



# Differences in fraud vulnerability in various food supply chains and their tiers



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## ABSTRACT

Food fraud results from the interaction of motivated offenders with opportunities, and lack of control measures. The vulnerability to food fraud varies across chain actors (tiers) though, but insights on prime fraud drivers and enablers, as well as chain areas where vulnerabilities might exist are lacking. In the current study the fish, meat, milk, olive oil, organic bananas, and spice supply chains were assessed for their fraud vulnerabilities. The differences and similarities in vulnerabilities across the supply chains, as well as between groups of chain actors were evaluated using the SSAFE food fraud vulnerability assessment tool. Multiple correspondence analysis and agglomerative hierarchical clustering were applied for exploratory data analysis, and differences between chains and actors were assessed by analysis of variance and post-hoc tests. Thirteen fraud factors related to opportunities and motivations scored high across all supply chains indicating their importance as fraud drivers and enablers. Control measures varied considerably across supply chains and actor groups, with technical (hard) controls generally being more in place than managerial (soft) controls. Approximately half of the fraud factors were impacted by the type of commodity chain, and one out of seven of the fraud factors by the actor group. From the current sample group overall fraud vulnerability appeared highest for the spice chain, which was followed by the olive oil, meat, fish, milk and organic banana chains. Among the actor groups, the wholesale/traders group appeared most vulnerable, followed by retailers and processors. The current results provide new insights in the fraud factors determining fraud vulnerability in various supply chains, and the (dis)similarities in fraud vulnerability across supply chains and actor groups which helps to combat future food fraud.

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## 1. Introduction

Food fraud is a form of criminal behaviour, no matter the definition of crime. The consequences of food fraud are devastating. Food companies and their reputation are damaged, stories go viral, whole supply chains are painted with the same brush, consumer confidence erodes, markets collapse, and management and/or employees are fired, prosecuted, and locked up. The general effects show similarities with other corporate frauds (Kuang & Lee, 2017). Losses for individual businesses may include social losses &

punishments, third party losses (e.g. extra testing), confidence losses, sales losses & over payment, as well as recall losses (Bindt, 2016). If we take the horsemeat affair as an example, it certainly had a huge economic impact: widespread product recalls and serious effects on all ground beef sales across Europe (Moyer, DeVries, & Spink, 2017). There is some popular belief that food fraud is mostly an external threat caused by organized crime groups seeking to permeate the food supply chain. Although politically convenient, in reality it is more often a problem within the food system itself and committed by legitimate food supply chain actors who make the most of criminal opportunities that arise (Lord, Flores Elizondo, & Spencer, 2017).

Fraud is the result of the interaction between motivated offenders, and the opportunities presented by victims and by those entrusted with controlling risks according to Levi (2012). Fraud vulnerability results from openings for undesirable events resulting

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from weaknesses or flaws related to the system (Spink, Ortega, Chen, & Wu, 2017). Further, criminogenic incentives can differ for the various tiers in production and distribution chains (Simpson, 2011). An assessment of the factors affecting this vulnerability is, therefore, the first step towards fraud prevention and mitigation. Food fraud vulnerability is defined by three key elements: opportunities, motivations, and control measures. These elements can be subdivided into technical opportunities, opportunities in time and place, economic drivers, culture and behaviour, technical control measures, and managerial control measures (van Ruth, Huisman, & Luning, 2017). A food fraud vulnerability assessment (FFVA) can identify areas in the food chain where vulnerabilities might exist. It can also determine the key drivers and enablers of the vulnerability in supply chains (Spink, Moyer, & Whelan, 2016). From the food fraud vulnerability concept of the three key elements described above, an FFVA tool was developed (SSAFE, 2017), and was made available as a free downloadable app (PwC, 2017).

Some commodities seem to be more associated with food fraud than others. An inventory of reports in the three global food fraud databases over the period 2008–2013 revealed that the six most frequently reported commodity groups were spices and herbs, olive oil, seafood, dairy products, meat, and other oils and fats (Weesepeol & van Ruth, 2015). In China, especially animal products have been surfacing often in media fraud reports in 2004–2014 (Zhang & Xue, 2016) and in the Netherlands the top 3 included meat, fish, and organic produce according to an analysis of media reports over the period 2008–2014 (van Wagenberg, Benninga, & van Ruth, 2015, p. 126).

