

FINAL REPORT

Risk Modelling Of Food Fraud Motivation – “NSF Fraud Protection Model” Intelligent Risk Model Scoping Project

FS 246004

NSF Safety and Quality UK Ltd



NSF International

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Executive Summary

The food industry faces unprecedented challenges to the integrity and safety of its food supply chain as that chain has become simultaneously more complex and global in nature.

The principal objective of this project was to enhance and develop a working version of a pre-existing model “NSF Fraud Protection Model” which has been developed to help reputable large scale food retailers and regulators anticipate the *relative* likelihood of fraudulent attack on the many and varied product lines offered to consumers.

With the aim of feeding into the development of the “NSF Fraud Protection Model” model, two major tasks were undertaken. The first was a detailed identification and review of other available tools and models being used for food fraud detection and prevention. The second was a survey and set of interviews of industry representatives to test the key assumptions underpinning the “NSF Fraud Protection Model”, with subsequent validation by industry and regulators.

The outcome of this project is a working prototype of the “NSF fraud protection model” model that has been developed through interactive sessions between project team members and tested by presentation for feedback from industry and regulatory representatives.

An overview of the development of the “NSF Fraud Protection Model”.

The model being enhanced is conceptual. It arose from a request for help to assess and manage the scale of food fraud being encountered in 2013 by a global supermarket retailer to one of the project team, David Edwards, the then head of consulting at NSF International, a US based, not for profit, public health and safety organisation.

A key aspect of the “NSF Fraud Protection Model” model is that it approaches the issue of fraud from the perspective of what is advantageous to the fraudster. In other words, to help organisations ‘think like a criminal’. The assumption being that fraudsters involved in organised deception are more likely to target high value, easy to implement and difficult to detect adulterations/substitutions, in essence to target situations where they perceive the greatest return financially for the least effort and lowest likelihood of detection. (Opportunistic fraudsters could be predicted to not conform to this model.)

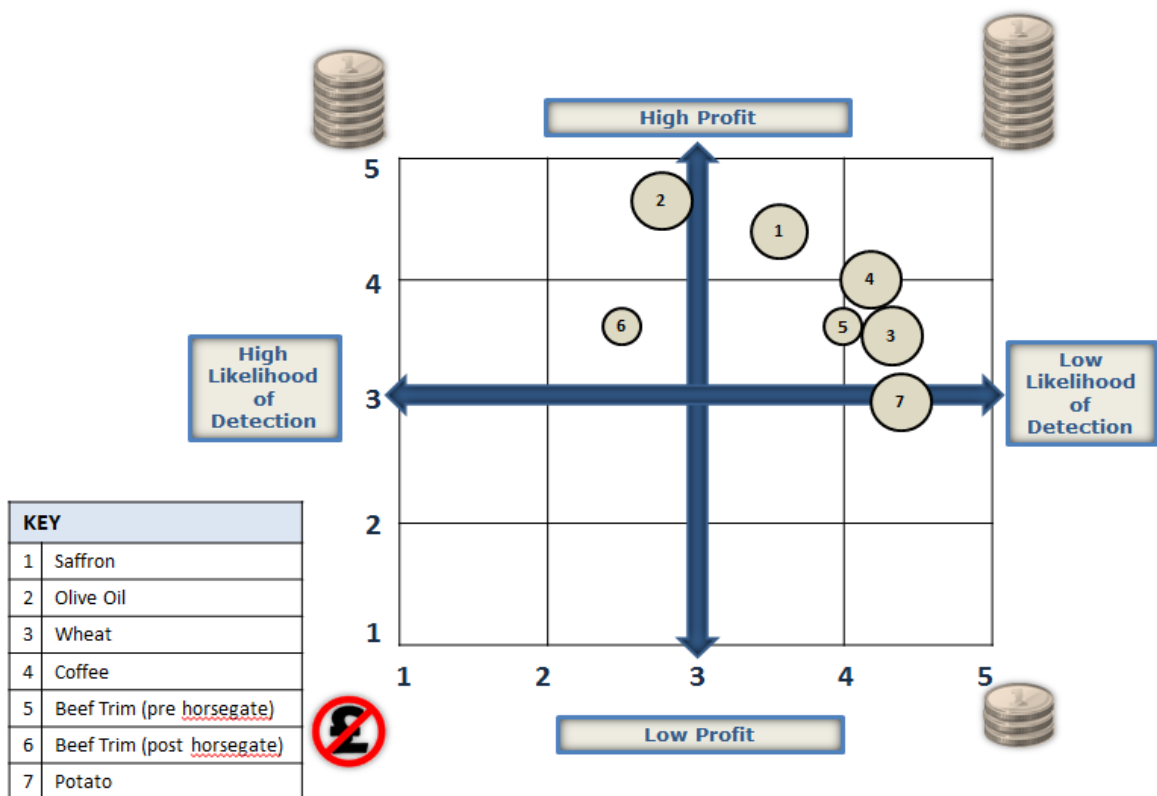
Three main factors were considered in the original model:

- The potential profit a fraudster can make
- The potential difficulty/cost for the fraudster of making a viable substitution (opportunistically and technically)

- The likelihood of detection by a reputable food business customer or regulators

This project examined whether these initially proposed factors were appropriate. The aim was to create simple indicative criteria of scale (measurement indices) or modifications to the conceptual model such that food groups/categories can be mapped onto a 4 quadrant Boston Consulting Group (BCG) matrix style framework. The intention is that the framework will provide a clear visual representation of relative product risk. Thus enabling easier and more consistent and prioritised targeting of surveillance measures, supply network controls and preventative interventions.

The project team designed a BCG style matrix which places product groups in quadrants - as illustrated below -with the top right quadrant containing products that are most attractive to a fraudster and bottom left being the least attractive. Size of the circle represents perceived difficulty to the perpetrator of undertaking the particular fraud, (for simplicity ranked as small, medium, large).



Illustrative only

In addition to prioritisation, the “NSF Fraud Protection Model” model also aims to provide a pro-active approach to anticipating the potential for fraud since it helps identify relative vulnerability.

Summary of model development work

The desk top review and interviews undertaken as part of the project research base suggested that the methods currently used by food companies and regulators to anticipate fraudulent activity can best be described as a combination of the experience embedded within the tacit knowledge base of their buying or technical teams together with evidence, where available, of past incidents and fraudulent activity within a particular sector or food category. Essentially the current anticipation of fraud is based on historical events and sector experience.

The industry survey suggested that there are considerable gaps in technical knowledge within industry as to which types of product are most vulnerable. It also confirmed that there are no identifiable predictive tools currently available, nor recognised training in the industry on how to anticipate fraud.

The final framework was reviewed and validated in several ways. Firstly through exposure to an end user groups comprising representatives of Industry, the FSA, and Defra and secondly by assessing questionnaire responses which amongst other things compared informed industry opinion “gut feel” in terms of different products relative vulnerability to the models predictions.

Use of the model

The final model delivers a working framework by which the technical and/or food safety teams in food businesses or in regulatory bodies can begin to better anticipate which product lines are most/least likely to be targeted by fraudsters and why, whether or not they have been attacked previously.

Once food products or broad food categories have been assessed in terms of their attractiveness to a “predator” fraudster i.e. one who is focussed on a deliberate systematic crime then interventions can be designed to thwart such activities by the application of interventions which move vulnerable products from the top right to bottom left of the BCG style matrix. These interventions might include

- Increasing detection likelihood by increasing the frequency of or forensic quality of auditing.
- Changing the nature of routine third party auditing to focus more effectively on fraud or introducing new Fraud Specific Audits.
- Enhanced frequency or sophistication of sampling and testing regimes
- Making the insertion of fraudulent replacement into the supply chain more difficult by enhanced security measures.

Limitations of the model

The developed model is probably less useful where the fraudulent substitution takes place for reasons other than systemic organised crime for example to meet unforeseen shortfall of supply when demand peaks or there is some form of short term supply failure.

Further sophistication of the model was considered by the project team to take account of this kind of opportunistic fraud but it was felt at this stage of development that approach added undue complexity to what is intended as a working tool.

The sample size was too small to allow statistically valid correlation of “gut feel” verses model prediction but the project team were encouraged that model predictions were in line with expectations. More work is required on validation of this kind and we suggest additional assessment using the model of past incidents would be helpful in this respect.

The “NSF Fraud Protection Model” was considered indicative of best practise by industry representatives. It was agreed adoption of the model would facilitate a more systematic and consistent approach particularly amongst SMEs who may not have access to larger technical teams of experts.

Potential for further development of a dynamic model

The scope of this project was to produce a static model. However, this model is ready to be developed into a dynamic and real time approach. For example, supply and demand fluctuations which significantly impact on potential profit and therefore fraudulent incentives, can be incorporated into a more fluid version of the model.

A concern was expressed that the model would need to be dynamic adapting to changing market conditions and should be able to be customised to particular companies circumstances. The project team see no particular difficulty with either need. The evaluation criteria for example indicative profit could be routinely updated ideally in real time using online sources and customisation is obviously possible for the three key assessment criteria relating to either the complexity or detail of detection methods to represent those actually in use in a particular company.

Background

The rising trend in globalised food trade is creating complexity in the supply network and a greater opportunity for food fraud. As a consequence, the global food industry is suffering sophisticated and increasing pressures from food fraudsters.

It was reported in Food Manufacture in 2011 - that organised crime is switching to food fraud from activities such as drug trafficking, because detection methods are less developed and penalties are softer. The Horse meat crisis in early 2013 provides recent hard proof of such a connection.

<http://www.foodmanufacture.co.uk/Ingredients/Criminals-drop-drugs-for-food-fraud>).

Intelligence gathering to fight food fraud is being addressed internationally through a number of Government led initiatives but industry intelligence goes currently largely untapped. Furthermore supermarket retailers and large food companies/manufacturers are themselves finding the scale of food fraud detection and the range of products potentially affected potentially overwhelming.

Arising from a private conversation with the technical director of a global scale supermarket retailer concerning the nature and scale of fraudulent practice being experienced in China David Edwards then Consulting Director at NSF International was asked to suggest a mechanism to risk assess broad areas of vulnerability to fraud in a typical supermarkets food supply network.

Whilst information on existing fraud was available and increasingly well documented and collated, no food specific predictive tools could be identified that are designed to help anticipate or risk assess products and product categories in terms of their vulnerability to fraudulent attack.

Drawing on previous experience of risk modelling in both health and safety and food a simple Boston Matrix style the “NSF Fraud Protection Model” was suggested as a viable approach to risk assessment. Developing this matrix into a framework focused on the key motivations for fraud where criteria indicative of likelihood provided a scale upon which to map in two dimensions formed the core of the project,

Project Objectives

This work was commissioned by the Food Standards Agency (FSA) in 2013 to:

- 1) Review what is known regarding current fraud incidents.
- 2) Identify any other fraud risk assessment tools.
- 3) Develop and enhance the initially proposed “NSF Fraud Protection Model” framework by incorporating information gained in objectives 1 and 2 above.
- 4) Propose means by which the initial framework can be used and or enhanced and integrated with other fraud management tools.

Approach to the work

The project aimed to create deliberately simple criteria indicative of likelihood of fraud (measurement indices) for either the three originally proposed or subsequently modified factors such that food groups/categories could subsequently be mapped on the Boston Consulting Group (BCG) Style framework to highlight vulnerabilities enabling better targeting of surveillance measures, supply network controls and preventative interventions.

A key aspect was to develop the model in an iterative series of events in order to add enhancements that were driven by informed stakeholders from industry, the FSA and other regulatory bodies. Thus, the first exploration of the focus and boundaries of the

model involved participation in a project team conference where considerable building and stress testing cycles were applied to each key component of the model.

Subsequent further refinement, via teleconferencing and substantive literature and database research, was followed by a stakeholder conference where both general and detailed feedback from stakeholders (industry, regulatory bodies and the FSA) was incorporated. In parallel, an internet-based questionnaire was posited with the survey result analyses informing development. Further refinement was adopted from key points arising from the stakeholder engagement.

The project team also suggested ways in which the framework can be used in a practical sense and enhanced by its development from a static model to a dynamic model wherever possible updated in real time as new information becomes available or measurement indices change for example price data.

