragraph 4.2, even if the supply chain leaders (integrators) are not the owners of all the assets, they have the indirect control of them (FAO, 2010). Generally, a small number of breeding firms supply breeding stock to a relatively small number of national and international integrators. The result is that exists only small differences exist in the production and management of the animal and in the primary processed product (Fallon, 2001).

First, the breeders are purchased from Italian or foreign specialized firms, which ensure the production of "commercial hybrids", obtained by crossing breeds and varieties, selected according to their productive characteristics.

At the breeding farms and production hatching eggs, after weaned and brought animals to sexual maturity, take place the deposition of fertile eggs destined for hatcheries.

The hatcheries are the plants where takes place egg collection from the breeding. Within 24 hours after their birth, chicks are taken to rearing farms. These facilities implement strict procedures and great care in carrying out activities to ensure hygiene standards very high, and a total traceability.

Figure 4.8. Supply chain of the poultry industry.



Source: Author's elaboration based on Aleandri at Al. (2015), Avitalia (2012), Fallon (2001), FAO (2010) and UNAITALIA (2012).

In Growing farms or commercial rearing farms, animals are grown up to get the required weight (small, medium, large). The breeding is done mainly with separate sexes, on bedding in closed (conditioned) environment or outdoor.

After rearing, the animals are transported to the processing facilities. The slaughtering activities are the first step in a long and complex series of processing activities that use mainly meat derived from slaughtered animals.

Attached to processing plants are generally located highly automated distribution platforms, which enable operators to ensure a high level of service, crucial element in order to compete on the market. The poultry processing can be split into four sub categories:

- Pre-processing: at the slaughterhouse, birds are kept in cages. Then are hanged by shackles on a conveyor, which moves them to the stunning area;
- Slaughtering, bleeding and scalding;
- Further processing and evisceration;
- Packaging.

Often the slaughterhouse provides also the cutting of the carcasses. Finally, the last step is the commercial distribution.

Concluding remarks

In the last decades the poultry industry has remarkably evolved thanks to technological and organizational innovations. Especially in developed countries like Italy, the majority of poultry meat production is controlled by few firms that control the market (integrator firms). Not in all case these firms own all the production assets. Nevertheless, these large firms control the supply chain through agistment contracts. In Italy, over 90% of meat production is controlled by roughly ten firms, which operates as supply chain integrators, determining a high level of vertical integration. Thus, the production process is highly standardised, setting a common structure of the supply chain. This peculiar context offers significant opportunities for integrator firms to set high standard in terms of traceability insurance. Given their high contracting power, they can impose strict traceability rules, with a potential positive outcome both for food safety and quality.

Chapter V. Regulations and voluntary traceability: the Italian poultry sector and the case of the Italian voluntary labelling UNAITALIA

European food legislation has significantly evolved in the last decade, and it influenced traceability requirements for all food operators. The recent regulations on food traceability have a great impact especially for food producers. The Italian poultry industry has been able to rapidly respond to this challenge. Already from 2005 set voluntary requirements to establish high-level traceability. Moreover, this positive attitude has been fostered thanks to the strong vertical integration of the supply chain. In this chapter is described the European and Italian evolution of traceability requirements. Wide emphasis is given to the Italian experience of implementation of the voluntary labelling for poultry meat supported by the UNAITALIA Association. The voluntary labelling production specification of UNAITALIA served as baseline to develop the survey on traceability that is presented in Chapter VI. Thus, an in-depth analysis of it, and of its consequences for traceability in the poultry sector is presented.

5.1 Food safety in the European legislative framework

Since the signing of the Treaty of Rome in 1957, which established the European Economic Community (ECC), European legislation regarding food safety is greatly evolved. Along with the consolidation of the role of the Community, in 2000s the issue of food safety has reached a good level of consistency, with a clear regulatory framework and guidance policy (Goodburn, 2001).

Four main periods characterise the Communitarian regulation in the food sector (Alemanno, 2007). The first, which can be divided into two parts, is mainly market-oriented. The first phase is characterized by vertical standards for specific type of product, the second by a more horizontal approach (van derMeulen, 2013).

The second phase goes from the enactment of the Single European Act (1986) until the outbreak due to BSE disease (1997). In fact, the previous policy of legislative harmonization had failed in managing the overall risk, which for the first time emerged. Food risk was then configured as a Community issue, rather than national (Chalmers, 2003).

Taking note of the difficulties encountered in managing the BSE case, in the third phase the EU institutions worked intensively for the presentation of a European food law. Just two years after the publication of the White Paper, was issued the Regulation usually called General Food Law (EC Reg. No. 178/2002 "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 "), considered the first real attempt to cover all aspects of food safety at European level. In fact, the goal was to create a horizontal legislation that would cover all stages of the food supply chain, from farm to fork (Alemanno, 2007). An important premise that is made in the Regulation is that the free movement of healthy food is a necessary condition for the proper functioning of the internal market, for this regulation is needed an horizontal regulation, to avoid different food and feed safety requirements among Member States (EC Reg. No. 178/2002 (1,2,3)). To achieve these objectives the Regulation is structured in two parts:

- - In the first are listed definitions and purpose of the Regulation, are then set out the general principles (Arts. 5-10), general requirements of food law (Arts.11-21), Rapid Alert System and procedures for emergencies (Arts. 50- 57).
- - The second officially *establish the* independent *agengy* European Food Safety Authority (Arts.22-49).

5.2 Traceability in the European food management

With the adoption of the general food law (GFL) in 2002, Europe has generated a comprehensive framework to guarantee the food safety along all the supply chain. In this context, traceability is set as an essential tool to address risk and protect public health. Indeed, the ability to identify the origin and the path of food and feed ingredients is one of the main elements that permit to react swiftly to any outbreak in the food chain. Traceability can be considered as a risk management tool, throughout public authorities and business operators can manage food recall if a product is considered to be unsafe (DG Heath and Consumer Protection, 2007).

Between the 90s and 2004 were issued a number of European legislation on traceability for specific food and feedstuff. In early 90s it was not mentioned the word “traceability”, and regulation aimed to voluntary labelling, such as the organic food. With the BSE scandal was introduced traceability as a mandatory requirement to ensure food safety. Furthermore in the case of fishery it was used to avoid the reduction of the resource. Thus, traceability emerged as a tool to better governing risk management. Then, with GMOs, it was also utilized to increase information disclosure to consumers (Arienzo et al., 2008).

Nevertheless the concept of traceability was introduced in the EC before the 90s. In the late 80s and early 90s was introduced the notion of “traceability of goods”, regarding non-food industrial products. Thus traceability was introduced in the EC as an instrument to enforce consumer protection (Nicoletti, 2005).

Shifting to the food sector, as for food safety in general, the European legislator since the 90s has introduced several dispositions in order to trace ingredients in specific food categories. Most of them were vertical regulations, which the prime objective was to harmonise the different Members State legislations (van derMeulen, 2013). These specific regulations introduced traceability to guarantee safety or quality of single products.

Since 1997, starting year of the mayor reform process of the European food law, traceability has emerged as fundamental risk management tool. Then with the enactment of the EC Reg. No. 178/2002 it officially becomes a general principle of food law.

In 2000, was issued the White Paper on Food Safety, in which was proposed the new legislative framework and principles for food safety. In Chapter 2 "Principles of food safety" was introduced traceability of food and feed as new principle governing a successful food policy. The main goal of the principle was to ensure the capability of food business to enforce efficient procedures to withdraw food and feed from the market in the case of risk for consumers' health. Furthermore, operators were also required to "*keep adequate records of suppliers of raw materials and ingredients so that the source of a problem can be identified*". However was underlined the complexity of the issue and the difficulties of tracing unambiguously feed and food of different sectors and commodities. Traceability was linked to the necessity to cover and connect all the food supply chain, establishing and high level of consumer protection. To do so the ability to trace products "from the farm to the table" was a key issue, both to address responsibility among operators and to "*take rapid, effective, safeguard measures in response to health emergencies throughout the food chain*".

With the EC Reg. No. 178/2002, traceability provisions come into force from January 2005. According to the Regulation a comprehensive system of traceability at all stages of the supply chain was needed to implement a better functioning of the internal market and to avoid any food safety problems. Traceability become so a general requirement of the new food law (EC Reg. No. 178/2002). The rationale for the introduction of mandatory traceability is linked to the previous food crisis, that demonstrated that the ability to trace food and keep records help to facilitate recalls and withdraws, avoiding useless obstacles to trade; helps consumers, giving them a more accurate information; and support control authorities in risk assessment (The Standing Committee On The Food Chain And Animal Health, 2010).

For the fist time was given a specific definition of it as "the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and

distribution". Other definition to better understand the Regulation requirements on traceability are Food Business Operator: "the natural or legal persons responsible for ensuring that the requirements of food law are met within the food business under their control"; and Feed Business Operator: "the natural or legal persons responsible for ensuring that the requirements of food law are met within the feed business under their control" (Art. 3(15), EC Reg. No. 178/2002).

According to Article 18 the business operators "shall be able to identify any person from whom they have been supplied…". In addition, they "shall have in place systems and procedures which allow for this information to be made available to the competent authorities on demand"(Art. 18, EC Reg. No. 178/2002). This requirement of traceability is called "one step back-one step forward" approach, and impose to operators to be able to identify just the immediate supplier and recipient of the product, excluding retailers to final consumers. It means the establishment of a link "supplier-product" and a link "costumer-product" (with the exclusion of final consumers) (Ansell and Vogel, 2006; The Standing Committee On The Food Chain And Animal Health, 2010).

The food business operator should "*be able to identify any person from whom they have been supplied*" and "*the other businesses to which their products have been supplied*" (Art. 18, EC Reg. No. 178/2002). Specifically the term supply should be intended as the transfer of the ownership of the good, not just the physical possession of it. In ration to the business that an operator have supplied have to exclude the final consumer (Ansell and Vogel 2006; The Standing Committee On The Food Chain And Animal Health 2010). Internal traceability is so not required by the Regulation, the food operator is not required to establish a link between inputs and outputs products.

To ensure traceability operators "shall have in place systems and procedures which allow for this information to be made available to the competent authorities on demand". It means that operators are free to use any kind of suitable system that permits them to satisfy this obligation. However, according to Article 18 there are some information that must be kept. This is because, especially during BSE crisis, the commercial flow was found to be insufficient to identify properly the physical flow of products. Therefore is essential to implement traceability system able to take trace of physical flow of goods. The minimum information available to competent authorities should include:

- The name of the supplier, identification of products supplied, date, volume or quantity.
- The name of the costumer, identification of products delivered, date, volume or quantity (Arienzo et al., 2008).

Regarding the minimum amount of time to keep records, the Regulation doesn't give any minimum period. Generally, for taxation controls are required 5 years of commercial

documents storage. For traceability records this amount of time is considered to be enough. Exceptions are applied in some cases like highly perishable products (six months after manufacturing or delivery) and for products with a "best before date" (shelf live plus six months) (Ansell and Vogel 2006; The Standing Committee On The Food Chain And Animal Health 2010).

The storage of this information is so necessary to satisfy the requirements of Article 19, which describes the food business operators duties in case of products withdraw, recall and notification to competent authorities. If a safety problem occurs and all operators have collected these data is faster for authorities to manage the crisis, and ensure consumers health protection (Art. 19, EC Reg. No. 178/2002).

In conclusion, the traceability requirements in the General Food Law are essential the identification of the food along the entire chain, ensuring the application of the "farm to fork approach" and the principle of primary responsibility of the food operator in enhancing food safety (Arienzo et al., 2008).

