613688 - Ensuring the Integrity of the European food chain

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Report on analysis of historical cases of food fraud

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1. INTRODUCTION

The objective of the Work Package 8 (WP8) is to develop and implement, in a user-friendly tool, a framework to enable assessment of probability of fraud in food chains (Food Fraud eARly wArning systEM: FRAME Fraud). The framework is expected to allow the early identification of food supply chains and products most vulnerable to food fraud, so that EU regulators and food industry can develop and implement targeted intervention strategies to prevent fraud. This deliverable report summarises the findings of review of the literature on food fraud, supply chains and drivers of food fraud in relation to three historic case studies of meat, milk and organic food sectors. The review is intended to inform the future WP8 work, in particular the design of expert elicitations with regulatory, industry, consumer and other stakeholders.

1.1 Background – context

New and challenging risks have emerged as food supply chains have become increasingly global and complex. Global food supply chains have changed from shorter, independent transfers to more unified relationships between producers, manufacturers, processors and retailers across countries and continents. Whilst in the past, the food systems of different countries were only weakly connected, today they are linked at all levels, from the trade in raw materials through to processed products (Foresight. The Future of Food and Farming, 2011). This globalised food system provides the consumer with access to a great variety of foods to choose from, all year round, at relatively low prices. The complexity of the supply chain has, however, increased health risks and opportunities for food fraud.

Food fraud activities conducted for economic gain has come to the attention of the UK government, industry and consumers (HM Government 2013a; HM Government 2013b). Food fraud is a collective term used to encompass deliberate and intentional substitution, addition, or misrepresentation of food, food ingredient or packaging; or misleading claims about a product, for economic gain (Spink and Moyer, 2013). The purpose of these fraudulent activities is therefore either to increase the apparent value of the product by intentionally misleading buyers or reduce production costs by using cheaper substitutes or even non-food grade ingredients, to undercut competitors (Moore et al., 2012).
The Grocery Manufacturers Association (GMA) provides the following definitions of “economic adulteration” as part of its report on consumer product fraud in the food, beverage, and consumer product industry: “Economic adulteration is defined as the intentional fraudulent modification of a finished product or ingredient for economic gain through the following methods: unapproved enhancements, dilution with a lesser-value ingredient, concealment of damage or contamination, mislabelling of a product or ingredient, substitution of a lesser-value ingredient or failing to disclose required product information” (GMA, 2010).

These definitions broadly reference three types of fraud, as defined by Moore et al. (2012), namely: replacement, addition, removal. A description of food fraud including the specific types of fraud included in each category is shown in Table 1 below.

**Table 1: Food fraud types, definitions and examples (adapted from Moore et al., 2012).**

<table>
<thead>
<tr>
<th>Type of fraud</th>
<th>Definition</th>
<th>Subtypes included</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement</td>
<td>Complete or partial replacement of a food ingredient or valuable authentic constituent with a less expensive substitute, usually achieved through the addition, dilution, or extension of an authentic ingredient with an adulterant or mixture of adulterants.</td>
<td>- A dilution, or extension of an authentic ingredient with an adulterant or mixture of adulterants. -False declaration of geographic, species, botanical, or varietal origin. -False declaration of the raw material origin or production process used to manufacture an ingredient. -False declaration of origin to evade taxes or tariffs.</td>
<td>-Addition of melamine to milk to artificially increase apparent protein contents measured by total nitrogen methods. -Addition of water and citric acid to lemon juice to fraudulently increase the treatable acidity of the final juice product. - Over treating frozen fish with extra water (ice). -Substitution of cow’s milk for sheep or goat’s milk. -Substitution of common wheat for durum wheat. -Substitution of Greek olive oil for Italian olive oil. -Substitution of synthetically produced vanillin for botanically derived (natural) vanillin. -Import into the United States from Vietnam of catfish labelled as grouper to avoid antidumping duties or transhipment of Chinese shrimp through Indonesia to avoid antidumping duties</td>
</tr>
<tr>
<td>Addition</td>
<td>Addition of small amounts of a non-authentic substance to mask inferior quality ingredient (or excess packing ingredients, including water and ice).</td>
<td>-Colour enhancement. -Taste enhancement.</td>
<td>-Addition of Sudan Red dyes to enhance to the color of poor-quality paprika. - Addition of sugar to mask the astringent taste of poor-quality pomegranate juice</td>
</tr>
</tbody>
</table>
The implications of these practices are that the consumers (and buyers in general) are likely to purchase poor quality and/or unsafe products as they cannot ascertain many of the quality and safety attributes before purchase or consumption (Hoffmann and Taylor, 2005; Unnevehr et al. 2010). In the literature, three classes of food quality attributes have been identified: search, experience and credence (Golan et al. 2005; Henson and Traill, 1993; Henson, 2006). Nelson (1970) classifies tradable products as “search” and “experience” goods. For “search” attributes, the consumer can observe the existence or otherwise of quality prior to purchase. In contrast, consumers cannot observe the quality of a product with “experience” attributes until after they have purchased it. Darby and Karni (1973) introduce a third term “credence” for products that consumers cannot observe the quality of a product even after its consumption and therefore have to rely solely on other information such as (a) brand reputation, and (b) the general performance of the food (control) system, for example food that is fairly produced is considered safer.

As such, the producers and sellers usually have far greater information and knowledge of the quality attributes of a product than the consumers and may opportunistically take advantage of this asymmetric information and knowledge gap to defraud consumers. The inability of the consumers to identify and buy products that meet their expectation not only creates incentives for sellers to misrepresent the true quality of products but also lowers buyers’ willingness to pay for high quality, ultimately leading to collapse for markets for these high quality products (Caswell and Andres, 2011). Therefore, in this instance the market mechanism may fail to guarantee the supply of high quality and safe food – an issue which justifies a government role in ensuring the supply of safe, authentic and high quality foods.

However, market failure alone does not necessarily justify government intervention nor does such intervention necessarily improve upon the markets, (Antle, 1999; Caswell 2005; Unnevehr and Jensen 2005). It is widely recognised that the market failure in food sectors is often incomplete as there are always intrinsic incentives for food companies to ensure product quality and safety even in the absence of government controls (Unnevehr and Jensen...
Indeed, certain companies may have sufficient incentives to secure quality and safety, including desire to protect their reputation and that of their brand name, building market share, meeting buyer requirements and protecting themselves from legal liability for unsafe food products (Caswell, 2005). The government therefore needs to strike a balance between costs and benefits in choosing an intervention, so that, for example, enforcement effort is targeted at areas of highest risk, where there are weak industry incentives for compliance. In particular, a greater understanding of working of globalised food supply chains and associated risks and vulnerabilities are necessary (HM Government 2013a; HM Government 2013b). This requires examining drivers of demand for food products, supply chain structures and dynamics, and regulatory and industry governance systems so that the development of more effective future policy options can be informed appropriately.

Last but not least, fraudulent activities could be performed by individual fraudsters, a small group of criminals, or be part of organised crime. This study examines the economic motives and health implications of fraudulent behaviour. Therefore the criminal aspects of the food fraud are outside the scope of FoodINTEGRITY. Wide food protection issues such as terrorist acts¹, which are covered by food defense analysis, also fall outside the scope of this study.

1.2. Overview of past fraud incidents and useful information for developing an early warning system for food fraud

Three past food adulteration incidents were evaluated in terms of potential useful information they may carry for the development of an early warning system for food fraud in WP8 in FoodINTEGRITY. The cases chosen concern (a) two incidents related to the same contaminant, occurring at very close dates, i.e. 2007 and 2008, and indicting human health and animal health issues (i.e. case 1.2.1.), (b) a recent food fraud incident in which the majority of implicated food products concerned high volume sales-low price diverse items (i.e. case 1.2.2.), and (c) an incident that implicated low volume sales – high price and diverse range of food products (i.e. case 1.2.3.).

The choice of these types of incidents aimed to cover a number of features common across the potential fraud cases. The common features include food safety, breadth of distribution of adulterated material or food, different targets in the consumer sector, responses to new regulations, social perception, etc., with the view to highlighting the measurable and observable quantities, and how they are related to each other, which can help for gaining insight in identifying in advance food fraud incidents.

1.2.1. Melamine - 2007 pet food recalls and 2008 Chinese milk scandal

In 2008 a food adulteration incident occurred concerning the contamination of powdered infant milk (produced in China) with melamine. The incident gained global attention as number of studies evaluating the timeline were carried out and the reported findings were widely reported, brief overview in IRGC, 2010; timeline of events in BBC, 2010; evaluation of details in Gosner et al., 2009. Two facts in connection with the 2008 Chinese milk scandal are central and therefore future work in WP8 in FoodINTEGRITY:

(a) It followed a previous incident in 2007 concerning the adulteration of products requiring high protein content with melamine, albeit in products primarily destined for animal feed (WHO, 2008; Flari et al., 2009; Crossley 2010). The speed which the melamine incident evolved highlights the necessity to draw information on potential triggers for food fraud from the feed sector as well as other associated food chains and sectors e.g. feed, food and packaging.