The work was undertaken in four principal phases:

Phase 1: Review Current Incidents and Fraud Assessment Tools

Phase 2: Stake Holder Interviews.

Phase 3: Initial Assessment

Phase 4 Organisational Validation

Phase 1: Review Current Incidents and Fraud Assessment Tools

Literature Study

A literature and internet search of available risk assessment tools, risk management solutions, available data and reports on known fraudulent incidents across the risk spectrum was carried out Appendix 1 – Framework Elaboration.

The outcome was 337 publications were scrutinised at the title, abstract or full document level (as appropriate) to identify if they met the remit of the review.

This established existing published work and media reports that were relevant to the task of creating and enhancing the proposed framework.

Details of other tools or frameworks for understanding fraud mechanisms and the motivations of fraudsters are also contained in Appendix 1 and were referenced where appropriate and to inform the development of the proposed framework.

Following the literature and internet scoping exercise, initial results were harmonised and scrutinised in order to identify appropriate search terms and approaches for the systematic review. This led to a dual approach of a systematic literature review in parallel with a search of the internet - including official regulatory sources. A literature search was conducted (in late September 2013) using the selected databases (ScienceDirect and Scopus) using the terms and parameters including Adulterant(s/ation), Authenticity, Corruption, Counterfeit, Anti-Fraud, Fraud, Food fraud, Forensic, Fraud Management, Incidents, Tools, Solutions, Procurement, Reporting over 30 months.

The outcomes were: a full review of key information from the literature, internet sources and professional network/regulators sources to inform the direction of the project in terms of 'state of the art', requirement for a new model and essential key components. The information was shared with the project team in advance of meetings to define a "working model".

Scrutiny of these sources item the literature study led to selection of 17 separate items relating to the focus of this project and creation of indicative or predictive criteria (measurement indices). These are summarised in tabular form and are discussed more fully in Appendix 1 – Framework Elaboration.

Findings of literature study relevant to the "NSF Fraud Protection Model" development

Key findings from these that were considered particularly relevant to the "NSF Fraud Protection Model" models subsequent development were as follows:

Food Fraud definition

Several definitions exist but an appropriate definition of food fraud for the purpose of the model was taken as a collective term that encompasses the deliberate substitution, addition, tampering, or misrepresentation of food, food ingredients, or food packaging, or false or misleading statements made about a product for economic gain (Spink, 2011).

Other fraud modelling and frameworks

The “Food Fraud Triangle” as defined by Grocery Manufacturers Association & A.T. Kearney (2010) considered key indicators as profit, avoidance of detection and opportunity. The proposed “NSF Fraud Protection Model” model already takes account of profit and detection. Opportunity was considered as a further enhancement of the “NSF Fraud Protection Model” but rejected at this stage to avoid additional complexity. Fraudulent substitution merely to meet short term customer supply chain demands rather than profit was also excluded from the model at this stage.

Morehouse (2010) states that the first step against fraud is to create a perpetual repository of information that consolidates all relevant historical information to include ingredient, adulterant, source, date of incidence, cost to the firm and actions taken.

Lipp (2012) identifies potential **profit** as the key criterion with supply and demand as a useful indicator, physical state (Liquids, powders & pastes being most at risk) and feasibility (Difficulty): ‘If it [the fraud] requires really specialist knowledge or specialist equipment then it may not happen.

Databases of previous incidents and rapid alert systems

Two key fraud databases the NCFPD (National Centre for Food Protection) and USP (US Pharmacopeial) were identified that outlined the frequency and scale of past incidents and these were used to determine some products that should be “tested” against the model and to guide the team in terms of examining varying profit potential between different food products.

Further modeling work is recommended in this area to “fine tune” the accuracy of the “NSF Fraud Protection Model” framework in terms of its predictive capabilities. Ideally had time allowed the project team would test all products listed in the two databases (NCFPD, USP).

Top 10		
	NCFPD	USP
1	Alcoholic Beverages	Olive oil
2	Oils & Fats	Milk
3	Meat & meat products	Honey
4	Honey	Saffron
5	Spices	Orange Juice
6	Grains & grain products	Coffee
7	Coffee & Tea	Apple Juice (Tie)
8	Fish & Seafood	Grape Wine (Tie)
9	Dairy	Maple Syrup (Tie)
10	Produce	Vanilla Extract

Information from known incidents

The evaluation of known incidents gave rise to 10 separate components which appeared to researchers to be important factors contributing to fraud. These significantly assisted the project team to build the scoring mechanisms for profit, likelihood of detection and ease of substitution. Appendix 1 – Framework Elaboration

Known incidents suggested the following factors were important:

- Knowingly buying below market price
- Presence of added value claims (organic, Healthy, free range)
- High profit margins
- Less likely to be detected
- Less detectable due to low concentration
- Evadable testing
- Demand exceeding supply
- Passed through many hands
- Cost of adulterant
- Physical form(powdered)eased adulteration process

Similar fraud indicators were also described at the Leatherhead/FERA launch of the Horizon scan Tool (April 2013) which were also incorporated into the “NSF Fraud Protection Model” development process as appropriate. These were:

- Raw material quality, cost, and availability
- Adulterant material cost and availability
- Profit associated with delivery of goods
- Loss and consequences associated with a failure to deliver goods.
- Perception of associated risk and consequences
- Likelihood of being caught
- Consequences of being caught
- Ease of adulteration particularly in comminuted, liquid, powder and processed ingredients of products
- Scale, profit and consequences
- Supply chain demands
- Legislative changes
- Links between productivity & reward
- Ability to hide deception
- Corporate awareness
- Sampling and testing

Factors contributing to Food Fraud. Source: Leatherhead/FERA launch 2013

Research into organised crime

Examination of research in the area of organised crime and the supply chain suggested that non-traditional sources of data could be used for fraud detection e.g. for example tax records and this could impact likelihood of detection if successful.

However, the team felt these detection methods were under developed at the current time and therefore did not include them as a factor.

Long or complex supply chains presented many challenges to detection. This fact was incorporated into the detection assessment.

Existing detection tools

Existing online fraud detection tools and data exchanges like the RASFF EU rapid alert system, Horizon scan (an alliance between FERA Food and Environment Research Agency and Leatherhead Food Research), Foodquest a commercial product were all considered in terms of their potential impact on detection.

The conclusion of the team was that this aspect of the “NSF Fraud Protection Model” (likelihood of detection) would need to remain under regular review to take account of any game changing detection methods which might significantly impact on fraudulent behaviours. It is not clear at this time how effective the horizon scanning tools will be.

Industry Standards

Industry standards and inspection standards were clearly one means by which the potential for fraud could be limited. The GFSI (Global Food Safety Initiative) now recognises food fraud as a food safety issue and is currently focussing on embedding fraud controls into standards, advised by a food fraud think-tank ([Spink 2013a](#)).

Compliance to the BRC Food Safety Standard is considered by many an industry 'ticket to trade' within the UK and or provides a degree of legal Due Diligence for retailers. It has provided significant improvement in traditional food safety & quality standards but does not currently provide any requirements for fraud management & control, although this is currently under review

Testing

Examination of this aspect of fraud control highlighted that organised Fraudsters are well aware of testing regimes. In summary testing methodologies are clearly continually being improved and enhanced and any fraud anticipation model will have to be dynamic enough to take account of these technological changes since significant improvements to testing efficacy may force fraudsters to alter the products they target. There is in effect a testing and detection avoidance "arms race" that must be continually monitored. Appendix 1 – Framework Elaboration discusses some of the latest analytical techniques.

When dealing with specific foods the model indices for likelihood of detection could be adapted and calibrated to take account of very specific tests and their known frequency of application. However, the project team took an approach that Individuals using the "NSF Fraud Protection Model" model would be cognisant of what testing was available and in use and therefore for the benefit of simplicity it was sufficient at this stage of the model's development to use a high medium low type of approach to testing efficacy.

Fraud risk management, Governance and best practice

A global survey on fraud risk management assessing the status of implementation of current best practice across a variety of business sectors was carried out between November 2011 & February 2012 ([Ernst & Young, 2012.](#))

- This was based on 1,700 interviews in 43 countries with chief financial officers and heads of legal, compliance and internal audit, to get their views of fraud, bribery & corruption risk and how their businesses are mitigating them.
- Forensic data analysis and other technology-related tools were seldom adopted and robust risk-based compliance audits, including transaction testing not common practice.
- Governance and Risk Compliance (GRC) flips the focus of food fraud from detection by scientific means to Board room Governance to identify vulnerabilities as compared to recurring events.

- [Spink \(2013b\)](#) advocates the adoption of Corporate Governance as a mechanism to prepare for a Black Swan event. [Black Swan events are the unknown unknowns and led to the evolution of Enterprise Risk Management ERM. [Spink & Moyer \(2011a\)](#)]
- [Spink & Moyer \(2011a\)](#) also relate the classic fraud triangle model to food fraud showing that improved internal control systems are critical to reducing 'Opportunity' factors in a business.

Phase 2: Stake Holder Interviews and Survey

Interviews

The purpose of the interviews was:

- To further understand what is currently known about the nature and extent of food fraud.
- To identify any information or fraud control methodologies that may not be currently known to the FSA or covered in available literature.
- To help establish what methodologies are currently used by large manufacturers and retailers to manage food fraud.
- To better understand the financial mechanisms and other commercial drivers that impact purchasing decisions and thereby how fraudsters might seek to exploit these.

An interview with John Questier and Jane Ince of the FSA was carried out to provide an understanding of the Food Standards Agency systems in place, their scope and reach and to identify potential shortfalls. The basis of the interview was to further explore the weaknesses identified in the findings of the National Audit Office Report on Meat Supply Chain Integrity ([NAO, 2013](#)). Associated interview questions relating to industry weaknesses were agreed with the FSA and developed into a semi-structured interview format.

Individual & collective stakeholder interviews were carried out using the semi-structured interview format to access relevant organisational literature, industry expertise and identify domain experts. Interviews were held with Retailers, Manufacturers and representatives from Local authorities.

The purpose of the survey and interviews was:

To further understand what is currently known about the nature and extent of food fraud.

To identify any information or fraud control methodologies that may not be currently known to the FSA or covered in available literature.

To help establish what methodologies are currently used by large manufacturers and retailers to manage food fraud.

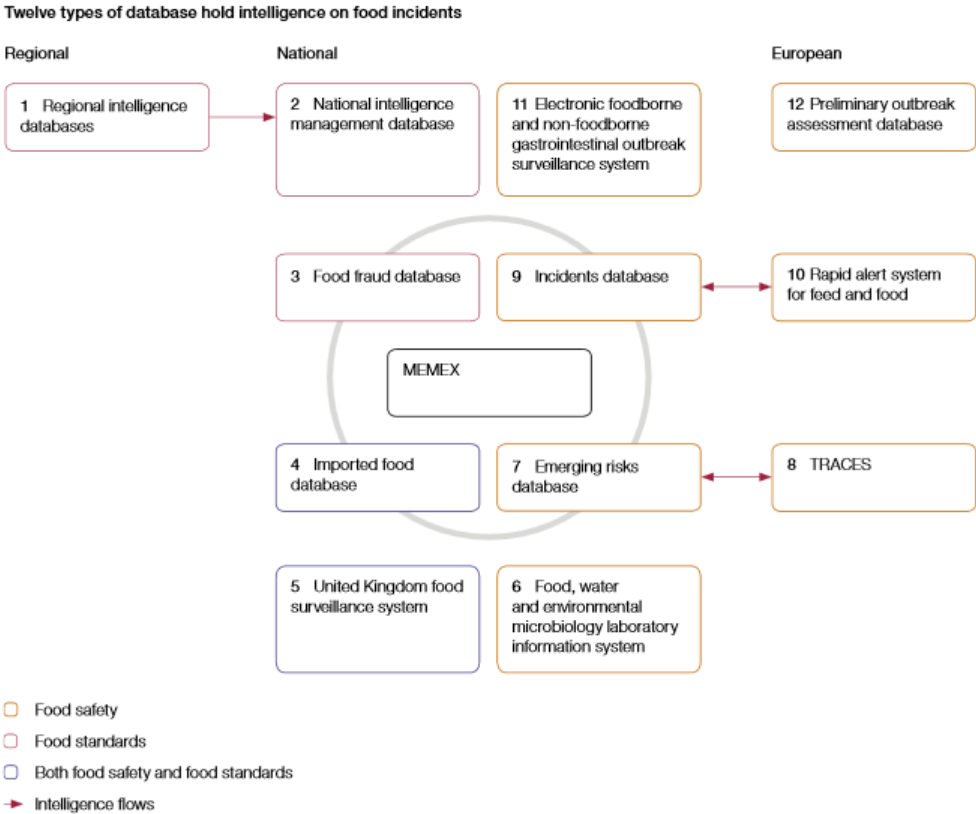
To better understand the financial mechanisms and other commercial drivers that impact purchasing decisions and thereby how fraudsters might seek to exploit these.