As discussed in previous paragraph the general requirements on food traceability set by the General Food Law for some categories of foodstuff are more specific. To give a thorough analysis of traceability enforcement in the EC should be cited the EC Reg. No. 931/2011, setting traceability requirements for food of animal origin. According to the Regulation, the food crises occurred in this specific sectors where documentary records and information kept by food business operators were not sufficient to guarantee full traceability of goods. This situation determined reduced consumers' protection and unnecessary economic losses due to inaccurate withdraws from the market (Bánáti, 2014). With the Regulation the business operators are obliged to made specific information available to food business operators to whom the food is supplied and, upon request, to the competent authority. The information to be made available are: *"(a) a description of the food; (b) the volume or quantity of the food; (c) the name and address of the food business operator from which the food has been dispatched; (d) the name and address of the consignor (owner) if different from the food business operator from which the food has been dispatched;*
(e) the name and address of the food business operator to whom the food is dispatched;
(f) the name and address of the consignee (owner), if different from the food business operator to whom the food is dispatched;
(g) a reference identifying the lot, batch or consignment, as appropriate; and (h) the date of dispatch" (Art. 3, EC Reg. No. 931/2011).

5.3 European legislative framework for food labelling

European food labelling regulation is one of the most controversial elements of food legislation. The European legislation has to take into account several requirements from different stakeholders. Among these the protection of consumers, the protection of the free movement of goods in the EU market, and the ability to handle emergencies resulting from food crises by providing targeted withdrawal from the market or isolating the point in the supply chain that produced the food which is unsafe (Rebufatti et al., 2012).

The first harmonization directive on food labelling dates back to 1978 (EEC Directive n. 79/112) and during years have been drafted numerous changes, in particular through Directives 89/395/ EEC ("on the approximation of the laws of the Member States relating to labelling, presentation and advertising of foodstuffs for sale to the ultimate consumer") and 89/396/ EEC ("on indications or marks identifying the lot to which a foodstuff belongs").

These Directives had been amended by Directive 2000/13/EC "*on the approximation of the laws of the Member States relating to the labelling, presentation and advertising of foodstuffs*", who represented the relevant Community legislation until 2011.

After a long negotiation of four years, in December 2011 entered into force the new EC Reg. No. 1169/2011, establishing new rules for food labelling and harmonization of the consumer's information principles. It consists of 55 articles and describes the guidelines to follow in drafting the labels; is it also accompanied by 15 annexes, which provide additional detailed information on the labels. The food scares that have occurred in Europe in recent years have undoubtedly helped to boost the institutions to review food security regulations, particularly on the obligation to indicate the origin of the raw materials used. In the new Regulation for non processed products is mandatory the country of production; for processed ones regards the place of last substantial transformation and the cultivation or farming of the agricultural raw material mainly used. This information is mandatory and its omission would mislead consumers. Moreover, in the new regulation, it is extended the obligation to indicate on labels the country of origin or place of provenance of all fresh meat, rule already in force only for bovine, but also extended to pigs, poultry, swine and sheep. Instead, with regard to meat processed and for the milk and derivatives, the mandatory indication is not mandatory. In the future, the labeling of the country of origin could be extended to other categories of food (such as meat used as an ingredient, milk or unprocessed foods), but before the Commission will carry out the impact assessments to check the practicability and potential costs that such labeling requirements would entail (Toti, 2011).

However, the Regulation in question has granted some discretion to the Member States: the Chapter VI, art. 38 "National measures" provides that "Member States may adopt national measures concerning matters not specifically harmonized by this Regulation provided that they do not prohibit, impede or restrict the free movement of goods in accordance with this Regulation" (Rebufatti et al., 2012).

In 2013 was issued the Commission Implementing EC Reg. No. 1337/2013, "laying down rules for the application of EC Reg. No. 1169/2011 of the European Parliament and of the Council as regards the indication of the country of origin or place of provenance for fresh, chilled and frozen meat of swine, sheep, goats and poultry". The Implementing act clarifies specific rules for all the four types of meat described in EC Reg. No. 1169/2011. The requirements for traceability on meat labels consider both the additional costs for operators and national authorities (with an impact on price) and requests from consumer to Access more information especially on the geographical provenience of products (2). The labelling system set has the main goal to ensure the link between the labelled meat and the animal or group of animals from which that meat has been obtained.

Article 3 states the basic rules to apply to ensure traceability in the supply chain. Food operators "*shall ensure between the meat and the animal or group of animals from which it has been obtained*". Moreover, the operators "*shall ensure the correlation between the batch code identifying the meat supplied to the consumer or mass caterer and the relevant batch or batches of meat from which the pack or labelled batch is constituted*". Finally, they "*shall ensure the correlation between arrivals and departures*" (Art.3). The Act gives also a precise definition of batch as "*meat, falling within the Combined Nomenclature codes listed in Annex XI to EC Reg. No. 1169/2011, obtained from a single species, with or without bone, whether or not cut or minced, that has been cut, minced or packed under practically identical conditions*"(Art.1.b).

Specific requirements are provided for each kind of meat. Concerning poultry meat the label shall indicate:

a) The Member State or third country in which the rearing took place indicated as 'Reared in", referred to the Member State or third country in which the last rearing period of at least one month took place or, in case the animal is slaughtered younger than one month, the Member State or third country in which the whole rearing period after the animal was placed for fattening took place;

b) The Member State or third country in which the slaughter took place indicated as 'Slaughtered in: (name of the Member State or third country)';

c) The batch code identifying the meat supplied to the consumer or mass caterer.

If in point a) is not attained its identification may be replaced by “Reared in: list of the Member States or third countries where the animal was reared”.

Food operators may replace the requirements of a) and b) with “origin” if animals were born, reared and slaughtered in one single Member State or third country.

The implementation act of the EC No. 1169/2011 entered into force in Member States in 1st May 2015.

5.4 Traceability in the Italian poultry sector

Shifting to the Italian context, labelling of poultry meat was regulated by the Legislative Decree number n.119 of 27 January 1992, relating to food labelling, presentation and advertising. This national law, was the national implementation of Directives No. 89/395/CEE and No. 89/396/CEE. Then, after the entry into force of the Directive 2000/13/EC, the national law was the Legislative Decree n. 181 of 23 June 2003.

Concerning the poultry industry, in August 2005 broke out in Italy the avian influenza alarm. It was feared that a pandemic could happen due to a mutation of the H5N1 virus circulating in Southeast Asia since 1997 and appeared in the European wild birds. To face the potential threat to public security, the Ministry of Health promulgated an Ordinance, for which the deadline was fixed at 31 December 2007 (Ordinance of the Ministry of Health of 26 August 2005 “*Animal health measures with regard to infectious and contagious diseases of poultry”*).

5.5 Voluntary labelling of poultry

Stimulated by the thread of the dioxin in Belgian poultry meat that crossed the Italian border, which had heavy repercussions on the domestic market, Avitalia (National Union of Poultry and Rabbit producers Associations) already in 1998 had started the first contacts with the MiPAF (Italian Ministry of Agriculture and Forestry) for the enactment of a provision regarding a voluntary labelling of poultry meat. After six year in 2004, entered into force the Ministry decree on "*how to apply a system of voluntary labelling of beef and poultry*", after gaining positive opinion from the European Commission and the State-Regions Conference (Mipaaf (Ministero delle politiche agricole alimentari e forestali), 2004). It sets the guidelines for a voluntary labelling of poultry meat. According to this decree, poultry industries may introduce a voluntary labelling in addiction to mandatory regulation requirements.

The voluntary labelling of poultry meat requires the predisposition of technical specifications by the proposing organization. The technical specification should include, for each stage of the supply chain, a system of identification and registration, to allow a

linkage between the identification of the meat and the production batch. It means that each group of slaughtered animals is given a lot number that corresponds to a single breeding farm. An independent control body certifies the reliability of the system, while the approval of the technical specification is up to the MiPAF in cooperation with the regions concerned. The MiPAF is also responsible for the supervision (Avitalia, 2008).

The four pillars of this voluntary labelling system are the proposing organization, the technical specifications, the control plan, and the authorization from the Ministry.

The proposing organization, which represents at least the phases of rearing and slaughter, presents the labelling technical specifications and it is responsible for product traceability throughout the supply chain. The operators that participate in the voluntary labelling should indicate some information on the label, while others are optional.

The labelling specifications is a document containing:

- Information to be provided on the label;
- Measures implemented to ensure truthfulness and the most suitable system of control;
- Criteria and procedures to ensure the link between the meat and the production batch;
- Characteristics of the logo;
- Operation of the system particularly with regard to self-control procedures;
- Disciplinary measures.

Once a firm subscribe the labelling specifications approved by the Ministry the label must contain the following information:

- Logo of the organization;
- Authorization code assigned by the Ministry;
- Country of the firm that produced chicks or the hatchery (name and location);
- Country of breeding farm (name and location);
- Country of slaughtering (name and location);
- Country of cutting plant (name and location);
- Type of farming and feeding.
- Traceability: a reference number or reference code ensuring the link between the meat and the production batch in farming (traceability). This number may be the identification number of the production batch or the transfer number to the slaughterhouse or to the sales points, provided that it is sufficient to guarantee the traceability and authenticity of all information. In any case, the lot of contribution to the slaughterhouse is a sub-set of the production batch in the farm[1].

[1] Batch means a set of sales units of a foodstuff produced, manufactured or packaged under practically the same conditions (Legislative Decree no. 109/92). The Production batch is a homogeneous group of animals by age,

Additional voluntary information are:

- Type of farming and feeding;
- Animal breed or genetic type;
- Age of the animal and fattening period;
- Date of slaughtering;
- Other approved information.

It is important to underline that any operator who wishes to give information about feeding and rearing conditions of animals must be enrolled in an authorized disciplinary. Labelling, then, is mandatory, as equally become mandatory controls, which are not left to the supervisory authority, but are expected by a plan of self-control (charged to the proposing organization) that affects 100% of those members, and a Control Plan (made by the independent control body) examined and approved by the Italian Ministry of Agriculture.

All operators who adhere to the voluntary labelling must implement a self-control plan, in which are reported critical points, self-control, and management of non-conformities.

The other main element of the system is the Control Plan. The third party independent body carries it out, and it is responsible for its dispatch to the Ministry. It indicates, for each operator in the supply chain: Sampling criteria on operators to be checked; Operating modes; Types of control; Frequency of Control; Management of non-compliance.

Finally, the Ministry of Agriculture and Forestry and on the basis of an agreed program carries out the supervision (Avitalia, 2008; Mipaaf (Ministero delle politiche agricole alimentari e forestali), 2004; Pedicone, 2007).

5.6 The voluntary labeling of UNAITALIA

Currently, have been approved by the Ministry several voluntary labelling schemes for poultry meat:

- IT 001 EA – UNAITALIA
- T 002 EA – Sant'Angelo (from 2008 merged with UNAITALIA)
- IT 003 EA – Agricola Tre Valli
- IT 004 EA – La Fornace
- IT 005 EA – ABCARNI
- IT 006 EA

category, origin and consignment, belonging to the same species, initiated to the fattening cycle with the same techniques and the same conditions (Dm 29 of July 2004).

In this work the IT 001 EA – UNAITALIA labelling scheme is the object of the investigation. This choice is due to the fact that the mayor firms producing poultry meat in Italy implement this labelling scheme UNAITALIA. To better figure out the impact of this scheme on the Italian market it will be examined in-Depth the production specifications of the UNAITALIA labelling scheme and its linkage with traceability assurance along the poultry supply chain.

5.6.1 UNAITALIA

UNAITALIA is the trade association, which protects and promotes the operators in the Italian meat and eggs food chain. Its represents more than 90% of the entire poultry supply chain, and a substantial slice of the pork meat production.

The history of poultry industry representation in Italy started in 1958, when it was founded UNA (National Union of Poultry Producers), which combined the first Italian poultry producers on a large scale.

Later in 1996 was born Avitalia (national union composed by regional associations of poultry and rabbit producers), which was a form of representation required by the European Community legislation. To get the national recognition and legal personality, the national unions must be composed of at least five associations regional officially recognized, composed of a minimum of 200 producers.