A specific emphasis should be given to the fact that this fraud was only noticed because of large number of reported deaths of pets (i.e. in USA). These incidents were linked to a specific pet feed that included a raw material from China followed by a border rejection by US (= signal). Therefore, signals (of a food fraud incident) could be linked to chronic, non-lethal adverse effects (and thus more difficult to be attributed to particular food items), and triggers of such effects could be found further away from the backbone of the food supply chain.

(b) The Chinese milk scandal was a “commodity focused” adulteration, i.e. milk, whereas the pet melamine incident concerned the adulteration of a raw material (i.e. feed) that would be introduced into a number of potential feed and food products, either directly or indirectly (see Figure 1 below). This difference implies the necessity to include a
dimension of “number of discrete consumer products affected” in any of the multi
criteria decision analysis models we will build in WP8.

(c) Both (a) and (b), cited above, imply the necessity to accommodate for dimension of
“temporal considerations” for the FRAME Fraud framework we will develop in WP8.
Although it seems obvious that such temporal considerations could be translated into
“number of days following the first signal indicating a potential fraud event”, one
would need to develop credible ways to identify the “first signal” and link it with
potential fraud scenarios as early as possible.

In this review we relate one supply chain with the melamine adulteration incidents, and in
particular the milk supply chain in the EU, as the latter concerns variable products that carry
similarities with the “victim products” or “victim supply chains” of the melamine adulteration
incidents, for example powdered milk and variable consumer products containing powdered
milk.

1.2.2. Horsemeat - 2013 meat adulteration scandal

The 2013 horsemeat scandal was initiated (in terms of regulatory control) on January 2013
when the Food Standards Agency of Ireland published the findings of a targeted study
examining the authenticity, or labelling accuracy, of a number of burger products that
revealed that some allegedly beef products contained horse and pig DNA. Although food
safety issues with this adulteration were considered as negligible, the incident implicated a
number of countries, including Cyprus, France, the Netherlands, Romania, United Kingdom
(BBC, 2013; The Guardian, 2013), and had wide variable effects on a number of sectors, i.e.
meat producers, distribution companies, manufacturers, retail, regulatory agencies, and senior
management at European Union level, apart from the consumers (BBC, 2013; The Guardian,
2013; Figure 2).

The extent of the incident’s effects is implied by the degree and depth of responses in the
European Union (EU). A number of issues and possible actions to address them were drafted,

\[\text{In the 2008 Melamine in milk incident, melamine contamination has been found in a number of different brands of powdered infant formula, in one brand of a frozen yogurt dessert and in one brand of canned coffee drinks. All these products were most probably manufactured using ingredients made from melamine-contaminated milk (WHO Questions and Answers to Melamine: http://www.who.int/csr/media/faq/QAmelamine/en/ Accessed 25 06 2014).}\]

and have been closely monitored\(^4\). A year later since the first evidence of the scandal surfaced the European Commission (EC) requested Member States run new rounds of tests of certain products that were affected by this food fraud event, mainly to re-assure the consumers. A European network of the competent authorities in Member States has been set up coordinated by DG SANCO. \(\text{http://ec.europa.eu/food/food/horsem eat/}\). Six months after the scandal first surfaced, the main retailer implicated in this scandal reported “small but discernible” impact on sales of certain products\(^5\); a year after the first evidence of this scandal surfaced BBC (2014) reports that “an Ipsos Mori poll run in partnership with the Grocer magazine shows that almost a third of respondents said the incident had "permanently impacted" the way they chose and bought food”. An interim report on the integrity and assurance of food supply networks was published in December 2013 highlighting the need for particular industry responses to food fraud incidents, \textit{i.e.} need for better labelling and traceability information in particular about product origin and its processing; need for better education, transparency and information for consumers, and need for improvement of enforcement with more checks and dissuasive penalties (HM Government, 2013a; HM Government 2013b). Gaps in traceability can in particularly exploited by fraudsters where analytical techniques used to detect the presence of adulterants rely on the adulterant or means of substitution being known (Manning and Soon 2014). Therefore, it is possible to adulterate food in a country where regulatory and market controls are limited and cause major human health consequences and economic disruption in another where on the surface such controls appear stringent.

The 2013 horse meat scandal is unique in terms of:

- The high diversity of products, ranging from ready-made hamburgers to more upgrade ready-made full meals, \textit{e.g.} lasagne, and a wide range of retailers and jurisdictions affected\(^6\) (Figure 3).
- Claims that the horse meat scandal was triggered by a change in meat regulation, in particular the moratorium of desinewed meat in processed meat products\(^7, 8\).

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\(^4\) What has the EU done so far to address the horsemeat scandal? [Online] Available at: \text{http://ec.europa.eu/food/food/horsem eat/timeline_en.htm} Accessed 25 06 2014


• There is a direct link between two, supposedly separated, food supply chains, *i.e.* processed meat chain and horsemeat trade chain (for updated information for horse meat trade see McCormick *et al.*, 2013)

1.2.3. Organic food - *“Puss in boots”* 2011 case study

The organic food scandal *“Puss in boots”* is the biggest known fraud case with organic products[^7]. It was discovered in 2011 by the Italian Tax Investigation Authority. The extent of the fraud goods was estimated at 703,000 tons from 2007 until 2011. Mostly feed was affected, particularly soy, wheat, corn and other cereals[^10]. The estimated financial damage was around €220 million. Many companies in different European Union Member States, mainly Austria, Belgium, France, Hungary, the Netherlands, Spain and Switzerland, were affected by the fraud.

In addition to organic operators employees of organic certification bodies were involved in the fraud. Several methods to commit fraud were used[^11],[^12]:

- Counterfeiting of certificates.
- Counterfeiting of documents regarding the certification process *e.g.* production plan, land title deed, land lease agreement.
- Counterfeiting of trade documents, *e.g.* delivery contracts, delivery notes, or invoices.
- Establishing limited existing firms

In this case, the employees of organic certification bodies counterfeited certificates of organic farmers. On the certificates, crops were named which had not been grown by the farmers. Organic operators and certifications bodies could not identify the counterfeiting of


[^12]: Interview with Dr. J. Neuendorff, Resource Protection Ltd., GfRS and Member of Anti Fraud Initiative ([http://www.organic-integrity.org/afi/about-afi](http://www.organic-integrity.org/afi/about-afi))
certificates because they appeared to be authentic and valid. In addition the production plans of organic farmers were manipulated for misleadingly increasing the harvesting size of products. The fraudulent operators established “short term” companies. These companies were trading organic products only for a relatively short time. After closing the company or replacing it from the organic control system, it was no longer possible for the certification bodies to reconstruct the trade flow of goods along the whole supply chain.

Regardless of the complexity of the system, one wonders how this fraud could happen for such a long period.

Nevertheless, the organic food (and feed) sector is monitored better than other uncertified food sectors. Based on the EU-Regulation 834/2007, all companies which are producing, processing or trading organic food and feed must be certified by authorized certification bodies and/or competent authorities. However, following the “Puss in boots” incident it is acknowledged that several shortcomings still exist, which if stayed uncorrected may let happen fraud, including:

- Inadequate access to real-time online certificates as required by EU regulation 426/2011; in some countries online certificate databases do not exist or do not include all information required by this regulation.

- Insufficient information about the exchanges between all responsible certification bodies for a product for cross-checks.

- Insufficient information exchange between the responsible certification bodies when companies are switching the certification body.

- Insufficient transfer of relevant information about frauds amongst the competent authorities and from the competent authorities to the certification bodies.

- Lack of access to relevant information from companies which decide to leave the organic control system.

- Lack of reliable objective methods of analyses to very many of the specifications that comprise “organic”.

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2. ANALYTICAL APPROACH

2.1. Description – supply chain approach

2.1.1. Aim and objectives

The aim of this analysis is to identify potential triggers\(^{13}\) of food fraud events with the view to informing ensuing steps of FoodINTEGRITY research in WP8, in particular (a) the development of potential food fraud scenarios in the future, and (b) the elicitation of probability of occurrence of such food fraud scenarios.

In order to address the above aim we followed a step-wise process; each step represents an individual objective in our study. First, we reviewed a number of food fraud incidents in terms of the complexity in the structure and the dependence of the respective food supply chains on external national and international factors. Subsequently, we analysed potential vulnerable points in each food supply chain, in terms of potential impact on consumers, retailers and regulators. Thirdly, we have considered the effect that responses by different stakeholders may have on each food fraud incident. Finally, we discussed the ways the outputs of this review will feed into subsequent steps of our research in WP8, and present anticipated results. The structure of this review is shown diagrammatically in Figure 4.