Interview results

Food Standards Agency

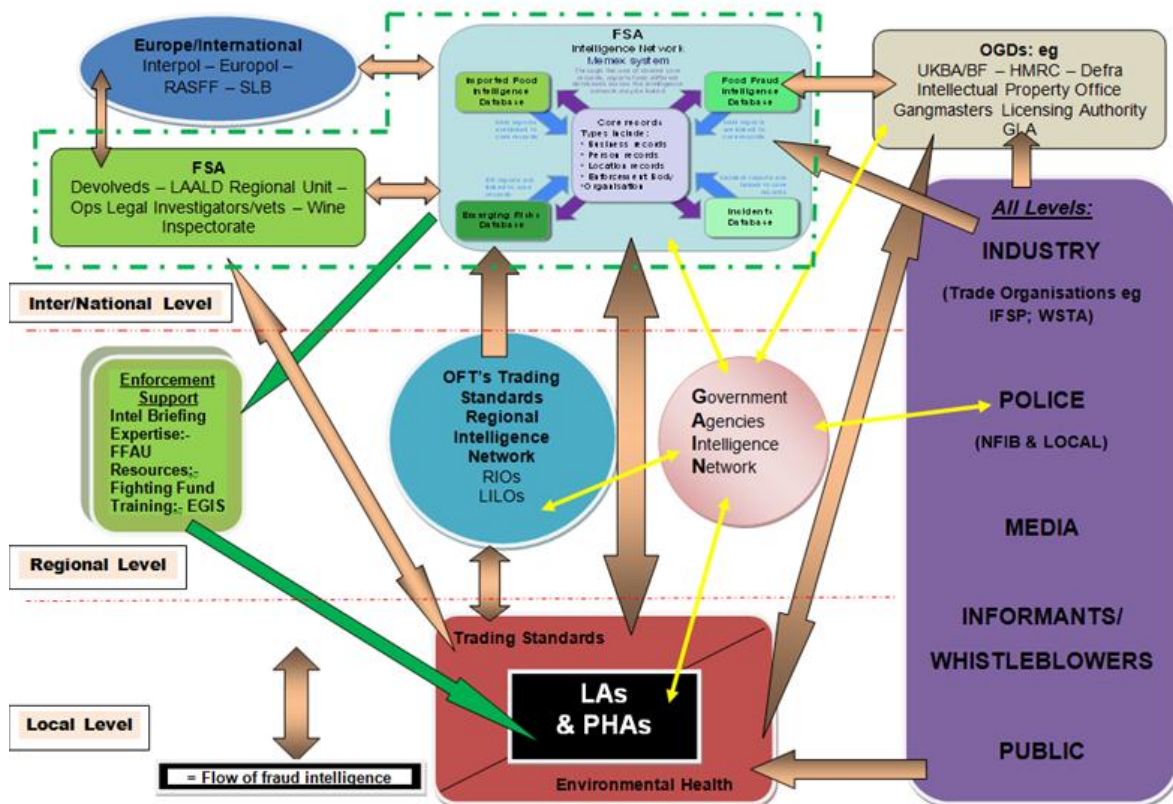
An interview with John Questier and Jane Ince of the FSA was carried out, using the framework of the findings from the National Audit Office Report on Meat Supply Chain Integrity ([NAO, 2013](#)).

Figure 1: FSA Intelligence Network



The best picture provided as to how FSA intelligence currently operates was a more detailed schematic diagram shown in Figure 2 of the inter-relationships of the various organisations in the intelligence network with no visibility of data sources or links.

Figure 2: Schematic representation of FSA Intelligence Interactions



The current quality & quantity of intelligence was questionable and the inadequate input from industry was highlighted. The limitations and reluctance to input on a blank page format for industry to provide intelligence was discussed; a template mechanism to facilitate industry input is in development by EU DG SANCO (New Food Fraud Department). There appears to be a strong perception by the FSA that industry has intelligence that they are not prepared to share.

The three notifications in the RASFF database on horse meat fraud in February and March 2012 were discussed. The response provided after the meeting was that they appeared to refer to horse carcasses/meat and as such appear to relate to the 'legitimate' trade in European horsemeat for consumption as such, (rather than dubious meat products). There is no information on the nature of the potential fraud, but there's no indication of meat species substitution. Also, the notifications are for UK general information only, as the UK were not a recipient of the meat and there is no requirement to take any action.

The FSA representative was not involved at the time of the notifications but was of the view that there is nothing to raise suspicions of the horsemeat species substitution affair – the legal trade in horsemeat has been subject to alerts for different reasons over the years as with most products.

The interview questions for industry were agreed with the FSA.

Industry Interviews

The list of questions and summary of responses are summarised in Appendix 2 – Industry Interview Responses and described below:

- There is a strong reliance on specifications and supplier assurance. The majority of businesses have introduced robust surveillance on meat since the Horse Meat Crisis.
- Confidentiality was identified as the key hurdle to overcome if businesses are to readily to share information.
- Authenticity testing protocols are predominantly advised by external laboratories. No independent sources of intelligence relating to testing protocols were identified.
- Supply chain assurance through 3rd party certification and site visits is commonly applied to secure the meat supply chain.
- Supply chains have been shortened, transparency strengthened, auditing increased, traders eliminated, tamper- proofing and testing introduced to increase protection by increasing the likelihood of detection and making it more difficult for the fraudster. This strongly supports the criteria and measures proposed within the “NSF Fraud Protection Model” framework.
- General agreement was established that authorities should be notified of suspected fraud. It was suggested that investigations into fraud should be handled covert to avoid driving fraud underground advised.
- In the main Food Research Associations & Trade Associations were identified as means of tracking emerging risks.
- A dis-joint was identified between industry response and those from Trading Standards & Public Analyst responses re the means of being notified of and investigations into fraud.
- A strong support for the “NSF Fraud Protection Model” approach was received.
- Industry was generally unaware of the National Sampling Programme for authenticity.
- There was a general willingness to share intelligence (strongly subject to confidentiality) and participate in a co-ordinated National sampling plan.
- Indemnity insurance was proposed as a means to protect the entire food chain.
- Unannounced audits were identified as a means to increase likelihood of detection of fraudulent activity.

A 'too good to be true' price pointing mechanism was recommended.

Survey

The project was modified post award of contract to amend the scope to include a survey to increase the number of industry participants and allow a more statistical approach to information gathering from industry.

An online survey was developed and circulated to a stakeholder list of industry contacts. This included 22 questions using SurveyMonkey to establish industry knowledge of food fraud, perceived risks and preventative measures already in place to defend against EMA.

The reason for creating a survey was to seek validation, or otherwise, from stakeholders of the key criteria drawn from the literature study and to seek any other aspects industry are aware of relating to food fraud as a basis for provoking further systematic thought processes and building an intuitive preventative model.

Prior to circulating the survey to the full stakeholder group it was trialled with the NSF consultancy group for evaluation and feedback. Minor modifications were made to simplify and clarify the question set. See Appendix 3 – Survey Questions.

A target list of Technical contacts within Retailers, Manufacturers, Laboratories, Public Analysts, Government Agencies was collated and the survey distributed.

In order to obtain the highest possible number of responses the survey was sent to NSF's database of manufacturers and retailers requesting that the link would be forwarded to their suppliers. See Appendix 4 – Survey Circulation List

Questions and response format were designed to ensure participants were required to respond in a positive or negative manner without allowing a neutral option, hence response formats of 1-6 and 1-4 were used so as not to allow a middle point to select.

Survey Monkey was used to capture results from which the results were extracted and statistically analysed:

Data treatment: 'I don't know' answers were treated as missing values.

The underlying data structure for Q1 was investigated using principal component analysis with Varimax rotation. For Qs 2, 3, 6 and 7, hierarchical clustering was used with Ward's methods using squared Euclidean distance. Paired sample t-test was used for comparing mean factor scores for Q1. Mean cluster scores in Qs 2 and 3 were compared using repeated measures ANOVA (with Sidak correction). Strength of relationships between measures were expressed as Spearman's r .

Level of statistical significance was set at $p < .005$ for all tests. To indicate the magnitude of difference or relationship independent of sample size, effect sizes are provided for all inferential statistics. Effect sizes were expressed as Cohen's d , r or

partial eta square (η^2). Interpretation of the effect sizes are summarised in Table 1 (Cohen, 1988; Rosenthal, 1996).

Table 1: Thresholds for interpreting effect sizes

Statistical test	Relevant effect size	Effect size threshold			
		Small	Medium	Large	Very large
Mean difference	D	0.200	0.500	0.800	1.300
	η^2	0.010	0.059	0.138	
Correlation	R	0.100	0.300	0.500	0.700

Data analyses were performed with IBM SPSS version 19.0. Effect sizes were calculated using Wilson's online Practical Meta-Analysis Effect Size Calculator (Lipsey & Wilson, 2001), available from:

<http://www.campbellcollaboration.org/escalc/html/EffectSizeCalculator-Home.php>;

and for paired sample t-test:

<http://www.cognitiveflexibility.org/efficientsize/efficientsizecalculator.php>

For repeated measures, calculations were corrected for dependence among means in order to make direct comparisons to effect sizes from between-subjects studies using Morris and DeShon's correction (Morris & DeShon, 2002).

Survey Results

To enhance information obtained from stakeholders via face to face interviews and two seminars a questionnaire was developed and circulated to industry representatives.

The full sample size was $n = 91$.

See Appendix 3 for full details of Survey Questions.

Appendix 5 provides detail of the respondents industry sector and experience.

Physical state of the food

Participants were asked to score various physical states of foods with respect to ease of food fraud perpetrated

84 participants answered

1303 individual question responses obtained

106 I don't know responses (8%)

Figure 3: Mean score of responses to show ease of fraud in relation to physical state of food.