In 2005, UNA lost most of its members who entered in Avitalia, or remained outside of both unions. In 2007 Avitalia evolved in "Common organization" and was the first national union in the livestock production to get this recognition.

In 2012 the main firms belonging to the two unions decided that the sector, to acquire greater strength, should be reunited into a single association. The previous two associations were closed and UNAITALIA was created, capitalizing on the assets of both representation and expanding to the pig sector.

UNAITALIA was formed by unanimous will of all the major industry in the belief that strengthening the institutional representation in a highly strategic sector of the food industry, constitutes an indispensable added value to increase strength and cohesion, ensuring protection and equal dignity to all the components of the poultry supply chain.

Currently, UNAITALIA represents member firms operating in various sectors of activity such as institutions and authorities, economic organizations, political organizations, labour and social services, and identifies and deals with problems that directly or indirectly affect these actors.

The activities UNAITALIA includes, among others, the protection of the activities of its members in the economic, legal and regulatory, technical and trade union domains. The organization carries out research activities, studies, conferences and any other

initiative of interest in the industry. Moreover, it participates in negotiations for the renewal of major contracts and collective bargaining agreements applied by member companies. The constitution of UNAITALIA is recent, but the association reflects the heritage of the previous two realities in the world of poultry meat, expanding its objectives and sphere of influence (www.UNAITALIA.com).

UNAITALIA is the organization that first gained recognition by the Ministry with the voluntary labelling scheme (IT 001 EA - UNAITALIA) and currently UNAITALIA members are responsible for the production of roughly 95% of Italian poultry meat production. Among its members over 15% of meat is produced according to the IT 001 EA label (Unaitalia, 2015a).

5.6.2 The UNAITALIA voluntary labelling system

UNAITALIA gained the accredited voluntary labelling scheme in 2004, which originally was implemented by 11 major Italian poultry firms, such as Amadori, Arena, Valverde, Bignami, Fileni, Martini, Ducale, Pollo Estuario, San Felice, Guidi, and Pollo del Campo (Avitalia, 2008), with the aim to ensure an unique and transparent system both for consumers and public authorities that could contribute to reduce the transaction cost in the supply chain (Avitalia, 2008).

Mandatory and optional information on labels

Companies who join the voluntary UNAITALIA labelling specifications shall indicate on the label:

- Reference number or a traceability code which allows to go back unequivocally to the slaughter batch and from this to the production batch;
- Country of birth of the chicks;
- Country and breeding farm of chicks;
- Country and slaughterhouse EC authorization number where the slaughter took place;
- Country and EC authorization number of the cutting plant;
- Organization logo or alphanumeric code assigned by MiPAAF.

To those mandatory information, the producer may add some optional according to the type of breeding:

- Free GMO feeding;
- Feeding free of animal meal;
- Feeding free of added animal fats;
- Feeding free of Coccidiostats;
- Raised outdoors;
- Extensive indoor farming;

- Backyard poultry holding (Rural outdoor breeding);
- Rural outdoor breeding in freedom;
- % of …. in the feed;
- Minimum age at slaughter;
- " Slow growth genotype " or "slow growth" or "slow-growing";
- Stocking density in the form of: "more space in breeding than the legal limits" or "more freedom of movement due to greater space on the farm than the legal limits";
- "Environmental Enrichment with straw bales and perches to encourage natural behaviour" or "" Environmental Enrichment with straw bales to encourage natural behaviour ";
- Availability or use of natural light;
- "Raised without antibiotics";
- Breed or genetic type (Unaitalia, 2015b).

Even though with the entry into force of the EC Reg. No. 1337/2013 at the EC level is required to indicate the rearing and slaughtering country, the mandatory information required by UNAITALIA labelling go further. In fact, it requires also the country of birth of the chicks and the country of the cutting plant. Moreover, companies who wish to communicate the characteristics of their production must be enrolled with a Ministry approved labelling scheme, and UNAITALIA offers this opportunity.

Specific features of the UNAITALIA labelling system

The labelling scheme contains some peculiar characteristics. Given the strong concentration of the poultry meat production, is defined the “Group-operator” as Group that manages the breeding and slaughtering of animals through direct control (ownership or agistment contracts) of rearing farms, slaughterhouses, cutting plants and sometimes animal feed producers. These are complex structures that integrate the phases of breeding, slaughter and cutting as if it were a single large company. The Group-operator is responsible for the proper application of the production specification (Unaitalia, 2015b).

UNAITALIA operates inspection and control activities directly on the Group-operator and, indirectly on single operators that are controlled by the Group-operator.

Through a memorandum of understanding are defined the modality and the schedule on UNAITALIA Access to the database managed by the Group-operator concerning lists, type of feed and breeding, and batches. The Group-operator makes the information available to the UNAITALIA, responsible for the availability of information on request.

Finally, the labelling scheme is structured to in order to reduce cost of recognition and management, and enhance commercial exchange among operators (Pedicone, 2007).

Traceability in the UNAITALIA labelling system

The rules adopted by UNAITALIA in order to ensure compliance of the information on the label and traceability involves the entire chain (from farms to distribution platforms of the finished product). The production specification gives the information that originate from any interested party, the methods of information recording, the mode of transfer of such information, the methods adopted to ensure traceability and compliance with the characteristics related to food and breeding operations (art. 5) (Unaitalia, 2015b).

Concerning traceability assurance, for each link along the supply chain are described the procedures to implement in order to maintain a continuous flow of information. The aim is to ensure information flow in all critical traceability points, and to anchor them to the key data elements.

Identification of the Traceable Resource Unit (TRU) and Granularity

For batch processes, as the poultry meat production, a TRU "*is an unique unit, meaning that no other unit can have exactly the same, or comparable, characteristics from the point of view of traceability*" (Kim et al., 1995).

According to the Ministry Decree "*how to apply a system of voluntary labelling of beef and poultry*" a batch is "*a homogeneous group of animals by age, category, origin and consignment, belonging to the same species, initiated to the fattening cycle with the same techniques and the same conditions*" (Mipaaf (Ministero delle politiche agricole alimentari e forestali), 2004).

In the case of UNAITALIA production specification the TRU is a batch, which characteristics and granularity change going downward on the supply chain.

In the growing farms it is defined the "*production batch*" as "*group of animals homogeneous for age, species, origin and source initiated to the fattening cycle with the same techniques and the same conditions. The encoding of the batch is at least composed by unique code of breeding combined with the number of cycle*".

When animals arrive at the slaughterhouse is defined the "*Slaughter batch*" as "*a group of animals belonging to the same production batch and to be slaughtered on the same day. At each slaughter batch it is assigned a unique code that is shown on the label of the finished product*". The granularity of the slaughter batch may be a subset or coincide with the production batch.

Then, the "*cutting batch*" is "*meat belonging to the same Slaughter batch and cut at the same time. To each Cutting batch is assigned a unique code that is shown on finished product label*". The Cutting batch may be a subset ort coincide with the production batch or be a subset.

Finally the "*packaging batch*" is the identification code affixed to the sales unit that identifies the slaughter batch and, from it, the breeding farm and their production batch.

Also the feed mills that supply growing farms shall maintain traceability identifying product batches, through which it must be possible to trace the raw materials and the silos of origin.

Forward and backward traceability assurance

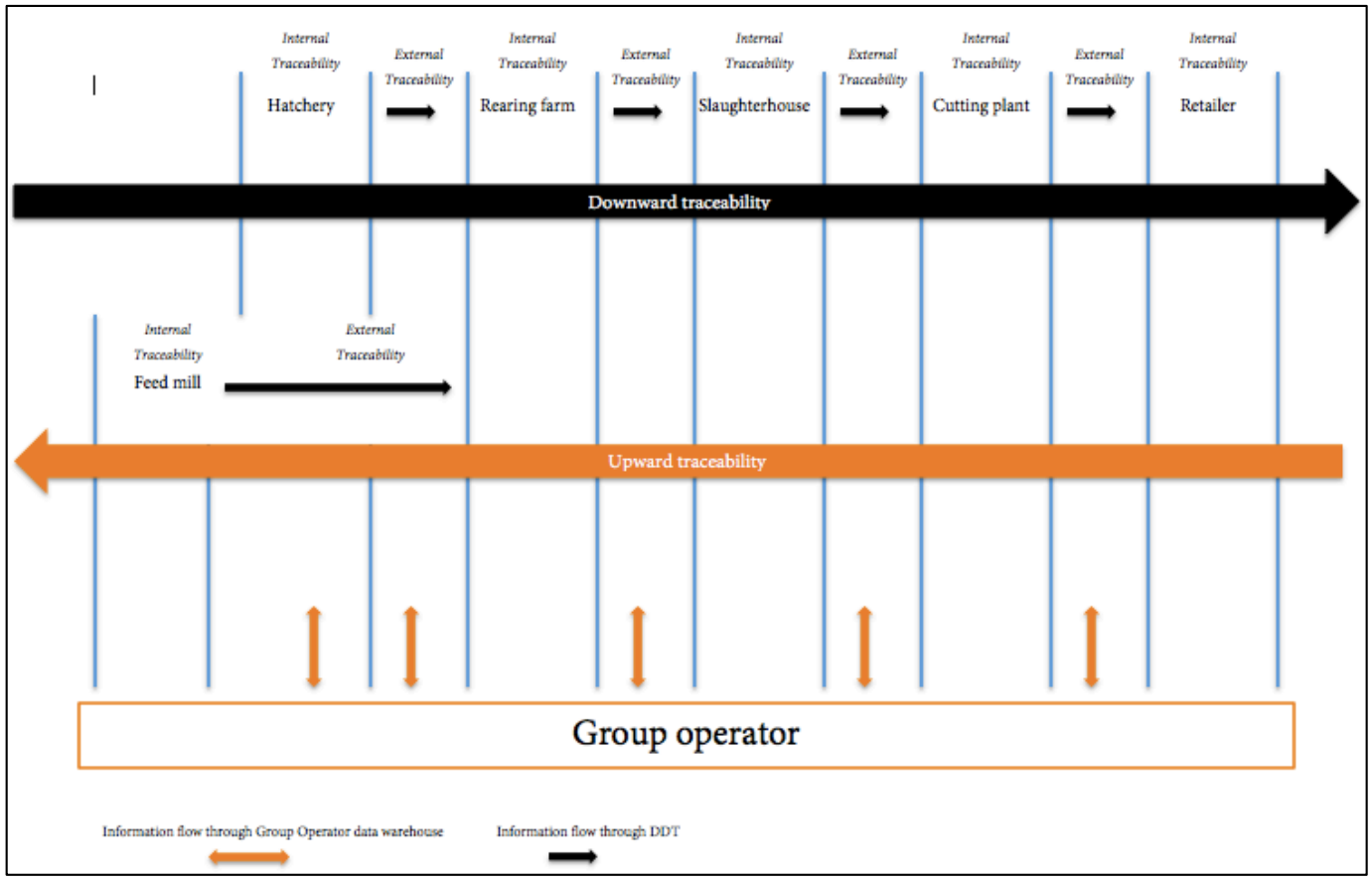
The UNAITALIA production specification defines the information that operators involved shall collect in order to ensure traceability along the supply chain. Thus, to ensure a correct flow of information, the production specification explains how and which information to record wherever there is a change of partner or operation. In fact, these are the Critical traceability Points/Events, representing the most critical operations in ensuring traceability and where information loss may easily occur (Karlsen et al., 2010; Mcentire et al., 2010; Olsen and Borit, 2013).

The production specification set rules for the group operators, feed mills, hatcheries, rearing farms, slaughter houses, cutting plants, and sales points (performing pre-wrapping and labelling activities).

In this paragraph are described for each critical traceability points of the supply chain which information is stored as required by UNAITALIA the production specification.