2.1.2. Supply chain definition – main challenges for FoodINTEGRITY to address

Our study concerns a number of food supply chains, in particular (a) dairy supply chain, (b) processed meat supply chain, and (c) organic food supply chain; these reflect the historical case studies cited and evaluated above.

BusinessDirectory.com defines supply chain as “Entire network of entities, directly or indirectly interlinked and interdependent in serving the same consumer or customer. It comprises of vendors that supply raw material, producers who convert the material into products, warehouses that store, distribution centers that deliver to the retailers, and retailers who bring the product to the ultimate user. Supply chains underlie value-chains because, without them, no producer has the ability to give customers what they want, when and where they want, at the price they want. Producers compete with each other only through

\(^{13}\) Includes potential causes, prompts.
their supply chains, and no degree of improvement at the producer's end can make up for the deficiencies in a supply chain which reduce the producer's ability to compete”\(^{14}\).

In our context, a supply chain is defined as “the sequence of a number of steps to facilitate the movement of either raw materials and/or processed food items from their source/s or manufacturing locations to the consumer”. As such, a supply chain could include a number of procedures, for example: sourcing materials, purchasing materials or processed items, manufacturing, warehousing, transportation, distribution, customer service, demand planning, supply planning, management, etc. In particular because of the current complex nature of global trade food supply chains often spread their activities across a number of countries, if not continents, and as a result they become dependent on, and respond to, an increasing number of national and international factors\(^{15}\).

Modern food supply chains are very complex, with many parallel physical and information flows occurring in order to ensure that products are delivered in the right quantities, to the right place in a cost effective manner. Currently, the European food industry consists of network of a large number of companies dedicated to manufacturing, processing and transformation of raw material and semi-processed products from primary production sectors such as crop production, livestock, forestry and fishing (Manzini and Accorsi, 2013). In order to gain cost advantage and market share, many food firms have taken strategic initiatives such as outsourcing of manufacturing operation in countries with low cost of production and product differentiation. However, whilst these initiatives are effective in stable environments, they can make a supply chain more vulnerable to various types of disruptions caused by uncertain economy cycles, consumer demands and natural and man-made adversities (Figure 5; Tang, 2006). In particular, as the number of supply chain partners increases across national boundaries and jurisprudences, these global supply chains can become longer and more complex, and a result be difficult manage risks and therefore vulnerable to food fraud (Tang and Tomlin, 2008; Spink and Moyer, 2013). These developments accentuate the degree of interdependence among different levels of the supply chain and create opportunities for food fraud.


\(^{15}\) Our study assumes one or more of the following: \(a\) production of raw materials or processed products anywhere in the world and imported for use or human consumption in the EU; \(b\) production of raw materials or processed products in the EU either consumed within EU or exported to countries outside EU; \(c\) “food laundering”, i.e. production and marketing in a particular EU MS for consumption in a country outside EU (where regulations allow it) and re-importation of the product (either raw or in a processed form) for consumption in the particular EU MS.
Product supply chains usually conform to one of a number possible generic supply chain models. Supply Chain Quarterly (2013\textsuperscript{16}) discussed six types of generic supply chains, grouped into two categories: one encompassing models that are oriented to efficiency, \textit{i.e.} "efficient," "fast," and "continuous-flow" supply chains, and one encompassing models oriented to responsiveness, \textit{i.e.} "agile," "custom-configured," and "flexible" supply chains. These types of supply chain models and their characteristics are described in detail in one of the published figures of Supply Chain Quarterly (2013)\textsuperscript{17}.

Different types of supply chains are linked with different industries, mainly because of the differences in orientation of each industry. Some industries are mainly orientated to address customer demand, e.g. packaging, whereas other industries are oriented towards low cost and high relevance of asset utilization to total cost, e.g. commodities. Supply chains may be parts of supply networks, and the degree of overlap amongst the various supply chains could differ.

Food supply chains can comprise four major segments: (a) agricultural input supply, (b) agricultural production, (c) food manufacturing, and (d) the food wholesale and retail sectors which is responsible for the distribution of end products to consumers (Jasnik \textit{et al.}, 2014).

Predictably, a number of challenges are related to the complexity of food supply chains in the EU. To account for these complexities as best as possible, the FoodINTEGRITY project will:

- Attempt to build a better understanding of relationships between an individual food supply chains, within one chain, and the influences of global trade on those relationships.
- Identify the degree of flexibility of individual food supply chains in terms of sustainability, and predict the most likely “\textit{break points}” in the future.
- Develop validated, meaningful and feasible safe nets for probable break points for each food supply chain.

An important angle to introduce in the work of WP8 in FoodINTEGRITY would be to take into consideration future trends of food supply chains when drawing the context for expert interviews and expert workshops to acquire information, and for the development


\textsuperscript{17} http://www.supplychainquarterly.com/figures/?filename=20130306supply_chain_strategies_ex3.jpg&article=20130306-supply-chain-strategies-which-one-hits-the-mark Accessed 17 07 2014
of any predictive models. For example, supply chain segmentation and customisation\textsuperscript{18}, increased level of sharing knowledge of multi-partner information amongst key stakeholders and collaborative transport from collaborative warehouses to city hubs and to regional consolidation centres\textsuperscript{19}. Additionally, any future changes of the food supply chains would need to be seen via anticipated innovations in the world, for example indoor crops, digital connection of all information\textsuperscript{20}.

2.1.3. Conceptual models to represent food supply chains of case studies

Conceptual models\textsuperscript{21} of supply chains are a valuable and effective tool to represent a system closely with the view to sharing and exchanging information, identifying potential risks, testing intervention approaches, indicating uncertainties, etc. Depending on the particular needs and requirements one needs to decide the detail of such conceptual models. Ideally, a conceptual model would offer a comprehensive footprint to facilitate the mathematical modelling of either parts of the system or the whole system it represents. An example of a high level conceptual model that could represent several food supply chains is shown in Figure 6.

The type of information, \textit{i.e.} steps in a process, inter-relationships, factors influencing different steps or outcomes, signified in a conceptual model depends on its aim/objectives, e.g. in a causal loop diagram (CLD) one would expect to include factors influencing one or more steps in a conceptual model as well as direction of inter-relationships between factors and steps; an example is shown in Figure 7.

As the purpose of this review is to identify potential “break points” in a number of food supply chains it is understood that any conceptual models (or parts of conceptual models) chosen will serve as an initial template for further in depth review and appraisal that will take place in specialised stakeholder workshops (to occur later on in the project). It is anticipated that the appraisal of the template conceptual models will provide crucial information on (a) separate “umbrella” modules of the conceptual models, e.g. providing potential factors / influences that could affect any step in the conceptual models, and (b) forthcoming pressures.

\textsuperscript{18} http://www.opsrules.com/supply-chain-optimization-blog/bid/322511/6-Reasons-to-Consider-Supply-Chain-Segmentation Accessed 17 07 2014
\textsuperscript{21} The term includes: Causal Loop Diagrams (CLDs); Flow charts or diagrams; Bayesian belief networks; Influence diagrams.
on the separate modules of the conceptual models and on the supply chain as a whole. Examples of the latter are discussed for the forthcoming EU milk quota abolition expected to be in place in 2015\textsuperscript{22}, and in particular the economic impacts of such change\textsuperscript{23}.

2.1.3.1. Milk supply chain-linked with: 2008 Chinese milk scandal

Following the 2008 Chinese milk scandal the European Union reported a synopsis of the structure, and challenges of the milk supply chain in the EU (EC, 2009). Milk and dairy product supply chains represent an important part of the agricultural turnover of the EU, with milk being the EU number one single product sector in terms of value at approximately 15\% of agricultural output\textsuperscript{24}. Its importance is enhanced by the key role the milk plays in terms of social dimension, in preserving the diversity of the European food heritage, as well as in shaping territories and the environment. The production and trade of milk in Europe is monitored closely, and up-dated trade information can be found in the EU Milk Market Observatory\textsuperscript{25}. As milk is one of the core products in the daily consumer basket they public opinion on any issues around it is very sensitive and needs to be taken into account in advance of forming and implementing policies.

The milk supply chain in the EU appears to comprise five (5) clearly segregated segments before reaching the consumer, in particular: agricultural inputs, milk production, dairy industry, food wholesale, and retail (Jansik et al., 2014). Although one may need to separate supply chains concerning unprocessed milk from these concerning processed milk (see Figure 8).

Conceptual models such the once cited above are “high-level”, and present a compressed view of the supply chain; one needs to take into consideration several other factors, for example: the fact that each module is rather an aegis for complex processes and inter-relationships within (an example is shown below for the milk production segment in Figure 9), the fact that each EU MS may have different differences in the market share of producers of milk (an example is shown for Republic of Ireland and Northern Ireland in Safefood report, 2008), etc.