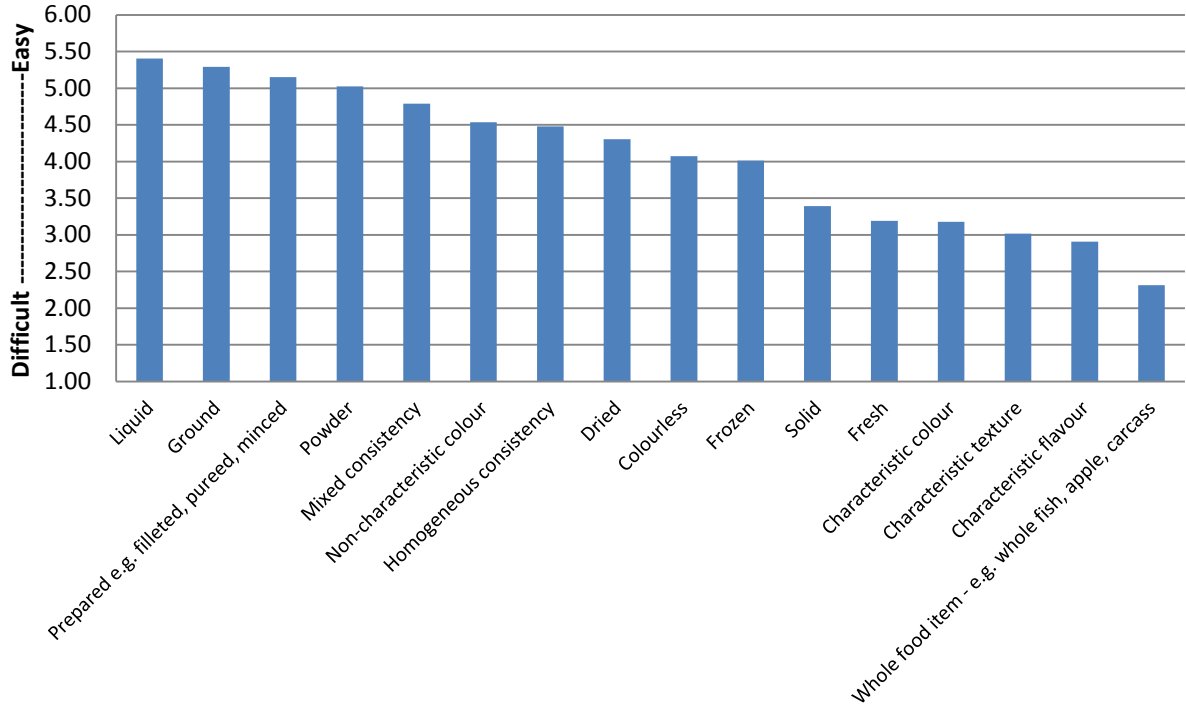
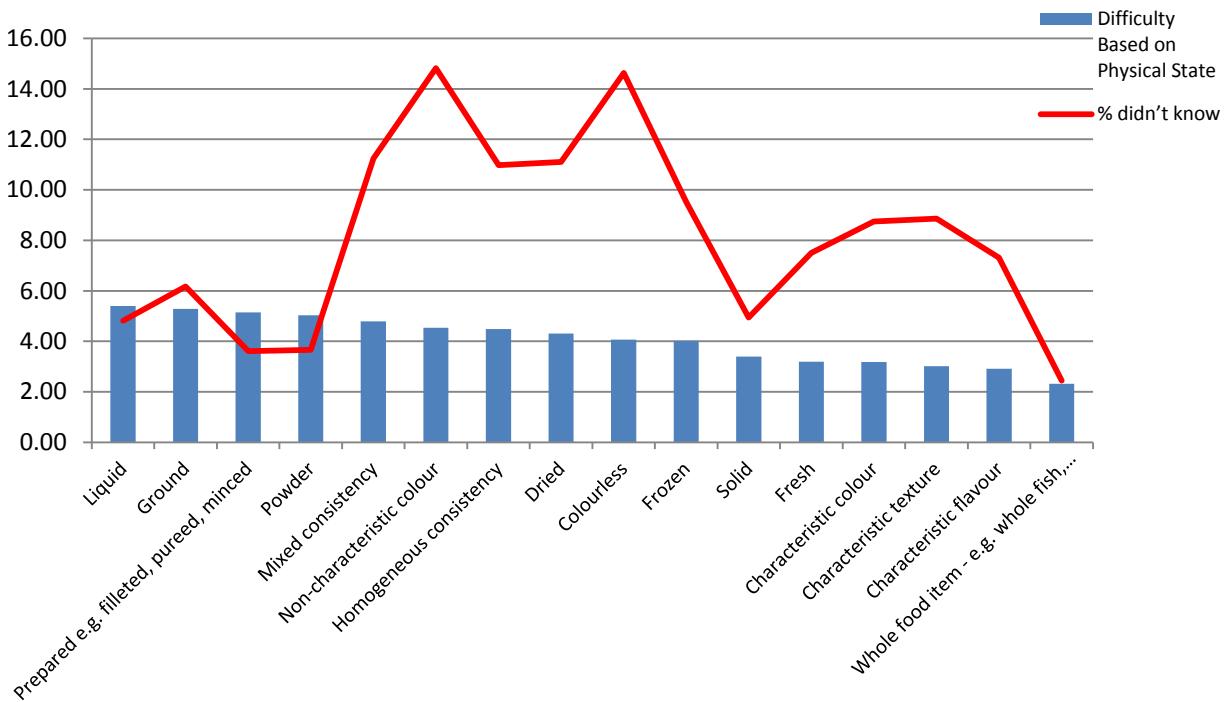


Figure 4: Percentage 'I don't know' responses per physical state.



Underlying structure was detected using principal component analysis with Varimax rotation. Factors were first extracted using eigenvalue > 1 criterion, then the number of meaningful factors to be retained was determined using Horn's parallel analysis (Horn, 1965; O'Connor, 2000; Kaiser, 1974) comparing the sample eigenvalues to eigenvalues generated from random numbers (Figure 3). The number of factors above the random number eigenvalue line were considered real factors and thus retained.

The presence of factor and sampling adequacy were tested using Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, respectively.

Assumptions:

Bartlett's χ^2 (120) = 33.569, $p < .001$ clearly indicated that the data contained detectable factors (components) with the adequacy of the sampling (KMO = .659) is above the minimum 0.5. Using the Kaiser (1974) characterization of KMO values, where KMO = 0.00 to 0.49 is unacceptable; 0.50 to 0.59 is miserable; 0.60 to 0.69 is mediocre; 0.70 to 0.79 is middling; 0.80 to 0.89 is meritorious and 0.90 to 1.00 is marvellous, it can be declared that the present KMO value of 0.66 is acceptable but mediocre.

The initial principal component analysis identified 5 factors with each eigenvalue > 1 which cumulatively explained 68.4% of the total variances. Although the first 4 factors were above the random number's eigenvalue line, the 3rd and 4th factors were very close (Figure 5). Therefore, principal component analysis was run again with only two factors. Factor loadings and factors for the 4 and 2 factor solutions are displayed in Table 3.

Figure 5: Sample eigenvalues plotted against random number eigenvalues (based on 100 correlation matrices, principal component analysis, 95% confidence interval, seed: 1000)

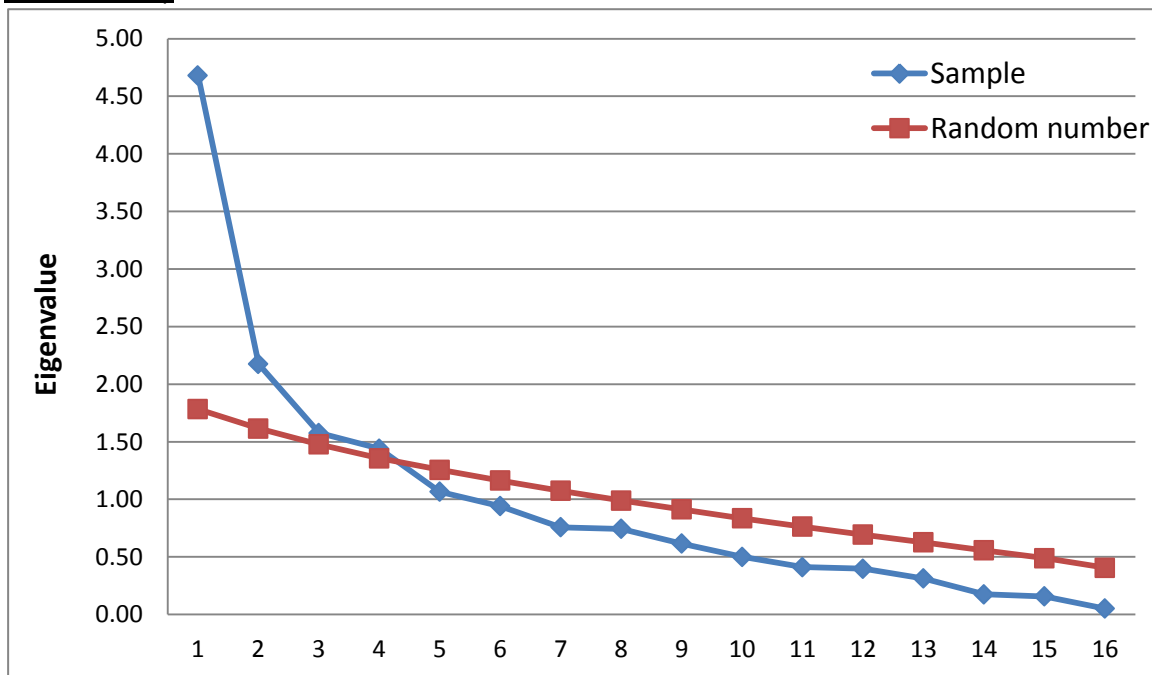


Table 3: Four factor solution of people's perception of food state characteristics for ease/difficulty to commit food fraud

	Component			
	1	2	3	4
Frozen	.786	.009	.038	-.049
Fresh	.730	.185	.193	-.210
Solid	.729	.198	-.197	-.018
Dried	.638	.155	-.089	.301
Prepared e.g. filleted, pureed, minced	.491	.194	.290	.196
Liquid	.485	-.006	.312	-.029
Characteristic flavour	.231	.899	.136	.073
Characteristic colour	.020	.889	.035	.014
Characteristic texture	.191	.886	.209	.050
Mixed consistency	-.123	.081	.781	.000
Homogeneous consistency	.060	.223	.624	-.036
Ground	.443	.204	.597	.119
Powder	.496	-.314	.504	.212
Non-characteristic colour	.151	.188	.092	.834
Whole food item - e.g. whole fish, apple, carcass	.366	.283	.189	-.638
Colourless	.091	.431	.205	.446

Cumulative explained variance = 61.7%; negative factor loading indicate reversed scoring (compared to the other variables).

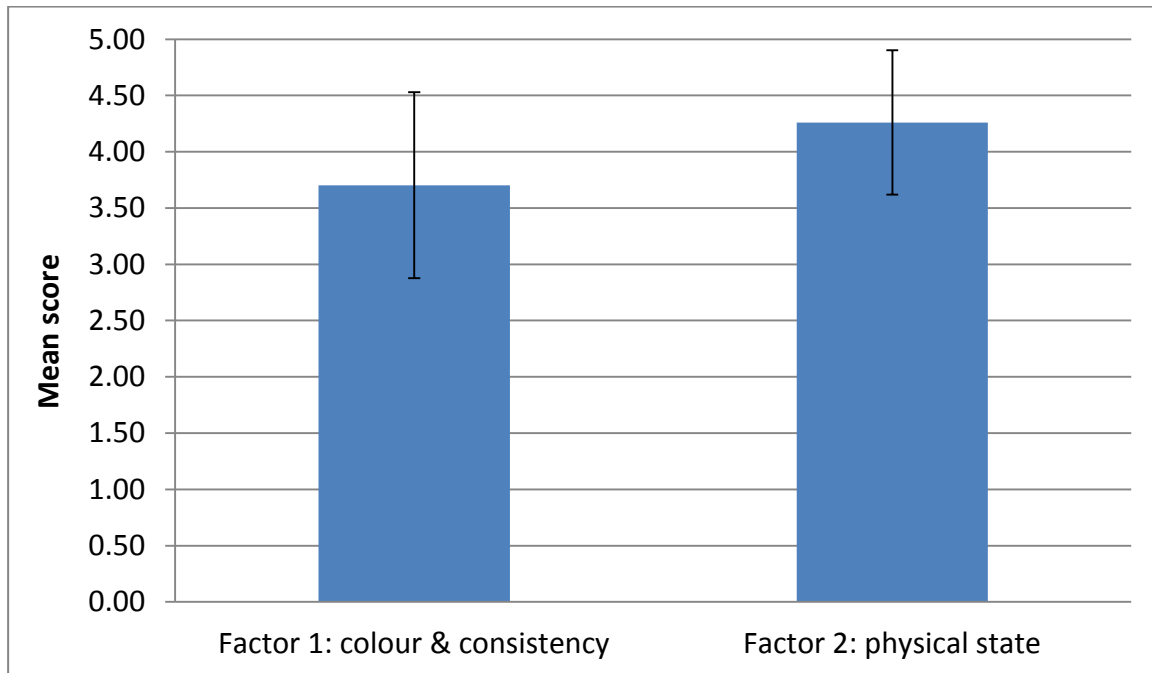
Table 4: Two factor solution of people's perception of food state characteristics for ease/difficulty to commit food fraud

	Component	
	1	2
Characteristic flavour	.913	.155
Characteristic texture	.912	.143
Characteristic colour	.861	-.075
Colourless	.542	.099
Non-characteristic colour	.355	.144
Homogeneous consistency	.355	.237
Mixed consistency	.255	.133
Frozen	.040	.748
Fresh	.213	.727
Powder	-.125	.666
Solid	.169	.595
Ground	.373	.587
Liquid	.081	.558
Dried	.206	.548
Prepared e.g. filleted, pureed, minced	.307	.531
Whole food item - e.g. whole fish, apple, carcass	.216	.377

Cumulative explained variance = 42.8%.