Figure 5.1 schematises the information direction flow among poultry meat supply chain links, according to UNAITALIA voluntary labelling. The production specification indicates for each actor both internal traceability and external traceability information to be shared with the downstream operator and with the Group operator.

Figure 5.1. Traceability management in poultry supply chain.



Thus, the system allows to Access information both downstream and upstream along the supply chain. Downstream traceability is kept thanks to each operator that sends information to the descending operator and to Group-operator data warehouse. On the other hand, the Group operator, through the data warehouse recalls traceability information received from supply chain operators, ensures backward traceability.

For each operator the production specification sets both internal traceability information to be store and information to send to the Group-operator and to the downstream operator. The exchanges of supply chain operator are the operations where information loss may easily occur. To overcome this issue, operators are required to send a shipping document with the product to the subsequent partner, and to send to the Group-operator this information. Thus, downward traceability is guaranteed through two channels: the shipment document and the Group-operator data warehouse. In case of necessity, the Group-operator may Access to data warehouse to trace back information on production of Traceable resource units.

Effect of the new labelling Regulation on the voluntary labelling

The recent entry into force of the obligation to indicate on the label the origin of poultry meat, has effected the UNAITALIA voluntary labelling system. In fact, the voluntary label included information that are now required by law. As consequence, from the voluntary label are now excluded information on the origin (rearing and slaughter country) of the production. Thus, the operators that used the voluntary labelling just for this information category, are excluded from the voluntary system. This circumstance determined the reduction of operators using the voluntary labelling Currently 9 members still use the voluntary UNAITALIA labelling (UNAITALIA, 2014). The specification is currently active as regards as all the remaining optional indication on the label, and UNAITALIA today represents 100% of voluntary labelling among its members (Unaitalia, 2015a).

Concluding remarks

The in-depth examination of the UNAITALIA voluntary production specification allowed to a better understanding of the complexity of the poultry meat supply chain. Even though the recent EC Reg. No.1169/2011 has reinforced the assurance of traceability in meat sector, the Italian poultry meat producers implemented with UNAITALIA a deeper system of traceability that allows responding to a growing consumers' expectations and ensuring an excellent system to guarantee food safety along the supply chain. The analysis of UNAITALIA voluntary production specification is the baseline of the survey presented in the next Chapter. In fact, it allowed to clearly identify the information exchanged between supply chain operators and the critical points for traceability implementation.

Chapter VI. Survey on the impact of traceability practices on Italian poultry industries

6.1 Target population and respondents

The target population selected are the members of UNAITALIA Association. The reason for this choice are mainly two. The Association gather all the mayor players, accounting for over 95% of poultry meat produced in Italy. Given the high level of integration in the supply chain, these operators control and set traceability rules for all firms in the different stages of the chain. Thus, they are the most informed elements of the supply chain in relation to traceability and, as consequence, on its impact on the operators. In addiction, thanks to the support received from UNAITALIA it has been possible to clearly identify firms' staff directly enrolled in traceability control. As stated in Chapter IV, the first 9 Italian poultry meat producers account for over 95% of production. Thus, these 9 industries are selected as survey target.

Once the questionnaire was built, it was emailed to the target firms. Then, each of them were contacted by phone in order to ensure their participation to the survey. Answers were collected from September 2015 to December 2015. The respondents were 8 out of an initial population of 9.

6.2 The construction of the questionnaire

In order to answer the research questions, which links the level of traceability to perceived barriers, costs, and benefits of its application, is was necessary to adapt them to poultry meat production. The questionnaire was adapted from other surveys that scholars conducted in the last years. Main references for this analysis are surveys conducted by Asioli (2009), Asioli et Al. (2012), Henson et Al. (2005), Mai (2010), Stranieri and Banterle (2015) which were analysed in-Depth in Chapter II.

The questionnaire is made up of 24 questions, organised in three sections. The first aims at defining firms' characteristics; the second the level of traceability; the third assesses benefits, barriers, and costs of traceability implementation.

6.2.1 Section one: firms' characteristics

In the first part is assessed the regions in which each company operates, and their size (turnover and employees in 2014). In the second part of the section is investigated both characteristic of the production process and their position in the supply chain. In order to figure out the configuration of their production process it was asked the percentage of production generated through a specific voluntary labelling approved by the Italian Ministry of Agriculture. Moreover, if they own other additional voluntary certifications and the procedure of provision from rearing farms.Finally, the type of meat produced (poultry, turkey, guinea-hen, duck), the weekly number

of slaughtered animals, the stages of the supply chain in which operate, and the type of costumers supplied.

Table 6.1. Firms' characteristics.

Firms' characteristics	
Region of operations	19 options
Size	Number of employees Turnover
Species of animals processed	Chicken Guinea hen Turkey
Amount of production	Average weekly number of slaughtered animals
Modality of provision from rearing farms	Property of rearing farms Agistment contracts Free market
Voluntary labelled percentage of production	IT 001 EA - UNAITALIA IT 003 EA IT 004 EA IT 005 EA IT 006 EA
Voluntary certification	Percentage of production generated through a specific voluntary labelling approved by the Italian Ministry of Agriculture Other voluntary certifications
Operation phases in the supply chain	Feed production Breeding Multiplication Hatchery Rearing Slaughterhouse Cutting Transformation Meatpacking Distribution
Customers	Processing industry National / International Retail chain Local Retail chain Other food retailers Restaurant chains Catering and restaurants Wholesalers Final consumers Public institutions Other

6.2.2 Section two: level of traceability

In order to assess the level of traceability, it was necessary to contextualise the previous literature assessing the level of traceability, adapting it to the industry under investigation. Information that firms collect to track and trace their production varies significantly in relation the characteristic of production processes. Thus, with the support of UNAITALIA, general aspects of traceability level were adapted to the research context.

As reported in Chapter I, traceability level may be defined by four dimensions: Breadth, Depth, Precision, and Access (Elise Golan et al., 2004; Mcentire et al., 2010). To those in the questionnaire is added also information on Technology used to collect information.

Breadth: "*describe the amount of information the traceability system records*". Firms are asked to express which information is collected both as input and output in their processes. Based on Regulatory requirements (EC Reg. No. 178/2002 and EC Reg. No. 1169/2011) and on voluntary information provided by the UNAITALIA voluntary labelling system are set 16 information that can be collected to at input and output stage.

Depth: "*is how far back or forward the system tracks*". According to EC Reg. No. 178/2002 operators have to maintain information relating to direct costumers and suppliers. To assess if respondents collect further information respect to regulatory requirements, they are asked to indicate if they are able to track production inputs beyond direct suppliers and if they are able to trace production outputs beyond direct customers.

Precision: "*reflects the degree of assurance with which the tracing system can pinpoint a particular food product's movement or characteristics*". To simplify the question and make it Accessible to all targeted population, respondents were asked if the traceability system is able to trace single batches of input and outputs from individual suppliers and costumers.

Access: "*the speed with which track and trace information can be communicated to supply chain members and the speed with which requested information could be disseminated to public health officials during food related emergencies*". To guarantee a high level of food safety and be prepared to manage emergencies, operators should implement a communication system with supply chain members and public authorities. Thus, respondents are asked to indicate if they own an IT system to communicate in real time potential threat to public health, and if it is directed to other supply chain firms, public authorities or both. In addiction firms are asked if they share with others partners of the supply chain an IT traceability system.

Technology: the Technology of the system that collects traceability information may be paper-based, bar codes, specific software, and R-FID.

Table 6.2. Traceability level assessment.

Level of traceability		
Breadth	Information tracked as input and output	
Precision	Ability to trace single batches of input from individual suppliers	
Access	Real time communication with: Supply chain partners Public Authority Supply chain partners and Public Authority Traceability system shared with supply chain partners	
Depth	Firm able to trace its output beyond the direct suppliers	Firm able to trace its output beyond the direct customers
Technology	Paper Based Bar codes Specific software R-fid	

6.2.2.1 Traceability level assessment: index construction

Previous works on traceability level assessment

In order to simply the results interpretation it is useful implementing an index to measure traceability level. It was done assigning a score from the questions related to information registered by firms to implement traceability in terms of Breadth, Depth, Precision, Access, and Technology. Other scholars attempted to set an index to summarise results of questionnaires in which traceability level of firms was investigated.

Asioli D. in 2009, through a questionnaire targeted to Italian firms of the fishery processing industry, sets three indexes for Breadth, Depth, and Precision (see Chapter II). From a list of 12 variables (both process input and output) to measure Breadth, He set an index with a maximum score of 24. To measure Depth He used 4 variables (both process input and output) with a maximum score of 8. Finally, Precision was measured by 2 variables (both process input and output) with an index score of 2 (Asioli, 2009).

Stranieri and Banterle in 2015 investigating the impact of voluntary traceability certification on Italian firms set a synthetic index to classify firms (see Chapter II). Authors propose a model in which the level of traceability is a function of other variables. They set a score for questions related to traceability in terms of Breadth, Depth and Precision. Breadth ranges from 1 to 4, Depth from 1 to 3, and Precision from 1 to 4. On the basis of the results obtained they proposed three different categories of traceability systems, defining a single index: 'low traceability rules' (scores from 3 to 6), 'Medium traceability rules' (scores from 7 to 9) and 'high traceability rules' (scores from 10 to 12) (Stranieri and Banterle, 2015).

In addiction to Breadth, Depth, and Precision of traceability system, in this work is presented also the assessment of other to variables that influence traceability: Access and Technology. Access is defined as "*the speed with which track and trace information can be communicated to supply chain members and the speed with which requested information could be disseminated to*

public health officials during food related emergencies" (Mcentire et al., 2010). Technology penetration relates to the means by which traceability information is stored.

Breadth

The variable is composed of 15 elements. First six concern mandatory information to be recorded descending from EC Reg. No. 178/2002 and EC Reg. No. 1169/2011.

Table 6.3. Breath of the traceability system.

	Breath of traceability system	**Mandatory regulation reference**	**Score**
1	Suppliers details	Reg. EC 178/2002	1
2	Date	Reg. EC 178/2002	
3	Quantity	Reg. EC 178/2002	
4	Rearing country	Reg. EC 1169/2011 & Reg. EC 1337/2013	
5	Slathering country	Reg. EC 1169/2011 & Reg. EC 1337/2013	
6	Chicks origin country		1
7	Cutting country		1
8	Type of feed		1
9	Type of rearing		1
10	Breed or genetic type		1
11	Minimum age for slaughter		1
12	Fattening period		1
13	Animal welfare		1
14	Environmental sustainability of production process		1
	Total score		10

Table describes how the index of breath is built. Given that data from 1 to 5 are mandatory for all poultry operators is assigned 1 point. Conversely, data from 6 to 14 are voluntary. To each is assigned 1 point. Thus, the maximum score is 10. Breadth index ranges from 1 to 10.

Depth

Depth index vary from 2 to 4. In input stage 1 is assigned if the firm is not able to record information inputs beyond direct suppliers, 2 if is able. In output stage 1 is assigned if the firm is able to trace production outputs beyond direct customers, 2 if is able. Minimum score of Depth is 2 and maximum is 4.

Precision

The dimension of batches that can be identified gives the level of Precision. In the questionnaire firms are asked if they can trace and differentiate batches from single suppliers. If they are not able to do so 1 point is assigned, while 2 points if they can trace single batched from each supplier.

Access

A crucial element to reduce the impact of a food safety emergency is the speed through which firms react informing all relevant parties in the supply chain. In case a firm owns a system to communicate in real time with supply chain partners is assigned 2 points. If a firm owns a system to communicate in real time with public authorities is assigned 2 points. If a firm owns both

systems is assigned 4 points. If none of the systems is applied is assigned 1 point. Thus, for Access minimum score is 1, and maximum is 4.