\textsuperscript{22} \url{www.dailyreporter.com} Accessed 14 Mar 2014; \url{http://www.dairyreporter.com/Markets/Milk-quota-abolition-will-create-North-European-production-belt} Accessed 20 06 2014
\textsuperscript{23} \url{http://ec.europa.eu/agriculture/analysis/external/milkquota/ex_sum_en.pdf} Accessed 20 06 2014
\textsuperscript{24} \url{http://ec.europa.eu/agriculture/milk/index_en.htm} Accessed 20 06 2014
\textsuperscript{25} \url{http://ec.europa.eu/agriculture/milk-market-observatory/index_en.htm} Accessed 20 06 2014
Further, a number of extended inputs / outputs amongst the different segments of the milk supply chain as well as further external business sectors can exist; for example Meuwissen et al., 2009 describes the pathway of dairy cows in industries other than the dairy industry, e.g. meat industry (Figure 10).

2.1.3.2. Processed red meat supply chain-linked with: 2013 Horsemeat scandal

Following the horsemeat scandal in 2013, a heavy focus on processed meat supply chain in the EU (and most prominently in the UK) still prevails. Media reports indicate that, before the horsemeat scandal, consumer trust in supermarkets was at 69% and that in February 2013, approximately a month after this fraud incident was officially reported, consumer trust dropped to 35% and has never fully recovered, and has possibly affected consumers’ preferences.

The processed red meat supply chain is embedded in the beef supply chain; two potentially useful conceptual models have been produced by Thankappan and Flyn (2006) and Safefood (2008) (Figures 11 and 12, respectively).

Both models cited above describe the flow of initial raw material to consumer products, but the detail within each step needs to be added. For example, one, potentially crucial, detail missing from such conceptual models is the flow of waste from each step, particularly in view of information indicating large quantities of waste linked with different processing steps in the food supply chains.

2.1.3.3. Organic supply chain-linked with: 2011 “Puss in boots” scandal

The organic food and feed sector has grown rapidly during the past 20 Years. The trade flows of raw-materials and processed food and feed became more and more international. Many existing organic food processing and trading companies expanded and big conventional food processing and trading companies entered the market for organic food. Due to this market development, the supply chains for organic food and feed in some product sectors became more equal to the supply chains of conventional food. Thus, today a typical supply chain for organic food or feed does not longer exist.

2.1.4. Considerations of special products within each supply chain – based on details for case study 1.2.1 (i.e. milk supply chain).

The basic structure of the milk supply chain is quite similar for both standard milk and special milk products. This supply chain has 6 levels (see Figure 13): feed production, milk production, cooling and storage, processing, retail and the consumer. The main differences between these products are in the processing level which depends on the product (see Figures 15 and 16). All the milk supply chain actors can adulterate the milk, especially the producers. Due to high testing costs and a large number of producers, it becomes unfeasible for the station to test each producer individually. This creates an opportunity for producers to supply adulterated milk (Siddhaye, 2010).

The first step in the milk process is the production of milk on farms, i.e. the keeping of cows for the production of milk for human consumption (see Figure 14). The raw milk is collected using tankers. Once the milk tanker has completed its scheduled route, raw milk is transported either direct to the dairy or to a reload point for cooling and storage. Dairy processors procure raw milk from farmers, which they then process into liquid milk or other dairy products for industrial use. e.g. milk powder, or end-consumption, e.g. whole milk, skim milk, yogurt, butter, cream, cheese, flavoured dairy drinks, etc., and retailers, which ultimately sell milk and dairy finished products to consumers.

The main parameters controlled in this process flow are temperature and time of processing. Two critical control points (CCP) normally identified during the processing of milk are reception and the heat treatment step (pasteurization) used to reduce to microbial load.
In accordance with hazards analysis and critical control points HACCP principles, the efficacy of these steps has to be verified on a periodic basis, among else through laboratory analyses of appropriate samples. Details of some official controls are provided in Table 2 below.

Whole milk production needs many processes, which are resumed in the following (see Figure 16):

- Receipt and filtration of the raw milk.
- Pasteurisation.
- Homogenisation.
- Holding.
- Packaging and storage, including cold storage.

In addition to the production steps, official controls should be respected (Table 2).

In the case of the adulterated milk incident in China in 2008 (case study 1.2.1), it is hard to imagine how the adulterated milk could have passed all the quality inspections along their supply chains to reach the marketplace in such a massive scale (Chen et al., 2014). Specific controls for milk quality like fat content should have detected such fraud, but these tests were either not carried out properly or were ineffective (Pei et al., 2011). Rapid automated systems for testing the content of protein, fat and other ingredients were also not used properly, thus were ineffective for detecting fake protein (Pei et al., 2011).

Also in processing step milk may also be watered down and then supplemented with melamine to artificially raise the apparent protein content and hide dilution. In the China fraud incident, the general manager of Sanlu admitted that she knew the fact that her company added melamine to milk (Gao, 2008).
Table 2: HACCP and CCP controls in Milk Chain.

<table>
<thead>
<tr>
<th>Product</th>
<th>What?</th>
<th>When?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Raw milk</strong></td>
<td>CCP for raw milk</td>
<td>- immediately after production,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- before processing,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- following heat treatment</td>
</tr>
<tr>
<td>Microbial counts</td>
<td></td>
<td>- upon delivery,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- before processing</td>
</tr>
<tr>
<td>Somatic cell counts</td>
<td></td>
<td>- upon delivery</td>
</tr>
<tr>
<td><strong>Listeria</strong></td>
<td></td>
<td>- following heat treatment</td>
</tr>
<tr>
<td><strong>Milk powder</strong></td>
<td>CCP for milk powder</td>
<td>- immediately after production,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- end of production,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- expiration date</td>
</tr>
<tr>
<td><strong>Listeria</strong></td>
<td></td>
<td>- upon production</td>
</tr>
<tr>
<td><strong>Salmonella and mould</strong></td>
<td></td>
<td>- expiration date</td>
</tr>
<tr>
<td><strong>Staphylococcus</strong></td>
<td></td>
<td>- end of production</td>
</tr>
</tbody>
</table>

To produce the skim milk (see Figure 15), the following steps need to be added to the whole milk process:

- Separation.
- Addition of vitamins A, B and defoamer.

The organic milk is produced from cows reared on strictly controlled diet, and are kept healthy without the use of the medicinal products. Legally, organic milk is a quality mark indicating that the milk has been produced from a dairy herd that meets the EU standards.

All the organic milk supply chain must meet the organic EU standards. For example, in the farm level, an organic farming system avoids the application of artificial fertilisers and pesticides, and uses crop rotation and other forms of husbandry to maintain soil fertility and control weeds, pests and diseases. To produce organic milk the farm must be registered with an organic control body and the production system adopted must meet the organic standards specified. As mentioned in section 1.2.3. (i.e. Organic food - “Puss in boots”) the certification of all operators along the supply chain of organic food is legally required. However, organic milk is a premium price food item, thus much more expensive, because organic milk means that the costs are higher at every stage of the supply chain (Elliot, 2000). Some of the key aspects of organic milk production are resumed in the Table 3 below.
Therefore, fraud happens mostly through replacement of organic with non-organic food. This fraud is not harmful to health but deceives the consumer.


<table>
<thead>
<tr>
<th>Process step</th>
<th>Organic Standard requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeding</td>
<td>• All feedstuffs used on the farm must be produced and certified to organic standards.</td>
</tr>
<tr>
<td></td>
<td>• Maximum use should be made of grazing and ideally all of the feed required should be produced on the farm. At least 60 percent of the feed should be obtained from the farm or from linked organic farms.</td>
</tr>
<tr>
<td>Forage</td>
<td>• At least 60 percent of the diet should come from organic forage.</td>
</tr>
<tr>
<td></td>
<td>• Both the pasture grazed and the forage conserved for winter feed will normally be produced on the organic farm itself.</td>
</tr>
<tr>
<td>Concentrates</td>
<td>• Organic concentrates can be purchased.</td>
</tr>
<tr>
<td></td>
<td>• Compound rations and purchased blends must be 100 percent organic.</td>
</tr>
<tr>
<td></td>
<td>• Protein sources in particular may be difficult to produce on the farm and may have to be purchased.</td>
</tr>
<tr>
<td>Minerals and Vitamins</td>
<td>• Mineral supplementation is only permitted where trace element requirements cannot be met by the practices of organic husbandry.</td>
</tr>
<tr>
<td></td>
<td>• Some synthetic vitamins may be used, but subject to permission being granted by the control body.</td>
</tr>
<tr>
<td>Grassland</td>
<td>• Clover is required to sustain good levels of productivity.</td>
</tr>
<tr>
<td></td>
<td>• Red clover, sown with Italian or hybrid ryegrass, can be used to produce bulky silage crops. Molasses, bacterial inoculants and enzyme additives may be used as silage additives.</td>
</tr>
<tr>
<td></td>
<td>• Artificial fertilisers are not permitted but lime and some ‘natural’ sources of nutrients can be used.</td>
</tr>
<tr>
<td>Animal health and Housing</td>
<td>• Stock must be provided with a comfortable, dry bedded lying area and loose housing which is well bedded is preferred.</td>
</tr>
<tr>
<td></td>
<td>• Dairy cows should be allowed a minimum of 6m² per animal and for young stock space requirements range from 1 to 1.75m² per 100 KG live weight.</td>
</tr>
<tr>
<td></td>
<td>• Veterinary medicines and antibiotics must not be used as a preventative medicine.</td>
</tr>
<tr>
<td></td>
<td>• Vaccination is permitted, under derogation, in cases where there is a known disease risk.</td>
</tr>
</tbody>
</table>
2.2. Identification of vulnerable points, i.e. “break points” – to whom and why?