Factors obtained from the two-factor solution (Table 3) suggest that Factor 1 represents 'colour and consistency' and Factor 2 represents 'physical state'. One item (Mixed consistency) had a low factor loadings on both factors thus omitted from further analysis. Using this categorisation, the mean scores from each factor were compared. The means scores suggest that physical state (mean score = 4.26 ± 0.64) were considered as a lesser barrier to food fraud than colour and consistency (mean score = 3.70 ± 0.83). The difference between the mean scores were tested using paired sample t-test. The difference was statistically significant ($t(49) = 4.77, p < .001, d = 0.689$). The two factors showed a medium but statistically significant, positive correlation ($r = .389, p = .005$). The medium-to-large effect size for comparison indicates a practically significant and meaningful difference.

Figure 6: Comparison of the mean scores from the two empirical factors. Bars (whiskers) represent standard deviations.



The results show industry opinion that Liquid, Ground, Prepared and powdered products lend themselves to adulteration, which supports the findings identified from the literature review.

Profit

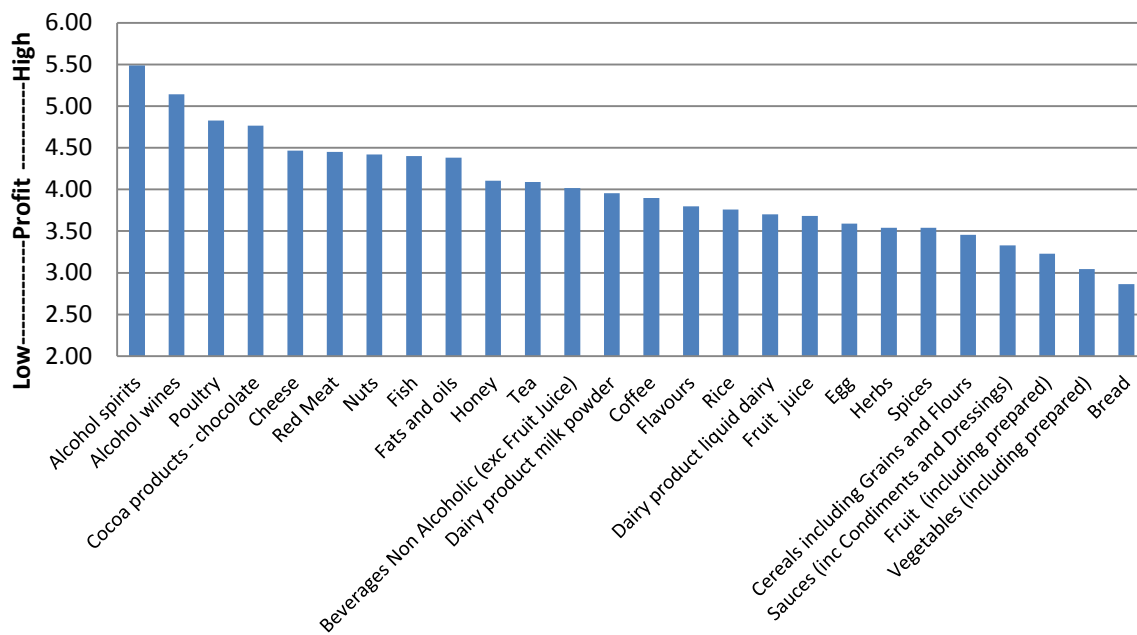
Participants were asked to estimate of the amount of profit associated to ingredient types with the proviso that partial or full adulteration of the item is undertaken.

75 participants answered

1943 individual question responses obtained

203 I don't know responses (10%)

Figure 7: Mean Profit score attributed to ingredient categories.

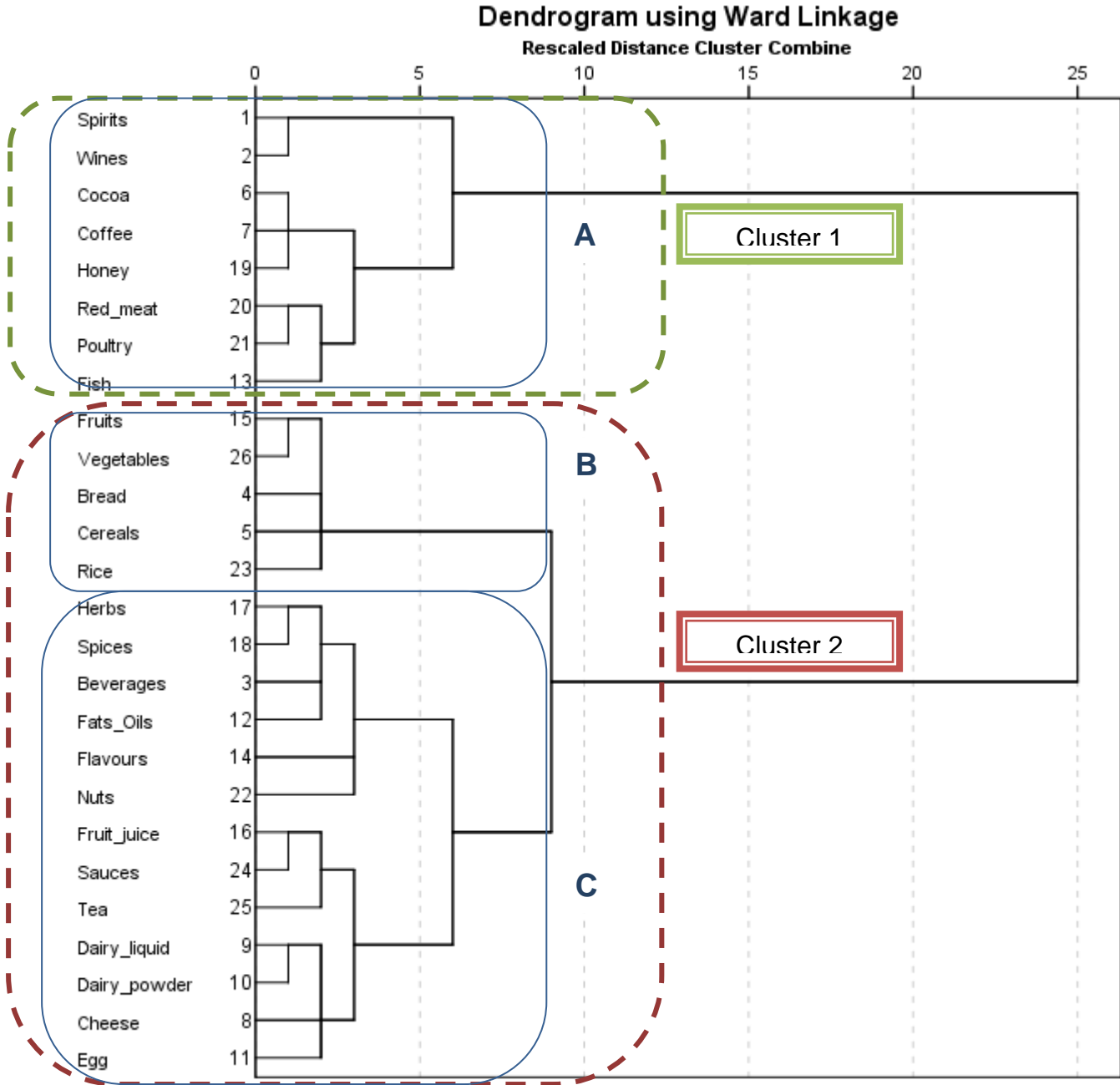


High value items were selected by participants as those with the highest profit associated. Alcohol, Poultry and Chocolate scored highest. These results are in line with the literature review conducted.

The reduction in participants answering this question and increase in the number of respondents selecting I don't know potentially indicates a lower confidence level of the industry when scoring profit. This could be due to category specific knowledge of the individuals participating hence they are confident to score the products they have experience compared to those they have no experience with.

Figure 6 shows the cluster formation process based on profitability of adulteration, resulting in 3 sub-clusters (labelled as A, B & C) and 2 main clusters (labelled as Cluster 1 and Cluster 2). Cluster 1 is equivalent to subclusters A, whereas the larger cluster 2 incorporated subclusters B and C.

Figure 8: Hierarchical cluster formation of the 26 food commodities based on profitability assessments



Likelihood of detection

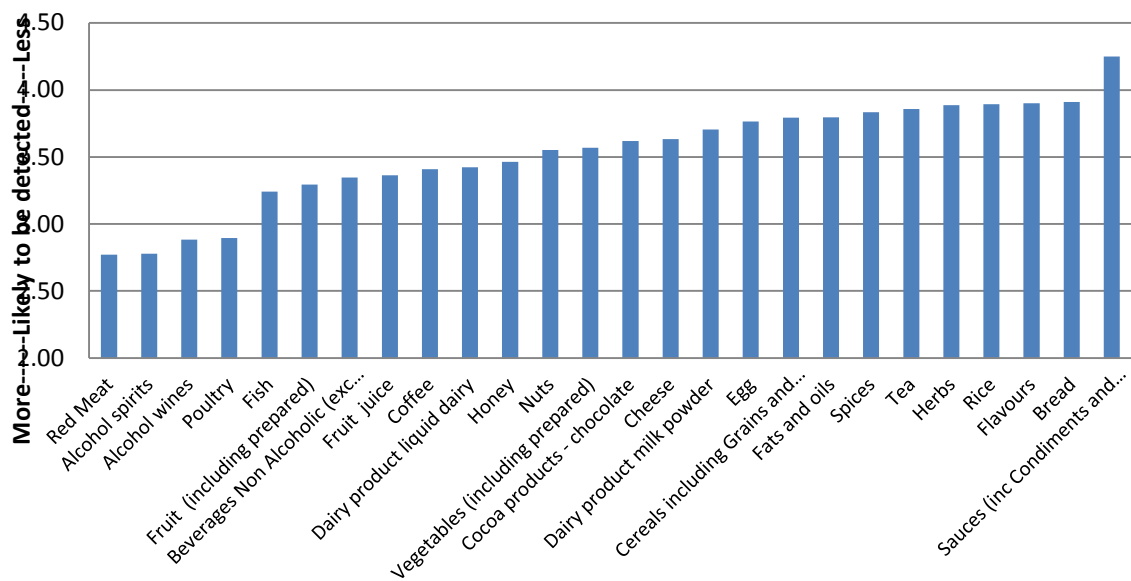
Using the participant's knowledge of current testing methodology available to detect adulteration participants were asked to score the likelihood of detection by authorities or purchaser for ingredient types.

63 participants answered

1630 individual question responses obtained

290 I don't know responses (18%)

Figure 9: Mean Score of Likelihood of detection attributed to product categories.