Technology

Technology adoption may contribute to traceability system efficiency (Kärkkäinen, 2003; Samarasinghe et al., 2009). If traceability data are collected through paper-based tools 1 point is assigned. An additional 1 point is assigned if a firm uses dedicated software for traceability. An additional 1 point is assigned if a firm uses also bar codes, and an additional 1 point is assigned if a firm uses also R-fid technology. Technology index varies from a score of 1 to 4.

Synthetic traceability level index

On the base of the scores of the 5 indexes is constructed a synthetic index (traceability level index) that gives an immediate description of the traceability level implemented in each firm. The traceability level index is calculated summing up the scores of the 5 indexes (Table 6.4).

Table 6.4. Traceability level index composition.

Traceability elements	**Minimum score**	**Maximum score**
Breadth	1	10
Depth	2	4
Precision	1	2
Access	1	4
Technology	1	4
Total score	6	24

Table 6.4 describes for each of the 5 dimensions of traceability minimum and maximum scores assigned, varying from 6 to 24. As proposed by (Stranieri and Banterle, 2015; Stranieri et al., 2015) in relation to traceability level firms are assigned to three groups. A score between 6 and 11 is "*Legal traceability"(1),* a score between 12 and 17 is "*Medium traceability*"(2), a score between 18 and 24 is "*Deep traceability*"(3) (Stranieri and Banterle, 2015; Stranieri et al., 2015).

6.2.3 Section three: benefits, barriers and costs of traceability

In last section investigates benefits, barriers, and costs of traceability implementation. Answers are provided with a Likert scale ranging from one to five (1=not important – 5=very important).

Benefits due to traceability implementation

Potential positive outcomes of traceability are divided into three main areas. First food safety management, as the ability to increase precision, speed of recalls, and as increased capacity to comply with regulatory requirements. Second group is potential process improvements, which relate to costs reductions, enhanced internal management, and increased personnel motivation.Finally, product differentiation for market and consumers. It relates to better relationships with supply chain partners, public authorities, consumers, and enhanced market opportunities.

Table 6.5. Traceability implementation potential benefits.

Benefits
Food safety management
Reduced numbers of withdrawals and / or recalls
Reduced withdrawals and / or recalls scope
Enhanced speed of withdrawals and / or recalls
Enhanced management of withdrawals and / or recalls
Enhanced ability to satisfy regulatory requirements
Internal processes improvements
Reduction of costs in case of withdrawals and / or recalls
Reduction of inventory costs
Reduction of production costs
Reduction of waste
Reduction of product supply costs
Enhances internal management
Reduction of errors in data management
Enhanced employees motivations
Product differentiation for market and consumers
Enhanced communication and coordination with supply chain partners
Enhanced relationship with public authorities
Enhanced relationship with consumers
Increased product selling price
Access to new markets
Increased market share
Enhanced costumers satisfaction
Enhanced firm image and reputation

Barriers to traceability implementation

The next questions estimate the level of perceived difficulties encountered by firms in the phase of traceability implementation. It relates to the necessity to modify management practices with employees and commercial partners, and in relation to data management.

Table 6.6. Potential difficulties in traceability implementation.

Obstacles in traceability implementation
Employees training
Employees motivation
Flexibility in production processes
New products implementation
Employees time dedicated to traceability
Managers time dedicated to traceability
Availability of competent consultants
Suppliers support and cooperation
Clients support and cooperation
Number of product / production features to register
Availability of a suitable software

Costs of traceability system maintenance and management

In this section firms were asked to indicate how relevant are costs of traceability system maintenance and management, from a list of eight potential costs.

Table 6.7. Costs of traceability system maintenance and management**.**

Costs of traceability system
Staff time dedicated to traceability
Equipment upgrade
Software upgrade
Laboratory testing
Control and monitoring of supplies
Training courses
External consultants
Inspections and audits

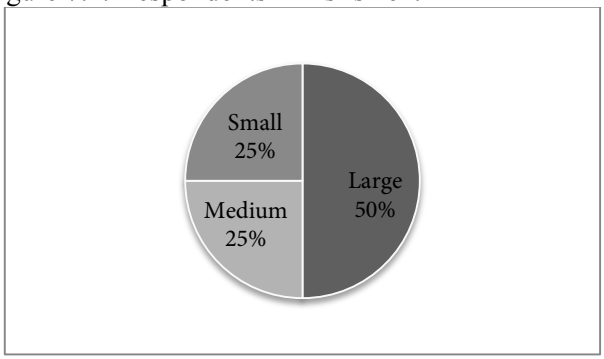
Chapter VII. Results and discussion

In this Chapter are presented main findings from the 8 firms that answered the questionnaire, from the initial population of 9 firms. First are described the main characteristics of firms. Then, is assessed the level of traceability for each respondent. The last part will test the assumption made through the research questions. Starting from questionnaire questions will be checked if empirical results will accept or reject the hypothesis made in Chapter III.

7.1 Section I. Firms characteristics

Population selected for the investigation are the 9 firms members of UNAITALIA association, which represent the main group operators operating in the Italian supply chain of poultry meat production.

Figure 7.1. Respondents firms' size*.



*EC Commission Recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises (C(2003)1422).

Four out of the respondents are Large size, with more that 250 employees and a turnover over €43 million. Two are medium size, with between 50 and a turnover between €43 million and €10 million, and remaining two are Small size, with less than 50 employees and a turnover less than €10 million (Figure 7.1).

Table 7.1 Species of animals processed.

Animal species	Number of firms
Chicken	8
Turkey	2
Guinea hen	4

Table 7.2 Weekly slaughtered animals.

Weekly number of slaughtered animals	Number of firms
Over 150.000	4
Between 50.000 - 150.000	2
Less than 50.000	2

Each firm produce Chicken meat. Four also produce Guinea hen, while two also turkey. In their slathering plant half firms process over 150.000 animals weekly (Table 7.1 and 7.2).

Table 7.3 Provision from rearing farms.

	No	1-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%
Property farms	2	2	1	1	1					1	
Agistment contract	2					1	1		1		3
Free market	3	2	2								1

Firms' animal provision from rearing farms, vary significantly. The most widespread modality is the agistment contract, implemented by 3 firms for almost the total of provisions. On the other hand, just one firm declared to supply just form the free market (Table 7.3).

Table 7.4. Supply chain phases covered by respondents.

Supply chain phase	Number of firms
Feed production	6
Breeding Multiplication	3
Hatchery	3
Rearing	7
Slaughterhouse	8
Cutting	6
Transformation	4
Packaging	4
Distribution	6

Table 7.4 shows that respondents are involved in several phases of the supply chain, confirming their position as Group Operators (see Chapter 5).

Table 7.5. Peoluntary labelled product.

Voluntary label	No	1-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%
IT 001 EA UNAITALIA	1			2	2				1		2
IT 006 EA	7										1

Of the six Voluntary Labels approved by the Ministry of Agriculture, only two of them are implemented by respondents. Moreover, seven firms implement the UNAITALIA label, of which two for all the production (Table 7.5).

Table 7.6. Type of customers supplied by firms.

Customers	Number of firms
Processing industry	4
National / International Retail chain	7
Local Retail chain	4
Other food retailers	4
Restaurant chains	2
Catering and restaurants	2
Wholesalers	3
Final consumers	3
Public institutions	0
Other	1

The mayor costumer of respondents is “National / International Retail chain” (7 respondents), followed by “Processing industry”, “Local retail chain”, and “Other food retailers” (in four cases). Notably none of respondents supply Public institutions (Table 7.6).

Table 7.7 Voluntary certifications.

Certification	Number of firms
ISO 9001:2008	5
ISO 22005:2007	3
ISO 22000:2005	2
Organic	2
ISO 14001:2004	1
IFS / BRC	1

BRC (British Retail Consortium) food safety standard.
IFS (International Featured Standard) food safety standard.

Finally, the most widespread voluntary certification owned by respondents is the ISO 9001:2008 (five cases), followed by the ISO 22005:2007 on food traceability (3 cases) (Table 7.7). Table 7.8 summarises the main characteristics of each firms involved in the survey.

Table 7.8 Main characteristics of respondents' firms.

	Size	Reg.	Products	Weekly slaughtered animals	Provision from rearing farms	Supply chain operations	Voluntary labelled production	Customer	Certifications
3	Large	4	Chicken Turkey	Over 150.000	Property farms 31-40% Agistment contract 51-60% Free market 1-10%	a-b-c-d-e-f-g-h-i (9)	IT 001 EA UNAITALIA 21-30%	a-b-e-f-g-i (6)	ISO 9001:2008 ISO 22000:2005 ISO 14001:2004 ISO 22005:2007 IFS / BRC
4	Large	1	Chicken	Over 150.000	Property farms 1-10% Agistment contract 91-100% Free market 0%	a-b-d-e-f-g-h-i (8)	IT 006 EA 91-100%	b (1)	ISO 9001:2008 Organic
8	Large	13	Chicken	Over 150.000	Property farms 1-10% Agistment contract 81-90% Free market 11-20%	a-b-c-d-e-f-g-h-i (9)	IT 001 EA UNAITALIA 21-30%	a-b-c-d-f-g (6)	ISO 22000:2005 ISO 14001 IFS FOOD v6
9	Large	21	Chicken Turkey Guinea Hen	Over 150.000	Property farms 11-20% Agistment contract 71-80% Free market 0%	a-b-c-d-e-f-g-h-i (9)	IT 001 EA UNAITALIA 21-30%	a-b-c-d-e-f-g-h-j (9)	ISO 9001:20008
5	Medium	8	Chicken	Between 50.000 e 150.000	Property farms 0% Agistment contract 0% Free market 91-100%	a-d-e (3)	IT 001 EA UNAITALIA 91-100%	b(1)	ISO 9001:2008 Organic
6	Medium	1	Chicken Guinea Hen	Between 50.000 e 150.000	Property farms 21-30% Agistment contract 41-50% Free market 11-20%	d-e-f-h-i (5)	IT 001 EA UNAITALIA 91-100%	b-c-d-h (4)	ISO 22005:2007
7	Small	3	Chicken Guinea Hen	Less than 50.000	Property farms 0% Agistment contract 91-100% Free market 0%	a-e-i (3)	IT 001 EA UNAITALIA 91-100%	a (1)	ISO 9001:20008 ORGANIC
1	Small	1	Chicken Guinea Hen	Less than 50.000	Property farms 81-90% Agistment contract 0% Free market 1-10%	d-e-f-i (4)	IT 001 EA UNAITALIA 31-40%	b-c-d-g-h-i (7)	

Table 7.9. Legend of Table 7.8.

Supply chain phase		Customer
Feed production	A	Processing industry
Breeding Multiplication	B	National / International Retail chain
Hatchery	C	Local Retail chain
Rearing	D	Other food retailers
Slaughterhouse	E	Restaurant chains
Cutting	F	Catering and restaurants
Transformation	G	Wholesalers
Meatpacking	H	Final consumers
Distribution	I	Institutions
Other	J	Other

7.2 Section II: Traceability level assessment

In order to assess research questions, it has been calculated the level of traceability as described in Chapter 6. Table 7.10 for each firms presents the results of the second section of the questionnaire.

With reference to Breadth, which varies from 1 to 10, scores are between 3 to 9. Thus, there is quite a relevant variety among firms in relation to the amount information recorded. Only one firm scored 9, while the average score is 5.87.

Depth score varies from 2 to 4. Seven out of the eight respondents scored 4, with the exception of one firm that scored 1 (No trace input or output beyond direct suppliers or customers).

With regard to Precision, which varies from 1 to 2, all firms declared to be able to trace batches of products from single suppliers.

Access varies from 1 to 4. The average score of respondents is 2.75. Only two firms declared that do not have a system to communicate in real time with supply chain partners and/or public authorities. Conversely, half of firms has a system to communicate in real time with supply chain partners and public authorities.