Inherent risks in a supply chain include systemic, operational risks due to status quo (at any time), and external risks due to natural disasters and/or other external factors. The term ‘systemic’ risk is widely used to indicate risk that a system fails to perform because of the ways in which its various components interact (Hennessy et al., 2003; Kleter and Marvin, 2009). In this regard, strong positive correlations among the risks of failure are a central feature of systemic risk (Hennessy et al., 2003).

The operational risks concern uncertainties like consumer demand, supply and cost, whilst disruptions refer to stochastic events such as earthquakes, unforeseen weather conditions or economic policy changes such as currency exchange valuations/devaluations which would lead to relative prices changes between importing and exporting countries. A good understanding of the source of failure is therefore necessary if the likelihood of a breakdown and the magnitude of the losses arising from any given breakdown are to be better understood and managed. Operational risks within the supply chain arise from interaction between constituent organisations across the supply chain due to mainly to sub-optimal interaction and co-ordination between the entities along the chain. Such supply chain risks could result from a lack of visibility, lack of “ownership”, self-imposed “chaos”, just-in-time practices and inaccurate forecasts (Cranfield University, 2002). To mitigate risks associated global supply chains, an effective chain-wide coordination and collaboration of activities among supply partners is necessary so as to ensure profitability and continuity, in terms of delivering safe and authentic products. This coordination and collaboration include activities related to supply and demand management, product management and information management (Tang 2006). At the centre of this coordinated supply chains are retailers who manage the upstream and downstream relationships with suppliers and customers in order to create enhanced value in the final market place at less cost to the supply chain as a whole (Willem et al., 1999).

To provide points of reference for further analysis in WP8, next sections discuss the nature and sources of systematic failure which may result in vulnerability to fraud in the EU food supply chains. These vulnerability points are discussed in terms of the different perspectives that consumers, industry and regulatory bodies may have.
2.2.1. Consumer perspective – expectation of food integrity in globalised chain

Consumers are usually the receivers of end products of supply chains. Main challenges and worries that consumers may experience when looking into a food supply chain would include:

- Price – “does the price ensure safety and quality”?
- Deceit concerns – “are the claims on the product true”?
- Ethical concerns – “is the product ethically produced”?
- Safety concerns – “is the product safe for my health”?
- Environment concerns – “is the product environmentally sustainable”?

Consumers require clear and accurate information to make informed choices about their diet and the foods they buy. The information given to consumers is therefore essential for them choosing one food product over another. Consumer choice might also reflect lifestyle or religious concerns (e.g. vegetarianism, preference for organic products, absence of pork for Jews and Muslims), or health concerns (e.g. absence of peanuts, lactose or gluten for individuals with particular allergies). Therefore, the description and/or labelling of food must be honest and accurate, particularly if the food has been processed removing the ability to distinguish one ingredient from another (Woolfe and Primrose, 2004). The information that must be given is enshrined in law in most developed countries, so that food supplied must be exactly what the labelling says it is. That is, the food must be authentic and not mis-described. However, recent reports of pervasive food fraud across countries have created doubts whether current labelling requirements are effective to prevent food fraud in increasingly globalised supply chain (Spink and Moyer, 2013; HM Government 2013a; Pei et al., 2011).

In absence of accurate labelling, uncertainties about quality and safety hamper consumers’ choice potentially have significant negative consequences for both industry and regulators. Substantial empirical evidence emerging from the literature on social risk regulation suggests that, under uncertainty, people’s reactions to risk frequently depart from the behaviour predicted by the expected utility theory, with serious implications for choice and more importantly demand for regulation of risk (Viscusi and Hamilton, 1999; Lichtenberg and Zilberman, 1988). In particular, food related incidents that are associated with increased consumer concerns can have economic consequences for the sectors affected and also
limiting their ability the regulatory authorities to develop effective consumer protection policies (Bruhn and Schutz, 1999). In the past, food related incidents have resulted in trade bans, price fluctuations, culling of animals, decreased consumption of affected products, and reputational damage of both the particular food sectors perceived to be responsible for such incidents and wider food industry in general (Verbeke et al., 2005).

Such economic losses due to heuristics’ response to risk may not be limited to the immediate time period following from an incident, but potentially have long-run effects and reach beyond local and domestic markets. De Jong et al. (2007) suggest that increasing public distrust and reduced consumer confidence in food safety may have adverse economic effects that go beyond a specific food industry to aggregate level, national and international economies. Such impact may have significant social costs as food industry is an integral part of the EU economy. In 2012, food industry had a turnover of €1,017 billion and accounted as the largest manufacturing sector in the EU (FOODDRINK Europe, 2013). It was relevant to 4.25 million people and exported food and drink products valued at €76.2 billion. In addition to the negative economic implications for the industry and regulatory institutions, such perceived risks might hamper consumer’s decision-making in terms of healthy eating choice (De Jong et al., 2007). For example, perceived risks associated with mislabelled fish might impose barriers to its consumption, whereas fish is considered an important component of the healthy diet due to high contents of omega fatty acids30 (Verbeke et al., 2005). In other cases, it may shift consumption toward products perceived to be safer. For example, food scares that resulted from BSE crises have reallocated consumer spending from beef to white meat and pork (Fousekis and Revell, 2004). The perceived safety of white meat and pork resulted in a complex spill over effects on consumption with reallocated spending spread over different species and meat cuts (Fousekis and Revell, 2002). More importantly, the consumers’ response to government and industry effort to restore confidence in beef meat safety affected demand considerably less than the adverse publicity of the BSE scares (Fousekis and Revell, 2004).

30 Omega fatty acids, which are present in oily fish such salmon and mackerel, have numerous health benefits including prevention of cardiovascular disease and healthy infant development. However, concern has recently arisen over potential harm from mercury, dioxins, and polychlorinated biphenyls (PCBs) present in some fish species-mostly shellfish. As a result, the public faced with seemingly conflicting reports on the risks and benefits of fish intake, become confused over the role of fish consumption in a healthy diet, see (Mozaffarian, 2006).
2.2.2. Industry perspective – commercial interest in an economic context

Food industry faces a number of challenges when managing a food supply chain, for example: retaining the economic sustainability of the chain, safeguarding the brand reputation, ensuring the longevity of the desired market share, ensuring quality and safety for all products at all times.

The food industry, for its part, has historically responded to the consumers’ demand for effective food safety controls with the development of a range of approaches to improving product quality and safety standards which have become a prominent driving force of agri-food supply chains (Henson and Georgina, 2000; Henson and Hooker, 2001; Henson and Reardon, 2005; Fearne and Garcia Martinez, 2005). An example of these new private food safety governance systems is the EUROPAP/GLOBALGAP, which sets voluntary standards for the certification of a range of agricultural products in more than 80 countries around the world. A second example is the British Retail Consortium’s food safety standard, which although originally developed for the UK food industry to meet due diligence requirements by the UK food safety Act 1990, has been adopted in more than 80 countries (see Humphrey, 2008; Unnevehr and Jensen, 2005; Henson, 2008; British Retail Consortium (BRC), 2008). These private governance systems have proven effective in improving food safety in number of food sectors and supply chains (Henson, 2008).

Recently, there has been a growing interface between public and private controls of food safety due to a shift from the traditional command-and-control regulation by government towards alternative flexible forms of regulation, such as self-regulation, and co-regulation systems of governance (Bardach and Kagan, 1982; Ayres and Braithwaite, 1992; Ogus, 1994; Fearne and Garcia Martinez, 2005; Garcia Martinez et al., 2007). In particular, there is an increasing tendency to regulate food safety through preventive risk management-based approaches that direct firms towards internal planning processes that aim at achieving social goals of safe food supply at minimal regulatory cost and without unduly restricting the firm’s ability to design their own food quality and safety management systems (Coglianese and Lazer, 2003; Balleisen, 2009). Recent development in the EU regulatory framework encourages such approaches. For example, the EU Regulation 178/2002 which lays down the

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For Hazard Analysis Critical Control Points (HACCP) plans to identification of foodborne hazards, risk mitigation and monitoring and corrective action) the firm is given freedom to devise its own food safety control measures.
general principles and requirements of food law recognises that food business operators are best placed to devise a safe system for supplying food and ensuring that the food they supply is safe. On this basis, the legislation places the primary legal responsibility for ensuring food safety on food business operators.