The present study deals with fraud vulnerability across supply chains that have been reported often in the food fraud inventories since it appears that fraud is occurring in those chains. Fraud vulnerabilities in the fish, meat, milk, olive oil, organic banana, and spice supply chains were examined in order to understand the contributions of various fraud factors to the overall fraud vulnerability. Furthermore, we evaluated the differences and similarities between commodity supply chains, as well as between groups of actors (tiers) across chains (e.g. processors, retailers). Detailed examinations of differences within the specific chains are not considered for this particular paper. For the spices chain such a detailed evaluation has already been published previously (Silvis, van Ruth, van der Fels-Klerx, & Luning, 2017).

## 2. Materials and methods

### 2.1. The food supply chain networks and actor groups assessed

Businesses in supply chains of six commodities were assessed

and compared for their fraud vulnerabilities. They involved (number of interviewed actors in brackets): fish (5), meat (5), milk (8), olive oil (8), organic bananas (8), and spices (8). The actors belonged to three actor groups: wholesalers (7), processors (22), and retailers (13). Wholesale included traders, importers, distributors, and auctions, i.e. all organizations that did not process the products but just passed them on in the chain. Processors included companies processing the primary product, such as olive oil, but also complex food manufacturers. Primary producers, such as farmers or fishermen were not involved.

### 2.2. The food fraud vulnerability assessment (FFVA)

Various factors contributing to food fraud have been identified and were collated in a practical FFVA (PwC, 2017; SSAFE, 2017). The assessment consists of 50 questions and associated three level answering grids (low-medium-high vulnerability). Each question relates to the previously identified fraud factors: 9 for opportunities, 20 for motivations, and 21 for control measures (Table 1). The assessment was developed and tested through an extensive, interactive and iterative process with representatives from the global food industry, retail, authorities, and scientific community (van Ruth et al., 2017). The assessments in the fish, milk, meat, olive oil, and organic banana chains were carried out as described previously (Silvis et al., 2017). Furthermore, the data of actors from the spice chain of a previous study were included as well (Silvis et al., 2017).

### 2.3. Data analysis

The answers to the questions, selected by the businesses, were transformed to a score system. For opportunities and motivations, a score of 3, 2, and 1 was assigned to high, medium, and low vulnerability situations, respectively. For control measures the reversed order was used. The answers/situations associated with the three vulnerability levels are presented in the FFVA tool for each fraud factor (PwC, 2017; SSAFE, 2017). The two questions on counterfeiting, question 6 and 7, were not further considered since they did not apply to the commodity chains examined. For exploratory analysis, multiple correspondence analysis (MCA) and agglomerative hierarchical clustering (AHC) was applied. Opportunities and motivations related fraud factors were considered prime drivers and enhancers if their scores exceeded the average for either the opportunities or motivations group. Furthermore, to investigate the specific differences between the supply chains (fish, meat, milk, olive oil, organic bananas, spices) and the actor groups (wholesale, processor, retailer), a multi-factor analysis of variance

**Table 1**  
The three key elements of the food fraud vulnerability assessment and the 50 associated fraud factors.

Key element	Fraud factors
Opportunities	(1) complexity of adulteration of raw materials; (2) availability technology and knowledge to adulterate raw materials; (3) fraud detectability in raw materials; (4) availability technology and knowledge to adulterate final products; (5) fraud detectability in final products; (6) complexity of counterfeiting; (7) detectability of counterfeiting; (8) access to production lines/processing activities; (9) transparency in the chain network; (10) historical evidence of fraud in raw materials; (11) historical evidence of fraud in final products.
Motivations	(12) supply and pricing raw materials; (13) valuable components or attributes; (14) economic health own company; (15) organizational strategy own company; (16) ethical business culture own company; (17) criminal offences own company; (18) corruption level country own company; (19) financial strains supplier; (20) economic health supplier; (21) organizational strategy supplier; (22) ethical business culture supplier; (23) criminal offences supplier; (24) victimization of supplier; (25) corruption level country supplier; (26) economic health sector; (27) criminal offences customer; (28) ethical business culture branch of industry; (29) historical evidence branch of industry; (30) level of competition branch of industry; (31) price asymmetries
Control measures	(32) fraud monitoring system raw materials; (33) verification of fraud monitoring system raw materials; (34) fraud monitoring system final products; (35) verification of fraud monitoring system final products; (36) information system own company; (37) tracking and tracing system own company; (38) integrity screening own employees; (39) ethical code of conduct own company; (40) whistle blowing own company; (41) contractual requirements supplier; (42) fraud monitoring system supplier; (43) information system supplier; (44) tracking and tracing system supplier; (45) social control chain network; (46) fraud control industry; (47) national food policy; (48) law enforcement local chain; (49) law enforcement chain network; (50) contingency plan

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