Finally, Technology score ranges from 1 to 4. Seven out of the eight firms use specific IT software for traceability. Half firms use paper-based, software, and bar codes. Only one uses also r-fid technology.

Total traceability index ranges from a score of 14 to 22, with an average of 16,87 corresponding to Medium traceability group. None of firms belong to *Legal traceability* group, while two are in *Deep traceability* group (Table 7.10).

Table 7.10 Respondents' traceability level assessment.

	Breadth		**Depth**		**Precision**		**Access**		**Technology**		**Score**	**Group**
	Info	Score	Info	Score	Info	Score	Info	Score	Info	Score		
3	L-D-G-H-I-I-K-L-N	9	A-B	4	A	2	A-B	4	A-B-C	3	22	Deep
4	L-D-G	3	A-B	4	A	2	A-B	4	A-B-C	3	16	Medium
8	L-G-H-J	4	A-B	4	A	2	C	1	A-B	3	14	Medium
9	L-D-G-H-I-J-K-L	8	A-B	4	A	2	A	2	A-B-C-D	4	20	Deep
5	L-D-G-H	4	A-B	4	A	2	A-B	4	A	1	15	Medium
6	L-D-G-H-I-J-K	7	A-B	4	A	2	C	1	A-B-C	3	17	Medium
7	L-D-G-H-I-K-N	7	C	1	A	2	A	2	A-C	2	14	Medium
1	L-D-G-H-I	5	A-B	4	A	2	A-B	4	A-C	2	17	Medium

Table 7.11. Legend of Table 7.10.

Breadth			**Depth**			**Precision**			**Access**			**Technology**		
		Score			Score			Score			Score			Score
Legal requirements	L	1	Trace input beyond direct suppliers	A	2	Trace batches from single suppliers	A	2	System to communicate in real time with supply chain partners	A	2	Paper-based	A	1
Chicks origin country	D	1	Trace output beyond direct suppliers	B	2	No trace batches from single suppliers	B	1	System to communicate in real time with public authorities	B	2	Software	B	1
Cutting country	G	1	No trace input or output	C	1				None	C	1	Barcodes	C	1
Type of feed	H	1										R-fid	D	1
Type of rearing	I	1												
Breed or genetic type	J	1												
Minimum age for slaughter	K	1												
Fattening period	L	1												
Animal welfare	N	1												
Environmental sustainability	O	1												
Maximum score		10			4			2			4			4

7.4 Results and research questions

The major goal of the investigation is to assess the impact of traceability in the Italian poultry supply chain. Thus, the main research question is "Which is the impact of traceability in the Italian poultry supply chain?". From this generic questions arise other more detailed, which take into account also the level of traceability implemented by firms:

1. Traceability level influences traceability benefits?
2. Traceability level influences traceability costs?
3. Traceability level influences difficulties in traceability implementation?

To these questions it interesting to investigate the linkage between traceability level and the perceived impact of the EC Reg. No. 1669/2011.

4. Traceability level influences the difficulty in implementing EC Reg. No. 1169/2011?

Thus, this section will assess the existence of a significant relationship between traceability level and traceability impact on firms.

As explained in Chapter V, considering Breadth, Depth, Precision, Access, and Technology level firms are assigned a score (traceability index). Then, according to the score classified into three groups (Legal, Medium, and Deep traceability). The eight respondents belong to Medium and Deep traceability groups.

Because of variables in consideration are ordinal (non-normally distributed) and because the sample consists of only 8 cases, to test hypothesis non-parametric statistical tests are the most suitable.

To test if there is a statistical significance difference between the two groups of firms (Medium and Deep level of traceability) is performed a Mann-Whitney U Test. (Corder and Foreman, 2014; Mann and Whitney, 1947; Nachar, 2008; Sprent and Smeeton, 2007).

Even if the Mann-Whitney Test is non parametric and can be applied to small sample size (Nachar, 2008), in this case a sample of 8 composed of two groups of 6 and 2 units is probably too small to produce results with sufficient level of robustness, leading to an imprecise estimation of p-values (Mundry and Fischer, 1998). Thus, to reinforce the analysis for each research hypothesis are shown descriptive tables comparing results of the two groups. If on one hand the small sample does not allow robustness in statistical tests, it give the possibility to analyse punctually each answer received.

Research hypothesis (RH) are:

1. H_0: there is no significant difference between the two groups in relation to traceability benefits

H_1: there is significant difference between the two groups in relation to traceability benefits

2. H_0: there is no significant difference between the two groups in relation to traceability costs

H_1: there is significant difference between the two groups in relation to traceability costs

3. H_0: there is no significant difference between the two groups in relation to difficulties in traceability implementation

H_1: there is significant difference between the two groups in relation to difficulties in traceability implementation

4. H_0: there is no significant difference between the two groups in relation to difficulties in implementing EC Reg. No. 1165/2011

H_1: there is significant difference between the two groups in relation to difficulties in implementing EC Reg. No. 1165/2011

Testing research hypothesis 1

Benefits are divided in three main areas. Food safety, Internal, and External.

Table 7.12. Ranks of benefits grouped with traceability level.

Ranks				
	group	N	Mean Rank	Sum of Ranks
Benefits food safety	Deep	2	3,00	6,00
	Medium	6	5,00	30,00
	Total	8		
Internal benefits	Deep	2	4,50	9,00
	Medium	6	4,50	27,00
	Total	8		
External benefits	Deep	2	4,50	9,00
	Medium	6	4,50	27,00
	Total	8		

Group 1=Deep traceability; Group 2=Medium traceability

Table 7.13. Test statistics Mann-Whitney test

Test Statistics			
	Benefits food safety	Internal benefits	External benefits
Mann-Whitney U	3,000	6,000	6,000
Wilcoxon W	6,000	27,000	27,000
Z	-1,025	,000	,000
Asymp. Sig. (2-tailed)	,306	1,000	1,000
Exact Sig. [2*(1-tailed Sig.)]	,429	1,000	1,000

The test for RH 1 point out that there is not statistical significant difference between the two groups. Both 2-tailed Asymptotic Significance and 1-tailed Asymptotic Significance have a p-value greater than 0.05 (significance level of 95%).

Thus, we accept the Null Hypothesis (H_0). The implementation of Medium or Deep traceability do not influence perceived benefits of traceability.

Do deepen the analysis Table proposes the results obtained by the two groups.

Table 7.14. Benefits of traceability for Deep and Medium traceability groups.

	Benefits of traceability		
Group	Food safety	Internal	External
Deep	3.58	3.50	3.81
Medium	4.17	3.73	3.91

Testing research hypothesis 2

The Mann-Whitney U test show that there is no significant difference between the two groups. Thus, the null hypothesis H0 is accepted: there is no significant difference between the two groups in relation to traceability costs.

Table 7.15. Ranks of benefits grouped with traceability level.

Ranks				
	Group	N	Mean Rank	Sum of Ranks
Costs	Deep	2	2,25	4,50
	Medium	6	5,25	31,50
	Total	8		

Table 7.16. Test statistics Mann-Whitney test

Test Statistics	
	Costs
Mann-Whitney U	1,500
Wilcoxon W	4,500
Z	-1,518
Asymp. Sig. (2-tailed)	,129
Exact Sig. [2*(1-tailed Sig.)]	,143

Table 7.17. Cost of traceability for Deep and Medium traceability groups.

Group	Costs
Deep	3.00
Medium	3.73

Even if there is no significant different in the Mann-Whitney U test, comparing average values for costs firms implementing Deep traceability consider costs lower (3.00) than Medium traceability group (3.73).

Testing research hypothesis 3

According to Mann-Whitney U Test there is significant difference between the two groups and perceived difficulties in implementing traceability system (RH 3). The p-value for RH 2 is 0.044 (2-tailed asymptotic significance). Thus, we reject the null

hypothesis (H_0). We accept the alternative hypothesis H_1: there is significant difference between the two groups in relation to traceability costs.

Table 7.18. Ranks of benefits grouped with traceability level.

Ranks				
	Group	N	Mean Rank	Sum of Ranks
Barriers	Deep	2	1,50	3,00
	Medium	6	5,50	33,00
	Total	8		

Table 7.19. Test statistics Mann-Whitney test.

Test Statistics	
	Barriers
Mann-Whitney U	,000
Wilcoxon W	3,000
Z	-2,012
Asymp. Sig. (2-tailed)	,044
Exact Sig. [2*(1-tailed Sig.)]	,07

Table 7.20. Difficulties in implementing traceability for Deep and Medium traceability groups.

Group	Difficulties
Deep	3.59
Medium	4.05

Table shows that firms with Medium level of traceability perceive higher difficulties in implementing the traceability system.

Table 7.21. Spearman correlation between difficulties and groups.

Correlations				
			Group	Difficulties
Spearman's rho	Group	Correlation Coefficient	1,000	,760*
		Sig. (2-tailed)	.	,028
		N	8	8
*. Correlation is significant at the 0.05 level (2-tailed).				

The significance of the relationship between the two groups and barriers to traceability implementation is confirmed also with the correlation analysis, in which the Spearman's Rho coefficient of correlation is equal to 0.76, with a significance level of 0.05.

Testing research hypothesis 4

The latter RH is that there is significant difference between the two groups in relation to difficulties in implementing EC Reg. No. 1165/2011.

The Mann-Whitney U test reveals significant difference between groups, with a significance level of 0.022 (2-tailed asymptotic significance). Therefore, we reject the null hypothesis, and accept the alternative hypothesis.

Table 7.22. Ranks of benefits grouped with traceability level.

Ranks				
	Group	N	Mean Rank	Sum of Ranks
Difficulties for Reg.1169/2011	1,00	2	1,50	3,00
	2,00	6	5,50	33,00
	Total	8		

Table 7.23. Test statistics Mann-Whitney test

Test Statistics	
	Difficulties for Reg.1169/2011
Mann-Whitney U	,000
Wilcoxon W	3,000
Z	-2,291
Asymp. Sig. (2-tailed)	,022
Exact Sig. [2*(1-tailed Sig.)]	,071

Table 7.24. Difficulties in implementing EC Reg. No. 1165/2011

Group	Difficulties
Deep	2.50
Medium	4.17

Table 7.25. Spearman correlation between difficulties and groups.

Correlations				
			Group	Difficulties for Reg.1169/2011
Spearman's rho	groupNUM	Correlation Coefficient	1,000	,866**
		Sig. (2-tailed)	.	,005
		N	8	8
**. Correlation is significant at the 0.01 level (2-tailed).				

Findings are confirmed also in the correlation analysis using Spearman's Rho coefficient (equal to 0.866 and significance level of 0.01). In Medium traceability firms the difficulties in implementing EC Reg. No. 1169/2011 is significantly higher than in the other group. Also Table displays that for Deep traceability group the perceived difficult is low (2.50), while for Medium traceability is notably higher (4.17).

Research hypothesis summary

Even if the small size of the sample reduces the reliability of results, it is possible to sum-up results of the Mann-Whitney U Test performed on the two groups of firms

identified thanks to traceability performance assessment previously presented in this Chapter and in Chapter VI.

Table 7.26. Summary of research hypothesis testing according to Mann-Whitney U test.