Theoretically, a firm can both co-ordinate and collaborate with up and down stream partners to efficiently ensure the safety and quality of the products it supplies. However, incentives for collaboration will vary depending on where a company is in the food chain and what products it produces, with supply chain segments carrying the higher risks of food fraud likely attracting the greater industry and regulatory attentions. The likelihood of detection and the severity of any penalty in place provide downstream stakeholders in coordinated supply chains (e.g. by multiple retailers) with a strong incentive to impose rigorous monitoring and detection systems on upstream stakeholders (e.g. manufacturers and primary producers), which in turn increases the probability of compliance relative to supply chains where there is less concentration at the point of consumption and the probability of detection of non-compliance is lower (e.g. catering and food service) (Garcia Martinez et al., 2007). As a result current regulatory and industry governance systems may not be able to prevent fraud, especially in long supply chains involving multiple supply partners across different trading countries.

2.2.3. Regulatory perspective including public authorities and industry governance systems

Lessons learnt from past food fraud incidents indicate certain challenges for regulatory responses, for example how quickly authorities react to an incident, the constraints of limited resources (in time, money), the importance of timely industry engagement, the complexity of lack of harmonisation amongst different legal systems (across different countries and across different jurisdictions), the significance of border controls.

In response to the political pressure from a growing public demand for more effective food safety controls, the Commission introduced a White Paper on Food Safety (European Commission, 2000). The White Paper triggered a series of regulatory reforms, including establishment of a new European Food Safety Authority (EFSA) and legislation explicitly making food safety the primary legal responsibility of food business operators (European Commission, 2002). However, the recent food fraud incident related to undeclared horsemeat included as beef in a wider range of processed products, including pastas and
burgers has highlighted need for more effective to prevent food frauds which may or note pose health risks (HM Goverment 2013a).

The protection of public health and consumer interest has risen to the top of the political agenda of the European Commission (EU) in past decade. This rise has been catalysed by a series of highly publicised food scares that resulted in a sharp fall of consumer confidence in the EU food safety governance systems and industry practices (see Cantley, 2004; Caduff and Barnaueuer, 2006; Halkier, 2006). Among these scares were the dioxin contaminations in chicken feed in Belgium; alleged abuse of and ban of growth hormones in beef production in several member states; and the outbreak of Bovine Spongiform Encephalopathy (BSE) in the UK and its transmission to humans in the form of a new variant of Creutzfeld-Jakob disease (Fousekis and Revell, 2004; Ansell and Vogel, 2006).

Although, recent public concerns about food fraud has placed increasing pressures on government agencies to be more proactive in their regulation of the food industry, this may not feasible given the scarcity of public sector resources, concerns about the impact of regulation on competitiveness, as well as technical challenges in detecting and anticipating food fraud (Garcia Martinez et al., 2007; Spink and Moyer, 2013; HM Government, 2013a). Furthermore, the traditional food safety approaches may not be the most effective option for detecting or deterring food fraud. As food fraud risk is based on economic gain motivations, the prevention is different from usual programs to improve food safety and food quality (Spink and Moyer, 2011). The latter is even more important due to presence of “out standers” of the food supply chains, e.g. criminals, or other parties interfering, e.g. traders, who are not closely linked to the performance of the food production chain.

To facilitate the shift toward prevention, it is therefore important to understand that the root cause of food fraud has fundamentally different properties than food safety's traditional microbiological, chemical, and physical hazards. Reducing food fraud opportunities requires in particular a deeper understanding of the public health risk in order to consider the specific types of food fraud risks. In relation to types of risks, there are technical constraints to keep up with increasingly sophisticate fraudulent activities across wide array of marketed products (Spink and Moyer, 2013). Although there is a wide-ranging chemical and biological detection methods developed to combat determine authenticity of food each method often applies to a limited cases of fraud and product types (Woolfe and Primrose, 2004; Primrose et al., 2010; Woolfe et al., 2013).
2.2.4. Fraudster perspective

Although a number of definitions for food fraud exist (see above introduction and Table 1), currently there is no consensus definition of food fraud within the European Union. Drawing on from this definition the key characteristics of food fraud are: 1) non-compliance with food law and/or misleading the consumer, 2) which is done intentionally and 3) for reasons of financial gain.

A fraudster can be defined as anyone who performs any of the above acts namely deliberate and intentional substitution, addition, tampering, or misrepresentation of food, food ingredients, food packaging; or false or misleading statements made about a product for economic gain. This means that a stakeholder of the food supply chain is a fraudster when he or she performs any of the above acts. Criminality of fraud can occur from someone within the industry but also from people standing outside a supply chain, e.g. commodity traders. Traders activities are not necessarily limited to specific commodities and may be driven solely by revenue or profit from a wide portfolio of commodities. It can be assumed that before a trader commits a fraud s/he would balance the risks against the additional expected benefits that gains. As such the fraud would be committed if the risks are perceived to be low and the expected benefits outweigh the potential penalties.

The risks of fraudulent activities depend on the consequences and probability of getting caught. Getting fined, sanctioned, and or prosecuted are some of the consequences of being caught. However which consequence arises from a fraudulent activity is often unknown. Transparent and known consequences defined by law will deter actors from committing fraud.

The probability of getting caught can be translated to the chance that anyone within or outside a food supply chain notices and reveals the fraudulent act. These chances greatly depend on the number and quality of inspections from regulatory bodies. Intense internal control and industry compliance with the regulations governing the food supply chain would also increase the probability of getting caught. Currently for food safety there is the FSSC 22000 Food Safety System including ISO/TS 22002-1 and PAS 223 (food packaging standard) in place for internal control and compliance, but unfortunately there are no checks and balances in place for detecting food fraud.
2.3. Links and relationships with other elements of global trade, e.g. other supply chains (e.g. transport, packaging), common inputs, cross-jurisprudence effect, nationally or internationally targets on areas other than food, e.g. energy.

2.3.1. Characterisation of dependencies

As discussed above, the European food supply chains are dynamic networks of interconnected firms and industries. Particularly during the last couple of decades the complexity of food supply chains has increased extensively due to the increased number of chain participants, and of countries and jurisprudences involved. No firm or sector can be seen as an island and even the most carefully controlled organisations are still only as resilient as the links and nodes that support them (Christopher and Peck, 1990). Dependencies for the supply chain include infrastructure, labour and shared imported/exported materials between trading partners. The degree of such interdependence has steadily increased over the past three decades (Commonwealth of Australia, 2011). Disruptions in supply systems can therefore have widespread effects through the mutual dependencies. Identifying vulnerabilities inherent in these global food systems is thus highly critical for the proactive management and avoidance of future food fraud crises.

The effects of these interdependences may be augmented by other external factors including economic crises, volatility of food prices, trends in industry practice towards consumer expectation and demand for cheap food, financial pressure on control services, low risk of detection and lack of a strong deterrent (penalties); all of these factors were cited to have contributed to recent food fraud incidents, for example the horsemeat scandal (Avery 2013; HM Government 2013a). Such dependencies need to be accounted for when developing models to predict food fraud incidents (Paté-Cornell, 2012)

2.3.1.1. In-balance between supply and demand, and regional and geographical differences

Changes in global food demand and supply systems may affect relative prices of food and ingredients which can be fraudulently substituted. It was the Food Safety Authority of Ireland that decided, in November 2012, to test for adulteration of beef products as they were concerned that while there had been a substantial rise in beef prices, this was not being reflected in retail prices. In addition, the worldwide price of horsemeat had fallen and the
Irish authority concluded that there were thus incentives for fraud. They found that beef products may have been adulterated with horsemeat since at least April 2012, and they believe it is likely to have been present for longer.

Additionally, there is an intrinsic link between the challenge we face to ensure food security in the 21st century and other global issues, most notably climate change, population growth and the need to sustainably manage the world’s rapidly growing demand for energy and water (Beddington, 2010). Recent food supply shocks resulting from an unusual coincidence of different factors have led FAO and OECD to believe that the world is entering into a period of recurrent episodes of supply shocks and extreme price (FAO and OECD, 2011). Most agricultural commodity markets are characterized by a high degree of volatility. Three basic factors are cited by these organisations to explain why this would be the case. First, agricultural output varies from period to period because of natural shocks such as weather and pests. Second, demand changes are relatively small with respect to price and supply changes, at least in the short run. In order to get supply and demand back into balance after a supply shock, prices have to vary rather strongly, especially if stocks are low. Third, because production takes considerable time in agriculture, supply cannot respond much to price changes in the short term due to seasonality, though it can do so much more once the production cycle is completed. The resulting lagged supply response to price changes can cause cyclical adjustments (such as the often referenced ‘hog cycle’) that add an extra degree of variability.