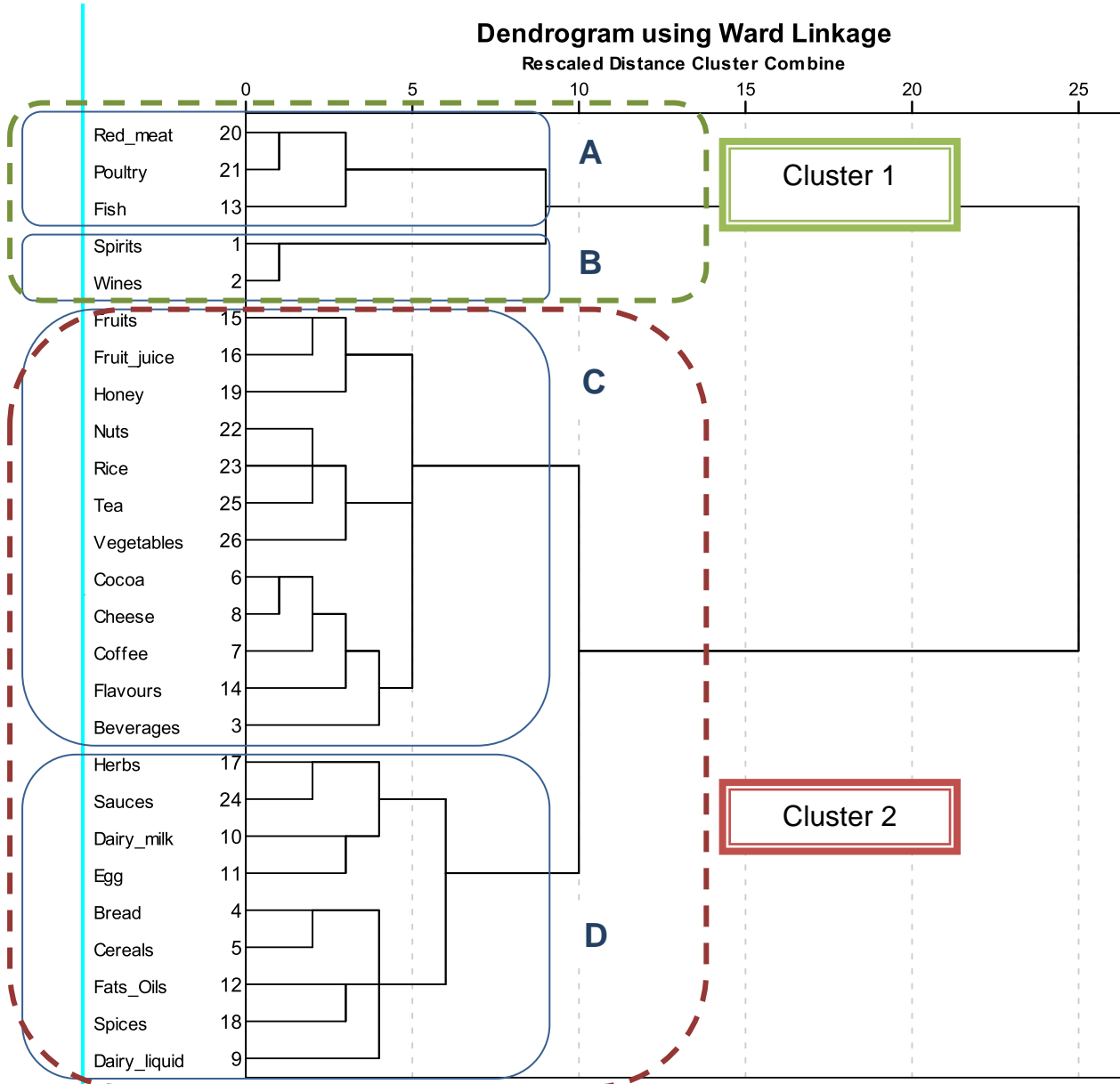


Unsurprisingly Red Meat was selected by participants as the category whose adulteration was most likely to be detected currently. Alcohol and Poultry are also identified as items if adulterated that would likely be detected.

The reduction in participants answering this question and increase in the number of respondents selecting I don't know may indicate a lower confidence level or reflect industry category specialisation.

Figure 10 shows the cluster formation process based on the likelihood of detection, resulting in 4 sub-clusters (labelled as A, B, C & D) and 2 main clusters (labelled as Cluster 1 and Cluster 2). Cluster 1 contains subclusters A and B, whereas the larger cluster 2 incorporated subclusters C and D. The common character of subcluster A and B is clear, each represent a type of foodstuff: varieties of meat in cluster A and alcoholic beverages for cluster B. The common factors in clusters C and D are less clear.

Figure 10: Hierarchical cluster formation of the 26 food commodities based on ease of detection assessments



Comparison of clusters from Q2 and 3

Despite that the two concept is expected to be inversely related (i.e., high likelihood of detection increases the 'cost' and thus lowers the expected profit), Figures 9 and 10 show that the same 26 food commodities were perceived somewhat differently for profitability from adulteration and the likelihood of detection of adulteration. Mean cluster scores, along with test statistics (repeated measures ANOVA) are shown in Table 5. (Note: In Q2, the response scale is downward bias, i.e., score 4 represent the medium on a 6-point scale).

Table 5: Summary table of within subjects comparisons of clusters from Q2 and Q3 individually; n = 55 for Q2 and n = 35 for Q3; high score indicates high profitability

		Mean ± SD	Test statistics and significance	Effect size (partial η^2)
Profit	Cluster 1 (also A)	4.7477 ± 0.51172	$t(54)= 13.349$, $p < .001$	1.919
	Cluster 2	3.6970 ± 0.73639		
	Subcluster B	3.2545 ± 0.87725	$F(2,53)= 103.549$, $p < .001$; A > B; B > C, A > C at $p < .001$	0.796
	Subcluster C	3.8671 ± 0.73402		
Likelihood of detection	Cluster 1	3.0400 ± 0.95769	$t(34)= -4.212$, $p < .001$	0.723
	Cluster 2	3.7347 ± 0.75295		
	Subcluster A	3.1048 ± 0.95579	$F(3,32)= 5.839$, $p = .003$ A = B ($p = .976$) A < C ($p = .008$) A < D ($p = .002$) C > B ($p = .023$) D > B ($p = .009$) D = C ($p = .681$)	0.354
	Subcluster B	2.9429 ± 1.38676		
	Subcluster C	3.6738 ± 0.77052		
	Subcluster D	3.8159 ± 0.86022		

Despite the small sample size, differences between the two main clusters, as well as between the subclusters within each question were statistically significant. The very large (Q2) and large (Q3) effect sizes for Question 2 confirms that the difference is, in fact, quite substantial in practical terms as well.

To facilitate examining the relationships between the clusters between clusters of Question 2 and Question 3, the full correlation matrix is displayed in Table 6.

Table 6: Correlation coefficients (statistically significant correlations are in bold)

		Cluster B (Profit)	Cluster C (profit)	Cluster A (detection)	Cluster B (detection)	Cluster C (detection)	Cluster D (detection)
Cluster A (Profit)	<i>r</i>	.372	.586	.143	.078	.169	.090
	<i>p</i>	.003	< .000	.329	.597	.325	.584
	<i>n</i>	62	56	49	48	36	39
Cluster B (Profit)	<i>r</i>		.726	.011	-.359	-.325	-.273
	<i>p</i>		< .000	.938	.011	.053	.088
	<i>n</i>		58	50	49	36	40
Cluster C (profit)	<i>r</i>			.009	-.050	-.311	-.143
	<i>p</i>			.954	.746	.078	.384
	<i>n</i>			45	45	33	39
Cluster A (detection)	<i>r</i>				.333	.387	.319
	<i>p</i>				.019	.015	.042
	<i>n</i>				49	39	41
Cluster B (detection)	<i>r</i>					.297	.170
	<i>p</i>					.067	.293
	<i>n</i>					39	40
Cluster C (detection)	<i>r</i>						.658
	<i>p</i>						< .000
	<i>n</i>						35

Note: Q2 - high score represent high profit; Q3 - high score represent less likely to be detected

The very large (Q2) and large (Q3) effect sizes for Question 2 confirms that the difference is, in fact, quite substantial in practical terms as well.

The mean scores of Profit and Likelihood of detection were plotted to provide the participants 'gut feel' placement of ingredient categories on the draft food fraud model.

Figure 11: Placement of ingredient categories on draft fraud model

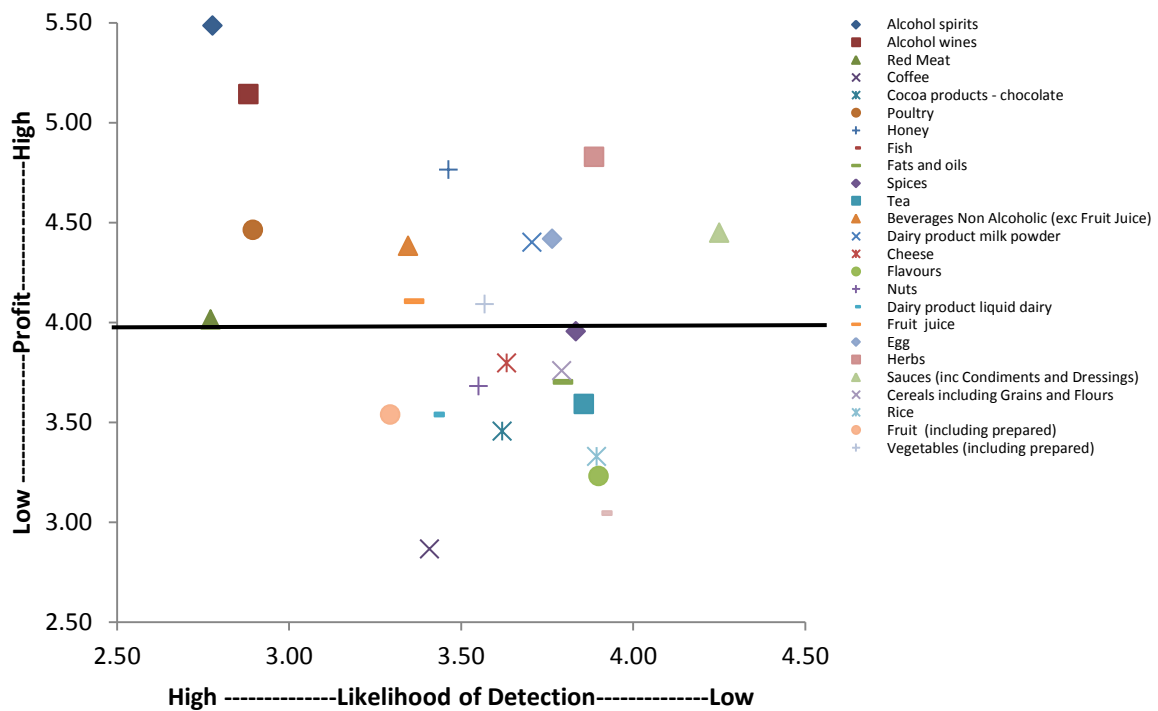


Figure 11 depicts the relationships between each food commodities based on assessment for profit level and likelihood of detection. Congruently with the identified clusters, spirits, wine and meat varieties dominated the left upper quadrant of high profit and high likelihood of detection. Cheese, Fats and oils, Egg and Milk powder were plotted in the top right quadrant- the most desirable scenario for a fraudster.

The opposite, least desirable, end is occupied by commodities such as coffee, fruit and liquid dairy products.

The above plot will be used within the model development to verify whether industry ‘gut feel’ is aligned with the EU Top 10 (as informed by the NCFPD Database reviewed) and the proposed “NSF Fraud Protection Model” systematic risk assessment model, necessary as a foundation to provide a predictive mechanism for collective industry improvement.

Methodology undertaken to assist with the detection of adulteration

This question was designed to identify the methodology in use in industry to assist in detecting food fraud to ensure that the project team were aware of all potential analytical and organoleptic methods in use.

43 Responses were collected:

The responses obtained were heavily biased towards species adulteration.

No additional techniques, tools or analytical methods were identified that had not been identified in the literature study.