	Null Hypothesis (H_0)	**Alternative Hypothesis (H_1)**	**Result**
RH 1	no significant difference between the two groups in relation to traceability benefits	significant difference between the two groups in relation to traceability benefits	accept the null hypothesis
RH 2	no significant difference between the two groups in relation to traceability costs	significant difference between the two groups in relation to traceability costs	accept the null hypothesis
RH 3	no significant difference between the two groups in relation to difficulties in traceability implementation	significant difference between the two groups in relation to difficulties in traceability implementation	reject null hypothesis
RH 4	no significant difference between the two groups in relation to difficulties in implementing EC Reg. 1165/2011	significant difference between the two groups in relation to difficulties in implementing EC Reg. 1165/2011	reject null hypothesis

Table 7.26 shows that for all three categories of potential benefits for traceability implementation there is no significant difference between Deep and Medium traceability groups. Nevertheless, Deep traceability firms in all groups expressed a lower score (Likert scale 1-5) in terms of perceived benefits. Concerning costs of traceability implementation, there is no significant difference between groups, but Medium traceability firms consider costs as more important respect to Deep traceability group. Conversely it exists a significant difference between groups in terms of difficulties in implementing traceability system. In this case to a lower lover level of traceability correspond a higher level of barriers. Finally, the higher level of divergence exists in the implementation of the recent entry into force of the EC Reg. No. 1169/2011. In this case the higher the level of traceability, the lower the difficult to satisfy the new EC regulation. Also the correlation analysis confirm that Medium traceability firms perceive the regulation implementation significantly more challenging.

Figure 7.2. Traceability implementation differences between the two groups.

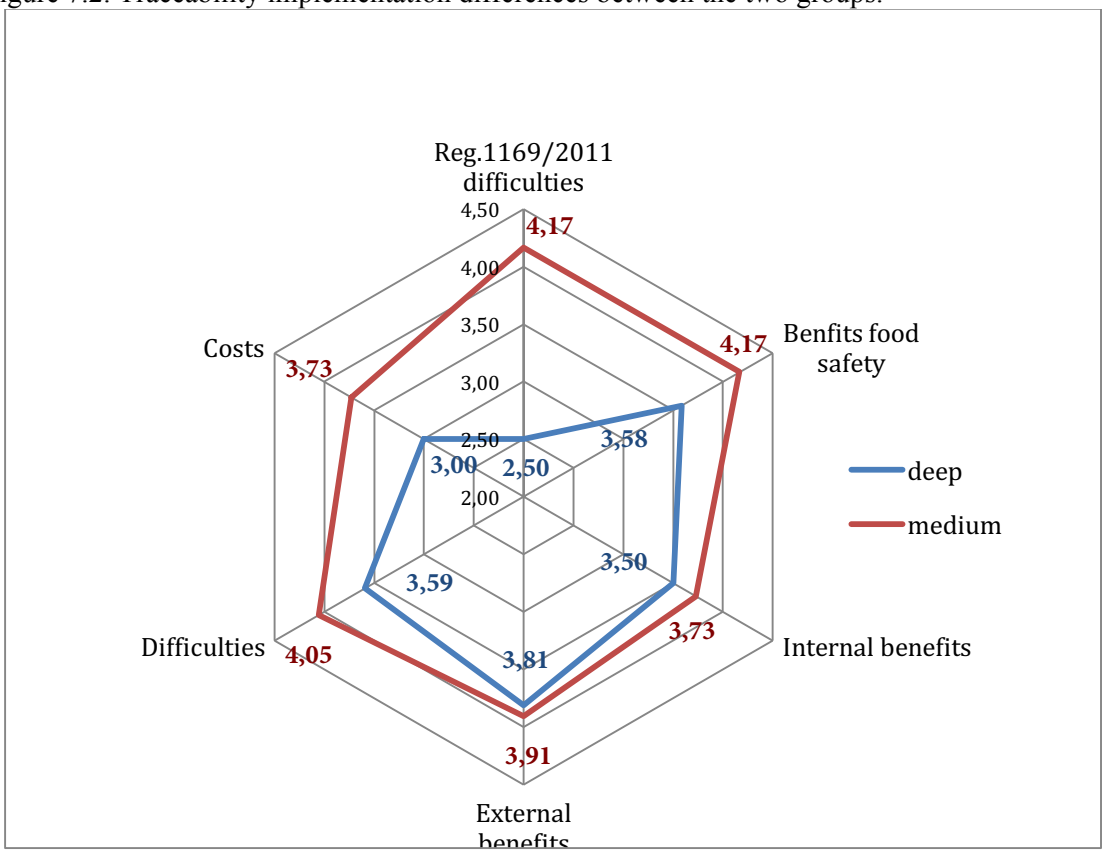


Figure 7.2 summaries main results of the survey. It is clear that in all six aspects considered firms in Deep traceability group answered lower scores on the Likert scale. This difference is even more evident considering the entry into force of the EC Reg. No. 1169/2011. Probably firms with a higher level of traceability did not had to significantly modify and update their traceability system, that already included all information and specifications required by the regulation.

Research conclusions, limitations, and future outlook

The present work investigates the role of traceability in the food supply chain. Starting from a broad revision of existing literature it intends to figure out how traceability impact on firms' operations. Traceability is a wide concept, affecting several aspects of firms, both as a single agent and as an element of complex supply chains. Previous investigations proved that traceability systems do not just improve food safety management, but have other implications for firms'. Traceability influences firms' internal aspect such as inventory and production costs, employees' motivation, internal management organizations, and waste management. Nowadays traceability is part of mandatory regulations, especially in the meat supply chain. Nevertheless, firms decide to go further, setting traceability systems that go beyond, in order to achieve additional benefits. Therefore, traceability has positive influence also on the external sphere of firms' operations. Potential external benefits relate to market opportunities, enhancement of firms image and reputation, better coordination with supply chain partners, and improved relationships with public authorities.

The overall goal of the thesis is to evaluate how traceability practices influence positively and negatively firms' activities. More specifically, it aims at evaluating the link between the level of traceability implemented by firms and its impact in terms of benefits, difficulties, and costs. Golan et Al. (2004) introduced traceability level assessment in 2004 with the concepts of Breadth, Depth, and Precision of traceability systems (E. Golan et al., 2004). Those aspects were integrated by McEntire et Al. in 2010, with the concept of Access (McEntire et al., 2010). Only two works have been identified in literature trying to effectively calculate the level of traceability empirically on a food supply chain. Asioli in 2009 investigated the Italian supply chain of fishery processing industry. According to the Author, Breadth level is Medium linked with actual and costs, benefits. Depth is most slightly linked with the business performance measures of traceability. Finally, Precision is not correlated with costs but is linked with expected and actual benefits (Asioli, 2009). Stranieri et Al. (2015) on the basis of Breadth, Depth, and Precision built three level of traceability. Findings of their research indicate that there is a positive link between the level of traceability and economic incentives perceived by firms (Stranieri et al., 2015).

Following this line of investigation this work aims to give both a theoretical and empirical contribution to understand the relationship between traceability level and its impact on firms' operations. On the theoretical side adds to the three aspects of traceability (Breadth, Depth, and Precision) also Access and Technology, as elements to consider in the construction of a synthetic index of traceability. On the empirical side it

explores traceability impact on the poultry supply chain, which was not investigated previously.

The supply chain target of the survey is the meat poultry supply chain of Italy. Thanks to the support received by UNAITALIA association (The National Union of meat and egg supply chains), it as been possible to in-Depth analyse the structure and operation of this sector. The supply chain is characterized by a high vertical integration of the supply chain, where the leader are the processing companies (Group Operators) while the farmer is mainly engaged in the rearing phase of the animal. Thus, there is a high concentration in the processing phase, determining that meat and eggs consumed arrive from few producers. Thanks to this high concentration and vertical integration, the supply chain has adopted voluntary traceability systems since 2004, demonstrating marked proactivity in terms of traceability. Given that Group Operators produce over 99% of meat distributed in Italy the target of the investigation is 9 firms. Only one firm did not participate in the survey. Thus, respondents are responsible for roughly 65% of poultry meat in Italy.

In Chapter III, are formulated four research hypothesis and in Chapter VII are presented results. In relation to traceability level assessment, three levels of traceability are set (Low, Medium, and Deep traceability). Six out of the eight respondents belong to the Medium traceability group while two to Deep traceability group. None of the firms are part of low traceability group. This result is consistent with the nature of firms questioned, which operates as integrators and need an efficient system to control and manage several operators in the supply chain.

Given the small population object of the analysis and the ordinal data used in the questionnaire to test the research hypothesis is adopted the Mann-Whitney U Test. Four research questions are set, aiming at verifying statistical significant difference between the two groups of firms (Medium and Deep Traceability) in terms of benefits, difficulties and cost of traceability implementation. Concerning benefits, there is not significant difference between groups both regarding food safety, internal, and external benefits. Also in relation to cost of traceability implementation, the Test show no significant difference between Medium and Deep traceability. On the other hand, the two groups show a significant difference in relation to perceived difficulties in traceability implementation. Correlation analysis confirms the result: the lower the level of traceability, the higher the difficulties in its implementation. Also regarding the forth research question is confirmed that there is a significant difference between difficulties in implementing EC Reg. No. 1169/2011 on food labels and the level of traceability. The group of firms with Deep traceability declared to have had lower difficulties in implementing the regulation than Medium Traceability group.

Findings show that the level of traceability may affect differently firms' operations within the same supply chain. Even if just in two research questions it has been identified a significant difference in relation to the level of traceability, the analysis of responses express differences concerning all hypothesis. Medium traceability group perceives slight higher benefits from traceability implementation. A possible explanation is that recording additional data on products is not always positively recognised by market and consumers, which do not perceive the added value of this information. In addition, Technology beyond specific software such as bar codes and R-FID is not perceived as an added value. In the case of costs, Medium traceability group perceives them as higher than Deep traceability group. The same conclusion is valid in relation to difficulties. This may be due to the fact that higher costs are perceived as higher barriers by firms. Finally, the greater difference relates to perceived difficulties in implementing the EC Regulation on labels, entered into force in May 2015. Medium traceability group considers its implementation as a big obstacle while is not significant for Deep traceability group. Probably Deep traceability firms were already prepared to satisfy the Regulation that implies to collect a greater amount of information, such as the country of rearing. In general, firms with a lower level of traceability perceive all aspects investigated (benefits, costs, and difficulties of traceability implementation) as having a greater impact on their operations compared to Deep traceability group. Medium traceability group considers greater the benefits of traceability (especially those related to food safety management), and at the same time, they perceive greater difficulties and costs. Clearly, the major difference relates to the difficulties in implementing the EC regulation on food labelling. For Medium traceability group is a significant barrier while for Deep traceability group is not an obstacle to firms' operations. This difference may be due to the maturity of the traceability system, which determines a decrease of the positive or negative perceptions of the firms. These findings are in contrast with previous literature examining the relationship between traceability level and benefits. For example Stranieri et Al. (2015) find out that the higher the level of traceability the higher are the positive outcomes for firms' operations (Stranieri et al., 2015).

The investigation enriches the awareness on the impact of traceability in food supply chains, but it is challenged by some limitations due mainly to the scarcity of studies previously conducted. As stated before few scholars tried to synthetically express the level of traceability in a specific supply chain, thus is a new branch of research and findings cannot be properly compared with the previous findings. A critical aspect of the research is the limited number of firms interviewed. The limitation of the sample is mainly due to the unique configuration of the Italian poultry supply chain, characterised

by a limited number of firms that operates as Integrator. Even though in the poultry supply chain there is a consistent number of firms operating at different stages, the firms that effectively as the power to address choices in terms of traceability implementation are few. That is why with UNAITALIA has been taken the decision to interview the nine firms that control over 90% of poultry meat production. The main limitation that this choice has determined is the lower statistical significance of the survey findings. On the other hand, the eight responding firms represent over 65% of the Italian poultry meat market. To overcome this limitation the analysis has been conducted with the aid of non-parametric statistical test (Mann-Whitney U Test and Correlation analysis with Spearman's Rho coefficient). Another constraint of the research is that empirically traceability impact was not previously studied in poultry supply chain.