Such shocks in global food demand and supply systems may also affect relative prices of food and ingredients which can be fraudulently substituted. For example, following unusual trend in beef prices, the Food Safety Authority of Ireland decided, in November 2012, to test for adulteration of beef products as they were concerned that while there had been a substantial rise in beef prices, this was not being reflected in retail prices. In addition, the worldwide price of horsemeat had fallen and the Irish authority concluded that there were thus incentives for fraud. They found that beef products may have been adulterated with horsemeat since at least April 2012, and they believe it is likely to have been present for longer. Therefore, supply and demand mismatches and resulting price changes can encourage fraudulent behaviour.
2.3.2. Legal framework

In looking ahead, a potential hurdle to effective implementation of new country of origin labelling (COOL) legislation, and consequently the predictive power of any model developed in FoodINTEGRITY based on this legislation, may arise from the possible lags in the international legal framework and different jurisdictions across EU trading partners. Globally, the United Nations FAO Codex Alimentarius, which underpin the World Trade Organisations (WTO) Sanitary and Phythosanitary rules, require the country of origin of all food products to be identified with the exception that “when a food undergoes processing in a second country which changes its nature, the country in which the processing is performed shall be considered to be the country of origin” (Jacquet and Paul, 2008). Without a substantial change in this international framework, trade disputes may happen if any fraud prevention measures taken by EU are deemed non-justifiable with the WTO rules and hence viewed as technical trade barriers (WTO, 2014). Furthermore, as the COOL provisions are sector-specific the effect of the legislation is likely to vary across member states as EU MSs have competence in this area and therefore the toughness of the sanctions for fraudsters, for example, may vary within the MSs (Avery, 2013). Hence, it is worth accounting for these differences and also develop and testing hypotheses about the effectiveness of the new provisions across different EU MSs.

3. RESPONDING TO THE FRAUD INCIDENT/S OF CASE STUDY – HOW IT COULD AFFECT LIKELIHOOD OF REPEAT

3.1. Brand reputation / Retailers

It is anticipated that a firm may desire to protect its reputation and that of its brand name, building market share, meeting buyer requirements and protecting itself from legal liability for unsafe or poor quality food products (Thomsen and McKenzie, 2001; Salin and Hooker, 2001). For example, the growth of own-label brands and institution of “due diligence” defence have created a strong driver for retailers to develop their own meat quality and safety following the BSE crisis (Spriggs and Grant, 2001; Garcia Martinez et al., 2007). Some of these retailers have developed partnerships with local producers who agreed to supply cattle under Assured Beef Standards to pre-specified abattoirs that in turn are approved by the retailers. This private governance schemes prevented the deterioration of food safety even
when the regulatory controls were broadly inadequate to mitigate risks. However, in long food chains where the relationship between retailer and producers is very distant, the reputational concerns for the producer may be minimal. In this setting, fraud risks within the supply chain may arise from suboptimal interaction due to the lack of visibility and lack of ownership of controls which may limit retailers’ ability to monitor quality (Cranfield University, 2002). Following the horsemeat scandal, UK multiple retailers like Tesco have indicated that they will mitigate future reputational risks and economic losses from food fraud through domestic sourcing of meat (Butler, 2013). Whether this was realised, and whether it had an effect on turning around consumer preferences is not known.

3.2. Penalty

Recent legislative reforms triggered by horsemeat fraud incident may affect the likelihood of certain fraud types happening in the future. Perhaps one of the “highest” penalties was delivered to the fraudsters of the Melamine in milk fraud incident (Xiu and Klein, 2010). With regard to legislation, although the general requirements of EU food law include the aim to “prevent fraudulent or deceptive practices; the adulteration of food; and any other practices which may mislead the consumer”, its focus has primarily been on food safety. However, from 13th December 2014, new rules will replace this legislation and, among other provisions, will extend country of origin labelling (COOL) to meat from pigs, poultry, sheep and goats. COOL is already mandatory for beef and some other products, including olive oil and honey (that are particularly vulnerable to fraud). The new rules will include regular unannounced checks along the food supply chain aimed specifically at identifying fraudulent activity, and mandatory testing programmes as part of an EU-wide coordinated control plan. The proposal also includes tougher penalties for food fraudsters, to ensure that crime does not pay. Hence, they provide greater opportunities to prevent fraud, at least at the products these measures are targeted for.

To account for these changes, research to be undertaken by this project, which was proposed prior to the horsemeat scandal, needs to develop and test hypothesis about the possible effects of these recent important changes on both industry practices and consumer behaviour. With regard to consumer behaviour, fraud is often possible because of similarities in taste, appearance and texture of different species. Therefore, in addition to stricter standards in product labelling, a solution for these industry sectors correctly labelling products is devising
an authenticity programme allowing such products to command a premium price through greater consumer awareness (Jacquet and Pauly, 2008). Products with stronger demand but lower prices are more likely to be susceptible to fraud compared to those with weaker demand; future authenticity programmes may include elements targeted to raise change consumer’s expectation and demand for risky products.

3.3. Communication – public control amongst countries / continents but also industry incidents

Public controls are largely oriented toward food safety and food fraud is not well researched and well known as food safety yet. As result the food fraud response currently begins at the intervention stage (that is, learning about the risks) then moves to the response stage (that is, public–private partnership coordination) (Spink and Moyer, 2011). However, as the response stage becomes better known, food fraud focus will naturally evolve to include the prevention stage facilitated by early detection and communication. To develop means to prevent food frauds/adulterations, it is important first to understand what kind of frauds/adulterations take place in the food production chain. Although reported cases via existing early systems such as RASFF, may be only report the tip of the iceberg, use of this systems for early food communication may also help to develop a deeper understanding of the patterns and variations at the international or national level of food frauds/adulterations. This would help in turn to amend the food control systems accordingly to better capture the frauds and adulterations within the food production chain systems (Tähkäpää et al., 2014).

Changes in legislation may also facilitate a better fraud detection and communication. In addition to the planned COOL legislation following horsemeat scandal, other EU policy initiatives such the creation of the EU Food Fraud Network (FFN) point toward preventive approach to food fraud controls. FNN comprises of the 28 national food fraud contact points plus the non-EU Member States Iceland, Norway, Switzerland and Europol (European Commission, 2014). The national contact points are the authorities designated by each EU MSs for the purposes of ensuring cross-border administrative assistance and cooperation, where action is required in more than one MS, on matters that relate to economically motivated violations of food law requirements.

On the industry side, The Global Food Safety Initiative (GSFI) – a business-driven initiative for the continuous improvement of food safety management system – has recently issues a
position document on food fraud which recognises that food safety management approach may not effectively prevent food fraud. They emphasise that mitigating food fraud requires a different perspective and skill-set than food safety as because socio-economic issues and fraud history are not necessarily captured by the traditional manufacturing, processing, or distribution system of a company (GFSI, 2014). GFSI recommends industry to carry out a ‘food fraud vulnerability assessment’ in which information collected at the appropriate points along the supply chain (including raw materials, ingredients, products and packaging) and evaluated to identify and prioritise significant vulnerabilities for food fraud. This new industry approach is necessary to mitigate risk across countries and continents as modern food supply chains have been lengthened, relationships became more complicated, and flow material became accelerated, the risk of food fraud has broadened to potential include a large proportion of global populations (Spink and Moyer, 2011). While the scope of food fraud may have remained the same over time and therefore information about historic incidents can be used to predict future incidents, globalisation and the profound recent changes manufacturing infrastructure and legal and regulatory environments have vastly expanded the scale and potential impact of food fraud. Therefore, the logical progression of public policies and industry governance, following horsemeat crisis, is prevention of fraud rather than response based on food safety approaches.

With regard to socio-economic aspects of food fraud, a hypothesis that is worth testing in the regard would be whether consumers’ willingness to pay for premium prices for COOL meat labelling has, for example, changed following media reported incidents of horsemeat and retail industry promise to increase domestically sourced meat.

A major aspect for developing predictive models for early warning systems for food fraud is the flow of information before, during and after a food fraud incident. In this front, manufacturers and suppliers may create a perpetual repository of information to project their premium margins and market share. Such repository may consolidate all relevant historical information about internal fraudulent incidents and external industry insights. The internal repository can capture information on internal adulteration/fraud incidents—including specific details such as ingredient, adulterant, source, date of incidence, cost to the firm and actions taken. The external repository could gather information through participation in structured industry clearinghouses, and informal communication networks and alert tools (Morehouse, 2010). Such repositories can be particularly useful for regulators, police and decision makers in spotting trends and identifying themes. For example, it can help
answering key questions such as what types of products or ingredient characteristics are most frequently targeted in particular supply chain? What are the issues within the supply chain? What methods are used to adulterate certain food/ingredient? This kind of information will help identify where the risk of economic adulteration lies at the particular time, hence can be included food fraud intelligence database intended to be delivery from this project.