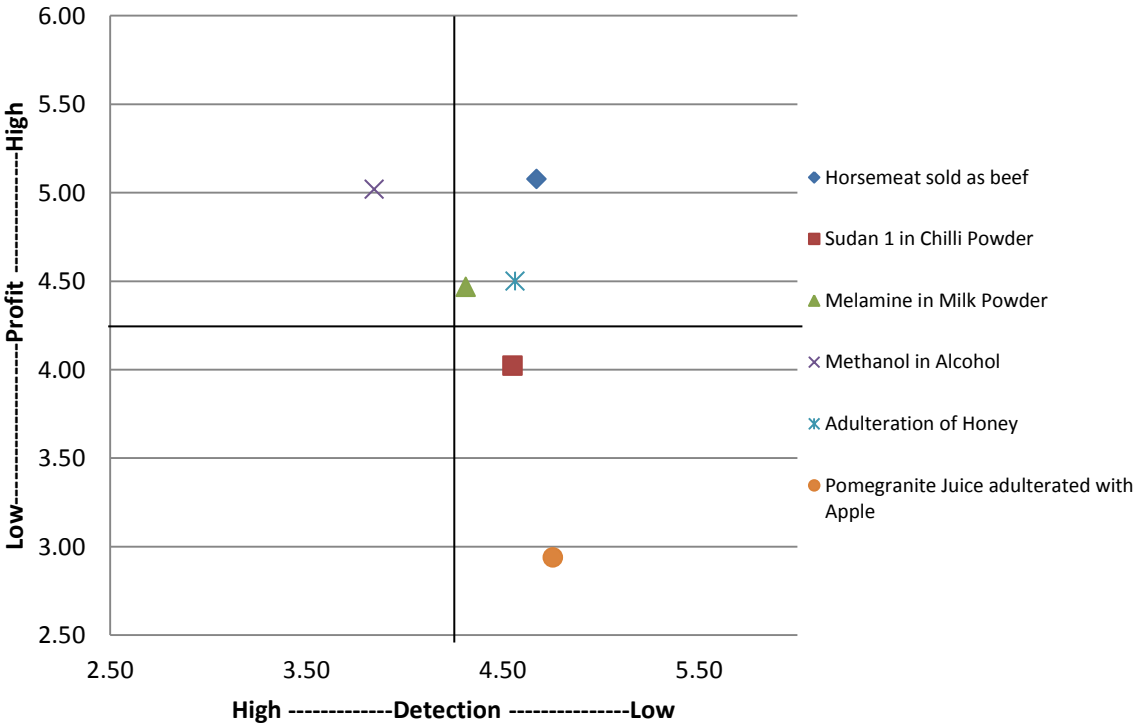
Participants were asked to score profit and risk of detection for well-known cases of adulteration.

This question was designed to ascertain the likely plotting of well-known high profile cases of food adulteration on the draft model and to validate the model.

Table 7: Profit & Risk Score for well-known incidents

Incident	Profit Score	Risk Score
Horsemeat sold as beef	5.08	4.67
Sudan 1 in Chilli Powder	4.02	4.55
Melamine in Milk Powder	4.47	4.31
Methanol in Alcohol	5.02	3.85
Adulteration of Honey	4.50	4.56
Pomegranate Juice adulterated with Apple	2.94	4.76

Figure 12: Well Known Incidents plotted on draft model



Mean results indicate that all incidents scored by industry would fall into the most appealing quadrant on the draft model, hence validating the thought processes informed by the literature review.

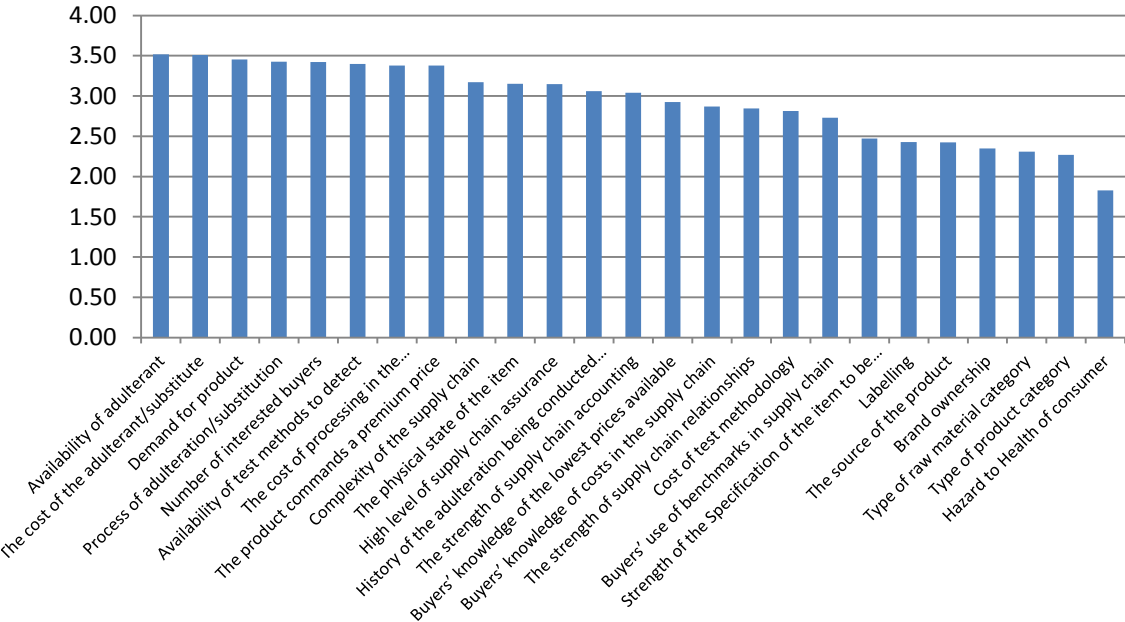
Important factors in the fraudster’s decision to commit fraud

Informed by the literature study, participants were asked to score criteria identified as key contributors to the decision to perpetrate fraud.

Table 8: Key contributors to perpetrate fraud

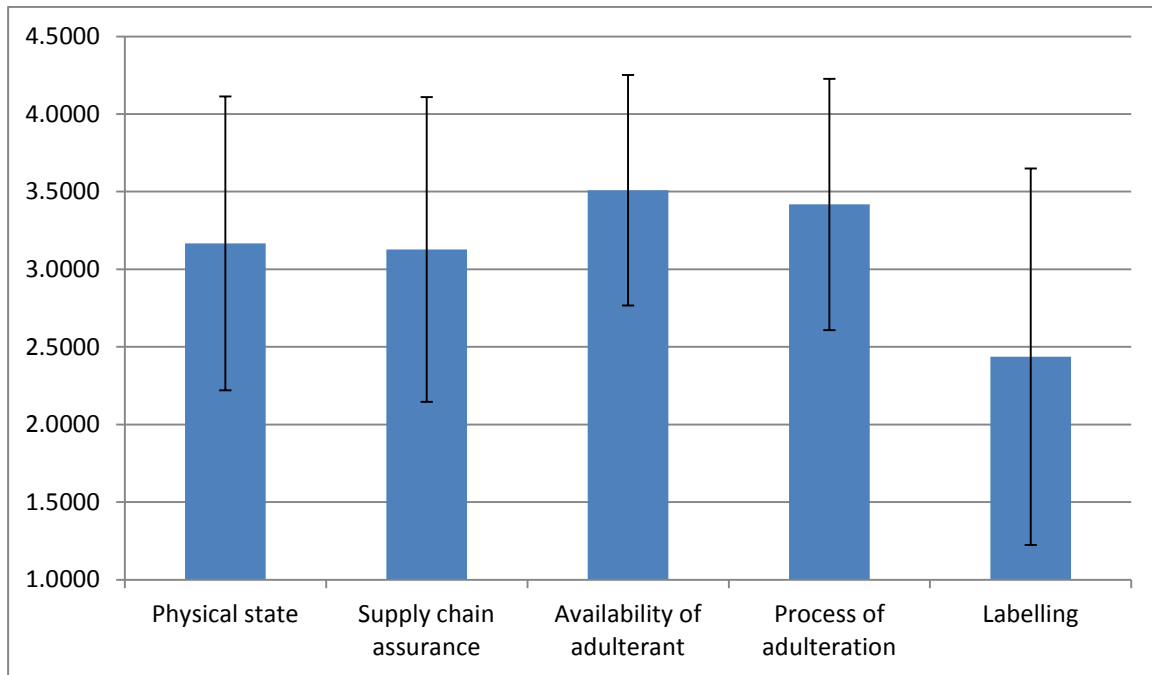
Importance of below in a fraudster’s decision to commit fraud?	Mean Score
	1 Not Important at all
	4 Very Important
The physical state of the item	3.15
High level of supply chain assurance	3.15
Availability of adulterant	3.52
Process of adulteration/substitution	3.43
Labelling	2.43

Figure 13: Factors in the fraudster’s decision to commit fraud



The perceived importance of motivators and deterrents are depicted in Figure 13. The key motivator appears to be the availability and the process of the adulterant or substitution. The relative low score, coupled with the wide spread is notable, particularly in the view of Figure 8.

Figure 14: Perceived importance of motivators and deterrents

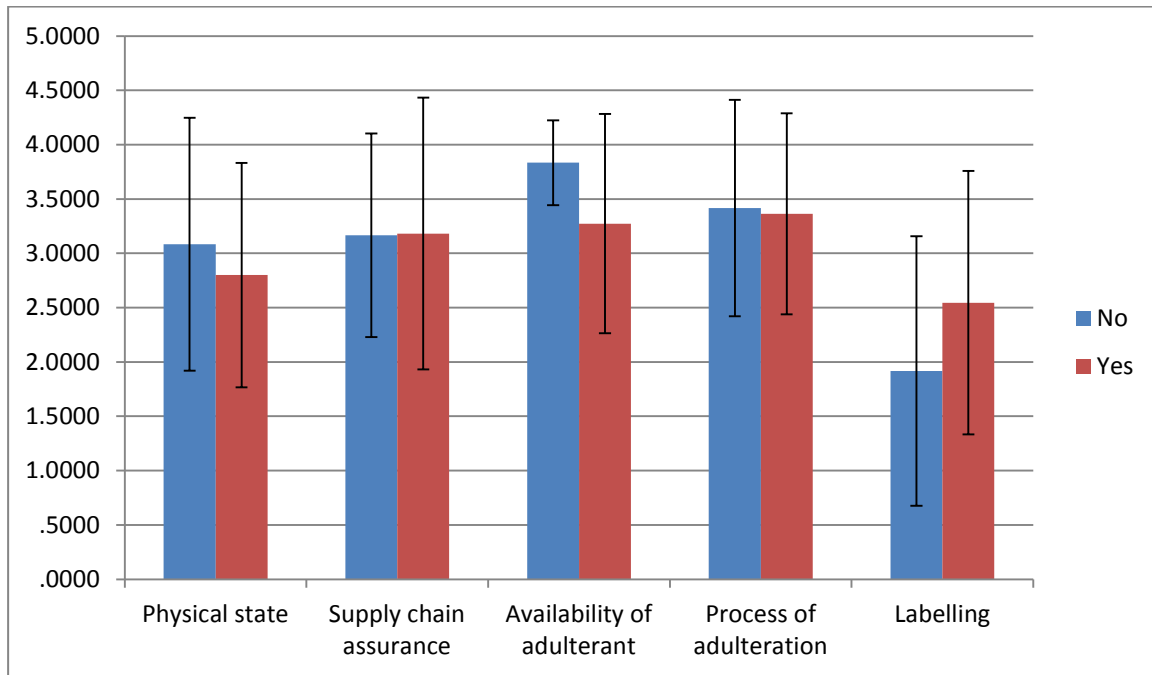


Comparison of the perceived importance of these motivators and deterrent factors by Q13 is displayed in Figure 14. Respondent who answered Q13 affirmatively considered four of the five factors less important, but labelling. However, there was no statistically significant difference in perception of importance for factors enticing/detering from adulteration, but in some cases it might be due to the small sample size ($n = 23$). Test statistics and effect sizes are given below:

- The physical state of the item: $t(20) = 0.598$, $p = .557$, $d = 0.258$
- High level of supply chain assurance: $t(21) = -.033$, $p = .974$, $d = 0.014$
- Availability of adulterant: $t(12.7) = 1.729$, $p = .108$, $d = 0.802$
- Process of adulteration/substitution: $t(21) = .132$, $p = .896$, $d = 0.055$
- Labelling: $t(21) = -1.227$, $p = .233$, $d = 0.513$

Two of the five factors, availability of the adulterant and labelling exhibited medium to strong effect size.

Figure 15: Comparison of perceived importance of factors in enticing/deterring fraud by Q13



There were 44 responses (48.4%).

Figure 15 shows the cluster formation process based on the likelihood of detection, resulting in 3 clusters provisionally names as 'cost/benefit' ('can I do it?'), 'others' and 'product'. Of these three, factors grouped in Cluster 1 were perceived to be the most important, followed by items in Cluster 2 and 3, respectively (Figure 16). The difference between the three clusters were statistically significant ($F(2,42)= 59.034, p < .001$, partial $\eta^2= 0.738$; Cluster 1 > Cluster 2 ($p < .001$); Cluster 2 > Cluster 3 ($p = .002$) and Cluster 1 > Cluster 3 ($p < .001$).