Findings of the thesis enrich the insights on traceability impact on firms. The first part of the work outlines an overview on the meaning and main theoretical implications of traceability, supporting a structured overview of definitions and key concepts. Then, it organises previous scholars findings on the consequences of traceability in terms of costs, benefits, and difficulties. On the practical side, the research tries to give a contribution to a better definition of traceability level assessment, enriching the concepts of Breadth, Depth, and Precision with two new elements: Access and Technology. On this baseline, this theoretical contribution is tested with the case study of the Italian poultry meat supply chain. Therefore, the research contributes reducing the existing gap in the literature regarding the measure of the traceability level in food a supply chain. Once measured traceability level it is useful to compare it with associated costs and benefits of its implementation, in order to figure out if which is the level of traceability that optimises the balance between costs and benefits. From the survey has been possible to figure out the level of traceability effectively implemented in the supply chain and to confront it with firms' perception of traceability. While to a greater level of traceability correspond a higher capacity to efficiently respond to stricter regulation requirements, it is not confirmed in terms of perceived benefits. Even if costs and difficulties are lower, to a higher level of traceability do not correspond necessarily higher benefits. This finding points out that is not automatic that implementing a detailed level of traceability leads to the most significant positive outcome for firms in terms of economic performances. In fact, firms have to consider many aspects such as the trend for regulatory requirements, and supply chain partners and consumers demand of additional information. The poultry industry investigated represents a valid model of coordination among supply chain partners that, through a third supervisor party (UNAITALIA), allowed to reach a deep level of traceability. This supported them in order to enforce food safety, coordination,

and respond to rising requirements from regulators and consumers. This model of operation might be a good case for other food supply chains that wish to strengthen their traceability system.

Understand which level of traceability to implement in specific food supply chains would be a relevant continuance of this research. Setting the optimum level of traceability that maximises positive outcome for firms need further analysis especially with respect to market and consumers' behaviour. Strengthen traceability is an investment and is crucial to figure out if consumers will recognise this effort in terms of willingness to pay a premium price for an increased information available in their purchasing behaviour. Moreover, it might be useful for firms figure out if and how consumers recognise their efforts to communicate additional information on products.

Another aspect to be further investigated is a punctual analysis of cost related to improved traceability system. In particular, each cost related to traceability aspects (Breadth, Depth, Precision, Access, and Technology) might be further investigated in order to give firms specific references on investments necessary to improve their traceability system.

Finally, researchers should reinforce investigations on the relationship between sustainability and traceability. From the survey firms declared not to use traceability as a mean to measure and control sustainability of their operations. But, in the last years, the number of traceability scheme aimed at sustainability have consistently grown. Traceability is a useful tool for firms that wish to enhance sustainability (Beamon, 2008; Bosona and Gebresenbet, 2013; Normansyah, 2011; Smith, 2007). Tracking and tracing are indispensable in proving more sustainable products. Traceability could reinforce transparency and so the capability to communicate both with supply chain partners and consumers especially on food origin, production and processing methods (Beske et al., 2014; Fritz and Schiefer, 2009; Parmigiani et al., 2011).

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Appendix I. Questionnaire

Departement of business studies

Università Roma Tre

Survey on traceability in the Italian poultry sector

The Department of Business Studies and Research Laboratory "Quality, innovation and sustainability" of Roma Tre University in collaboration with UNAITALIA is conducting a study on the implementation of traceability systems in the food industry. The working group at the university is coordinated by Professor Maria Claudia Lucchetti.
The main purpose is to analyse the impact of the practices of traceability on Italian companies in the poultry sector. In summary, the survey aims to identify the level of traceability in the supply chain, analysing perceived benefits by firms and the main problems in the implementation of traceability systems. The survey is addressed to firms operating at slaughter stage of poultry meat production that implement one of the voluntary labelling approved by the Italian Ministry of Agriculture.
As part of the survey we send a questionnaire by mail to the organizations surveyed. The success of the study depends on your participation and we sincerely hope that you can find the time to compile it.

Basic information to answer the questionnaire:
- Please answer all questions. A general answer is better than not giving any response.
- Given the complexity of the supply chain, the questions concerning the traceability refer mainly to the phase of the slaughter.
- You 'can answer the questionnaire online by clicking on the link in the email received or filling out this questionnaire in Word format (to be sent once filled at michele.preziosi@uniroma3.it).

All information will be treated according to the ethical procedures of the University Roma Tre. All questionnaire responses will remain confidential at the study group of the University of Roma Tre.

For further information and questions please contact:
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Questionnaire
Section I: Firm' characteristics

1. Regions in which operates the firm

- Abruzzo ☐
- Basilicata ☐
- Calabria ☐
- Campania ☐
- Emilia Romagna ☐
- Friuli Venezia Giulia ☐
- Lazio ☐
- Liguria ☐
- Lombardia ☐
- Marche ☐
- Molise ☐
- Piemonte ☐
- Puglia ☐
- Sardegna ☐
- Sicilia ☐
- Toscana ☐
- Trentino Alto Adige ☐
- Umbria ☐
- Valle d'Aosta ☐
- Veneto ☐

2. Supply chain stages covered by the firm

- Feed production ☐
- Breeding multiplication ☐
- Hatchery ☐
- Rearing ☐
- Slaughterhouse ☐
- Cutting ☐
- Transformation ☐
- Packaging ☐
- Distribution (wholesales) ☐

– Other

☐

3. Number of employees in 2014

a. From 1 to 9 ☐ b. From 10 to 49 ☐ c. From 50 to 249 ☐ d. Over 249 ☐

4. Turnover in 2014

a. Less than €2 million ☐ b. Less than €10 million ☐ c. Less than €43 million ☐ Over than €43 million ☐

5. Number of slathering plants

☐

6. Weekly number of slaughtered animals

a. Less than 50.000 ☐ b. Between 50.000 and 150.00 ☐ c. Over 150.000 ☐

7. Species of animal processed

a. Chicken ☐
b. Turkey ☐
c. Guinea hen ☐

8 Type of customers supplied

a. Processing industry ☐
b. National / International Retail chain ☐
c. Local retail chain ☐
d. Other food retailers ☐
e. Restaurants chains ☐
f. Catering e restaurants ☐
g. Wholesaler ☐
h. Final consumers ☐
i. Public institutions ☐
j. Other

☐

9 Modality of provision from rearing farms

	No	1-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%
Property rearing farms	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Agistment contract	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Free market	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

10 Other certifications

a. ISO 9001:2008 ☐

b. ISO 22000:2005 ☐

c. HACCP ☐

d. ISO 14001:2004 ☐

e. ISO 22005:2007 ☐

f. Organic (Reg. (CE) n. 834/2007) ☐

g. Other

☐

11 Percentage of meat with voluntary labels

	No	1-10 %	11-20 %	21-30 %	31-40 %	41-50 %	51-60 %	61-70 %	71-80 %	81-90 %	91-100 %
IT 001 EA - UNAITALIA	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
IT 003 EA	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
IT 004 EA	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
IT 005 EA	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
IT 006 EA	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Section II: Level of traceability

Please answer considering that the object of this section are slaughterhouses.

12 Information tracked for each batch in input and output

Tracked information	Input	Output
Details of supplier	☐	☐
Date and time of batches arrival	☐	☐
Batch quantity	☐	☐
Chicks origin country	☐	☐
Rearing country	☐	☐
Slaughter country	☐	☐
Cutting country	☐	☐
Type of feed	☐	☐
Type of rearing	☐	☐
Breed or genetic type	☐	☐
Minimum age for slaughter	☐	☐
Fettering period	☐	☐
Date of slaughter	☐	☐
Animal welfare	☐	☐
Environmental sustainability of production process	☐	☐
Other ☐	☐	☐

13 The traceability system is able to trace inputs behind direct suppliers?

a. Yes ☐ b. No ☐

14 The traceability system is able to trace outputs behind direct customers?

a. Yes ☐ b. No ☐

15 **The traceability system is able to identify single batches of animal from each supplier?**

a. Yes ☐ b. No ☐

16 It is in use an informatics system to communicate in real time any problem that may compromise food safety?

a. Yes, to competent authorities ☐

b. Yes, to supply chain partners ☐

c. Yes, to competent authorities and supply chain partners ☐

d. No ☐

17 It is in use a traceability system shared with supply chain partners?

a. Yes ☐ b. No ☐

18 How are collected traceability data?

a. Paper-based ☐
b. Bar codes ☐
c. Specific software ☐
d. Radio Frequency Identification (R-Fid) ☐

19 Which has been the impact of the new European Regulation. 1169/2011 in terms of reorganization of the traceability system?

a. Very important ☐
b. Important ☐
c. Moderately important ☐
d. Of little importance ☐
e. Unimportant ☐

Section III: Benefits and barriers in the implementation of the traceability system

20 Which is the impact of traceability system on each listed aspect?

	Very positive	Positive	Neither positive or negative	Negative	Very negative
Reduced numbers of withdrawals and / or recalls	☐	☐	☐	☐	☐
Reduced withdrawals and / or recalls scope	☐	☐	☐	☐	☐
Enhanced speed of withdrawals and / or recalls	☐	☐	☐	☐	☐
Enhanced management of withdrawals and / or recalls	☐	☐	☐	☐	☐
Enhanced ability to satisfy regulatory requirements	☐	☐	☐	☐	☐
Reduction of costs in case of withdrawals and / or recalls	☐	☐	☐	☐	☐
Reduction of inventory costs	☐	☐	☐	☐	☐
Reduction of production costs	☐	☐	☐	☐	☐
Reduction of waste	☐	☐	☐	☐	☐
Reduction of product supply costs	☐	☐	☐	☐	☐
Enhances internal management	☐	☐	☐	☐	☐
Reduction of errors in data management	☐	☐	☐	☐	☐
Enhanced employees motivations	☐	☐	☐	☐	☐
Enhanced communication and coordination with supply chain partners	☐	☐	☐	☐	☐
Enhanced relationship with public authorities	☐	☐	☐	☐	☐
Enhanced relationship with consumers	☐	☐	☐	☐	☐
Increased product selling price	☐	☐	☐	☐	☐
Access to new markets	☐	☐	☐	☐	☐
Increased market share	☐	☐	☐	☐	☐
Enhanced costumers satisfaction	☐	☐	☐	☐	☐
Enhanced firm image and reputation	☐	☐	☐	☐	☐

21 How important are the following problems in the implementation and maintenance of the traceability system?

	Very important	Important	Moderately important	Of little importance	Unimportant
Employees training	☐	☐	☐	☐	☐
Employees motivation	☐	☐	☐	☐	☐
Flexibility in production processes	☐	☐	☐	☐	☐
New products implementation	☐	☐	☐	☐	☐
Employees time dedicated to traceability	☐	☐	☐	☐	☐
Managers time dedicated to traceability	☐	☐	☐	☐	☐
Availability of competent consultants	☐	☐	☐	☐	☐
Suppliers support and cooperation	☐	☐	☐	☐	☐
Clients support and cooperation	☐	☐	☐	☐	☐
Number of product / production features to register	☐	☐	☐	☐	☐
Availability of a suitable software	☐	☐	☐	☐	☐

22 How important are the following costs in the implementation and maintenance of the traceability system?

	Very important	Important	Moderately important	Of little importance	Unimportant
Staff time dedicated to traceability	☐	☐	☐	☐	☐
Equipment upgrade	☐	☐	☐	☐	☐
Software upgrade	☐	☐	☐	☐	☐
Laboratory testing	☐	☐	☐	☐	☐
Control and monitoring of supplies	☐	☐	☐	☐	☐
Training courses	☐	☐	☐	☐	☐
External consultants	☐	☐	☐	☐	☐
Inspections and audits	☐	☐	☐	☐	☐

23 In which percentage the cost of traceability affects the cost of plants' management?

1-2%	3-5%	5-10%	10-15%	15-20%	20-30%	30-40%	Over 40%
☐	☐	☐	☐	☐	☐	☐	☐

24 Overall benefits of traceability exceed its costs of implementation?

Yes ☐ No ☐

Many thanks for your valuable contribution to this study. Please send the completed questionnaire to the following address: michele.preziosi@uniroma3.it