4. EMPLOYMENT OF OUTPUTS IN THE NEXT STEPS IN WP8 - ENRICHMENT OF KNOWLEDGE ON FOOD SUPPLY CHAINS

WP8 will employ information from a number of sources in order to develop a validated early warning system for food fraud. An overview of the work plan of WP8 is shown in Figure 17. These sources include (a) this review, (b) diverse data inputs, e.g. trade data, food prices data, weather data, imports/exports data, etc., (c) web mining and text mining, and (d) elicited information from experts for building up plausible food fraud scenarios, developing multi criteria decision analysis models, and evaluating the plausible food fraud scenarios in terms of health, environment and socio-economic risks. The latter will be acquired via a number of approaches, including one-on-one interviews, structured workshops, and structured (remote) questionnaires. Structured methods to elicit experts’ knowledge will be preferred as they will enable us to produce auditable and transparent results (Cooke, 1991; Bedford and Cooke, 2001; Aspinall, 2010; EFSA, 2014). The particular approaches for the elicitation, for example elicitation of preferences, elicitation of probabilistic estimates, Delphi approach, will depend on the particular missing information that needs to be acquired each time. Irrelevant to the approach that will be followed, remote elicitation will be applied as often as possible, as face to face workshops can be resource demanding, and subject to constraints because of the availability of participants.

Furthermore, the response rate to a Delphi survey generally does not exceed 25%. Therefore, to have sufficient number of respondents to allow a quantitative assessment a large number of experts is need, which may be difficult to identify for specific groups of experts.

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32 The Delphi approach involves a series of sequential rounds (questionnaires), interspersed by controlled feedback, that seek to gain the most reliable consensus of opinion of a group of experts (Delbecq et al., 1975; Linstone and Turoff, 1975. Delphi method has been described as a quick, cheap, and relatively efficient method to combine the knowledge and abilities of a group of experts (Lindeman, 1975; Murphy et al., 1998). The drawbacks are related to its costs and time. The duration and cost of a Delphi study will be related to the scale of the survey, the complexities involved in the processing of the questionnaires and the number of rounds (Williams and Webb, 1994; EFSA, 2014).
4.1.1. Selection of experts for building up scenarios and multi criteria decision analysis models

Ultimately food fraud incidents are highly complex, and due to the fact that a high number of different stakeholders are involved in single food supply chains, it is anticipated that variable expertise will be needed for WP8 elicitation sessions; for example: food technologists, risk assessors, trade experts, border control experts, mathematicians, chemists, microbiologists, risk analysts, policy making professionals, food fraud analysts amongst others. Professionals within a food supply chain as well as other supply chains would be equally desirable.

The analysis of historical food fraud cases in this review shows that food fraud is not limited to a specific region or country; a food fraud incident may happen in either a short or a longer food supply chain; food frauds related to a particular adulterant may reoccur, albeit in a different food item than the one in which it was recorded previously. This information will be vital for designing the selection of our experts. Due to the reoccurring nature of food fraud it is important that these experts do not hold any bias. Selecting unbiased experts is not an easy task; nevertheless, we will apply methods that involve statistical tests that way of filtering out biased experts (Cooke, 1991; Neslo and Cooke, 2011; Flari et al., 2011).

Most updated information on possible ways to select experts is found in a guidance document published by EFSA on expert knowledge elicitation in food and feed safety risk assessment (EFSA, 2014). In our problem the selection of individual experts as workshop participants may be challenging, depending mainly on (a) availability of experts, and (b) sensitivities mainly due to confidentiality issues. Food fraud is solely caused by humans, and experts who are humans may not be willing to participate, because of the sensitive nature of food fraud. The sensitive nature should be taken in the account both when selecting the experts as well when consulting them for inputs. Thus, it is most probable that for the great majority of expert elicitation sessions we will not mix regulators and industry, and it is also probable that particularly for the industry participants we will hold one-on-one interviews instead of multi-participants workshops.
4.1.2. Workshops with regulatory authorities of EU MSs and international food fraud researchers

It is anticipated that WP8 will hold a number of “closed” workshops with regulatory authorities of the EU MSs, with the view to (a) mapping weak points in EU food supply chains, and (b) identifying plausible food fraud scenarios in the EU. In order to facilitate the organisation of such workshops we will most probably hold separate sessions for four EU geographical regions, in particular North, South, East and West. Recognising the importance of how global food supply chains are we will try to involve representatives from main trade partners of the EU, *i.e.* USA, China, Russia, AUS/NZ, Japan.

4.1.3. One-on-one interviews with industry representatives

To understand the food fraud problem and to develop methods and systems to reduce the number of incidents and/ or prevent fraud to occur, options and views of all stakeholders operating in the food production chain on a daily basis is crucial. Inevitably, to evaluate potential food fraud incidents knowledge and views from various industry partners on the incident would be required. In light of the observations cited above in sections 4.1, 4.1.1. and 4.1.2. it is anticipated that one-on-one interviews will be particularly important for eliciting information from industry experts. Spiegel *et al.* (2012) applied this approach successfully to analyse the effects of climate change on food safety hazards in the dairy production chain with twelve preselected industry experts from the Netherlands.

4.1.4. Framing elicitation questions

The goal of framing elicitation question is to get a grip of variables that are known and have a high degree of uncertainty and or are currently unknown for detecting food fraud. For some of the elicitation questions experts will be ask to update and or append the currently know variables.

The experts will also be asked to not only provide additional and appropriate variables, but also to provide observable, measurable, and operational units that can be used for detecting food fraud. If no observable, measurable, and operational units can be found or if this variable is perceived to be sensitive then the experts will be asked to provide proxy variables and units from which almost the same information might be inferred. For example suppose
experts from the industry may not be able to provide variables about their own business that will be useful for detecting food fraud then the question might either be rephrased so that it asks about the whole industry rather than the specific business.

One thing that was noted in the EFSA guidance (EFSA 2014) is that in order to get the best out of an elicitation procedure it is necessary that experts will be provided with as much as possible information for answering the questions. The questions should be framed so that the experts, together with the information that is already present and known about food fraud, can give the best possible answers to the questions.

What should also be kept in mind, when framing the questions for the elicitation, is the use of language. Experts from various regions and domains will be selected for the elicitation so it is important to phrase the questions as much as possible in the language they understand using unambiguous words. Words that may have multiple or interchangeable meanings should either not be used or clear definitions should be given what is meant. Terms and definitions that are sensitive and or controversial should be avoided as much as possible.

As mentioned before biased should be avoided. There are a number of ways that bias may occur either experts may be biased before starting the elicitation rounds or they might become biased during the elicitation rounds. Screening for bias beforehand can be done using again the EFSA Guidance. During the elicitation bias can be reduced by grouping experts from various domains and expertise to discuss and elaborate about food fraud.


5. REFERENCES


Accessed 20 06 2014


Interview with Dr. J. Neuendorff, Resource Protection Ltd., GfRS and Member of Anti Fraud Initiative (http://www.organic-integrity.org/afi/about-afi)


NAO (2013) Food safety and authenticity in the processed meat supply chain.


Appendix: Figures

Figure 1: Sequence of key events in the 2007 Melamine incident. From: Flari et al., 2009

The ‘horsegate’ step by step
Figure 4: Structure, *i.e.* aim and objectives, of deliverable 8.1.

Figure 5: Diagram illustrating goals of integrated supply chain management; the diagram is based on a number of assumptions on food shortage and energy shortage.
Figure 6: Generalised conceptual model of supply chain collaboration. From: Matopoulos et al., 2007. [Image Available online] at: http://www.emeraldinsight.com/content_images/fig/1770120301003.png Accessed 17 07 2014

Figure 7: Causal Loop Diagram. From: Notes from Bristol’s 1st Food System research workshop within the framework of Converge EU project.
Figure 8: Segments involved in the production of unprocessed or processed milk; example from Eastern Europe milk supply chain. From: http://www.euromonitor.com/medialibrary/Image/PF_MappingtheDairySupplyChainEE.jpg Accessed 20 06 2014
**Figure 9:** Steps within the segment of milk production in the milk supply chain in the EU. From: Salampasis *et al.*, 2012. Each of these steps may or may not be linked with further external supply chains and/or influential inputs, e.g. energy sector. [Image Available online] at: http://www.emeraldinsight.com/content_images/fig/3650140402003.png Accessed 17/07/2014

**Figure 10:** Sample of extended relations amongst the 5 different segments in the EU milk supply chain. From: Meuwissen *et al.*, 2009. [Image Available online] at: http://www.emeraldinsight.com/content_images/fig/0701110810001.png Accessed 17/07/2014

**Figure 13:** Generic flow chart of milk supply chain configuration; the chart is presented at a “high level” of details.
**Figure 14:** Flow chart diagram for whole milk production

**Figure 15:** Flow chart diagram for skimmed milk production.
Figure 16: Milk Process flow description

Figure 17: Flow diagram of WP8 work plan.