Figure 16: Hierarchical cluster formation of the 20 motivators/deterrents

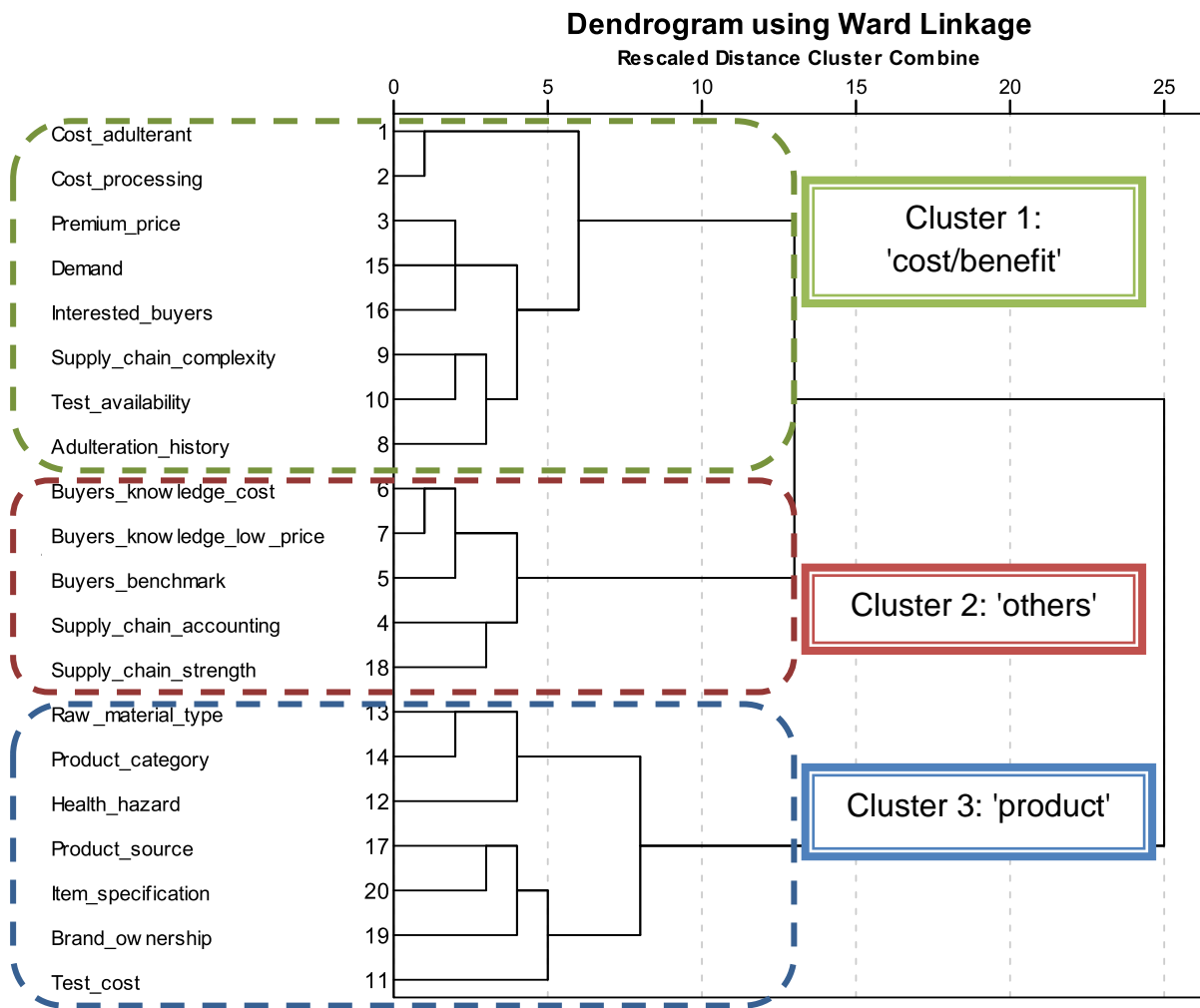
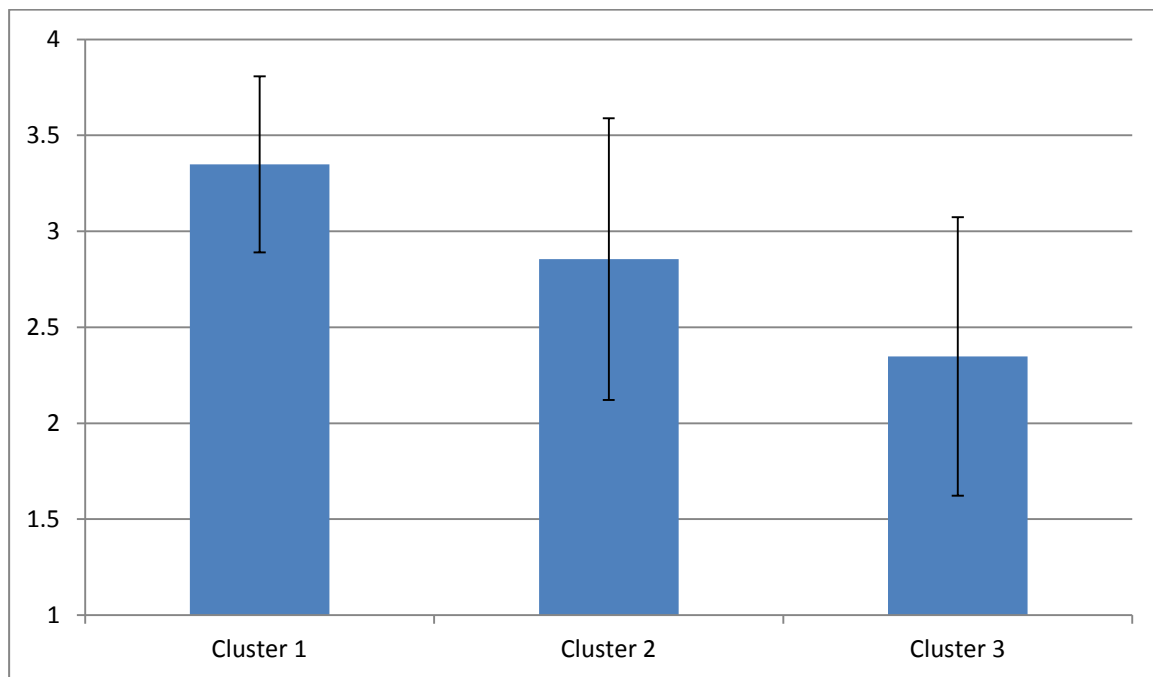


Figure 17: Comparison of cluster mean scores (high score represent high importance)



Supply of Retail and Branded product and Impact on means and Q3

Mean scores for each food commodities, as well as for the clusters were compared depending on whether the respondents supply retailer own product (Q13).

Note: There are only 23 responses (25.3%) for this question, of which 11 responded 'yes' and 12 responded 'no'.

With the exception for likelihood of detection in poultry and red meat (Q3), there was no significant effect for Q13. However, the sample size was very small which may result in non-significant test results for otherwise meaningful difference.

Tools and information sources the participant is aware of to assist in the detection and prevention of food fraud

The Her Majesty's Revenue and Customs (HMRC) import control system was identified as an additional source of information that had not previously been reviewed that warrants further consideration.

Details of mechanism to alert of 'too good to be true' pricing (Price Pointing)

63% of respondents stated that a mechanism was not in place to alert of too good to be true pricing offered by suppliers.

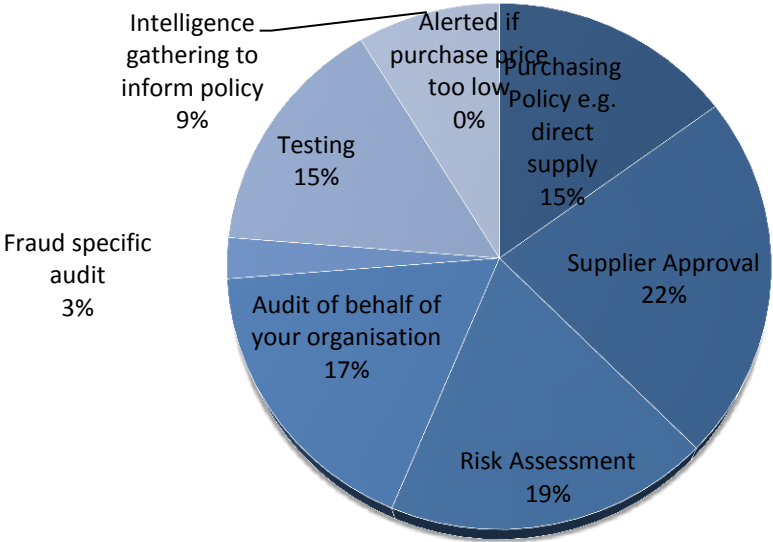
The answers to this question were vague with very few direct answers to the question given. Key themes were specifications, long term relationships, systems

along the whole chain, unannounced audit, benchmarking and intimate knowledge of market pricing.

This potentially indicates a lack of Governance & oversight or disconnect of internal departments, i.e. buying and sourcing could potentially have mechanisms in place however the respondent's predominantly technical contacts are unaware of such.

Measures to protect against fraud in use

Figure 18: Measures in place to protect against food fraud



Results show that only 19% of respondents include fraud within their product risk assessment, with a lower percentage of 9% monitoring intelligence relating to food fraud. This potentially identifies a key shortfall in the industry.

Responses to this question support the themes drawn from the literature review

Further comments pertinent to report

Claims were identified as a key theme for further exploration; Halal, Organic and Country of Origin were identified as key.

The approach of National Agencies and their handling of food fraud was identified as a key aspect for further focus, participants identified that agencies were not necessarily taking a business friendly approach but business were scared of enforcement authorities.

Guidance on how businesses can avoid food fraud was requested to be made readily available

Economic climate of a country was identified as a potential driver for individuals to commit adulteration as everybody is looking for the cheapest price in order to survive.

A centralized 'whistle-blowing' facility specific to the food industry should be considered. The major UK retailers all have their own systems, but they are too focused on their own brand protection, rather than the big national / international picture which came to light in horse-gate. They would be better off investing this resource into a specialist food fraud unit, ideally under the auspices of the FSA or some other government agency rather than their own private interests, or umbrella bodies such as BRC or the Food and Drink Federation. Neither of these can really be trusted by the public, as they exist only to protect and promote their members' interests.

The role of discount retailing and retail buyer's pressures and retailer margins
Customer expectations in terms of pricing. Lack of regulatory enforcement capabilities

Phase 3: Initial Assessment Framework

Framework Population

A five-point scale used to define and map the key parameters of the framework was designed and tested against a number of food categories. These food categories were selected to cover as broad a range of the framework criteria as possible: Beef Trim (pre- and post- the horsemeat crisis), Saffron, Coffee, Wheat, Potatoes and Olive Oil were tested against the framework to establish its ability to identify foods, most and least likely to be targeted by fraudsters.

The project team met to discuss the findings and to incorporate additional metrics within the proposed framework from the information gained during the research phase. The model was adapted as an iterative process to reflect the motivation for the fraudster to commit the crime, hence increasing the likelihood of a risk to industry.

The model remained based on a Boston Consulting Group (BCG) type Matrix as originally intended although the project team felt that a MARCI style model might also be appropriate as a visual means of displaying and formatting risk assessments.

The BCG style chart is particularly useful when the primary purpose of the prioritization exercise is for risk response: risks plotting the farthest in the upper right quadrant represent the highest impact and risk and would benefit the most from additional management effectiveness in managing the risks (COSO, 2012).

A MARCI style chart remains an option or alternative for the visual display of data.

Developing the Metrics

In each case, the indicative criteria included within the assessment table are ranked from 1-5, where 1 is the least attractive or beneficial to the fraudster and where 5 is the most attractive.

Likelihood of detection is calculated as an average score from the criteria & plotted on the x axis and profit is calculated as an average score and plotted on the y axis.

Difficulty to the Fraudster is represented by the size of the circle or plot on the model calculated from an average score as small (1-2), medium (2.1-3.5) or large (3.6-5).

Quadrants

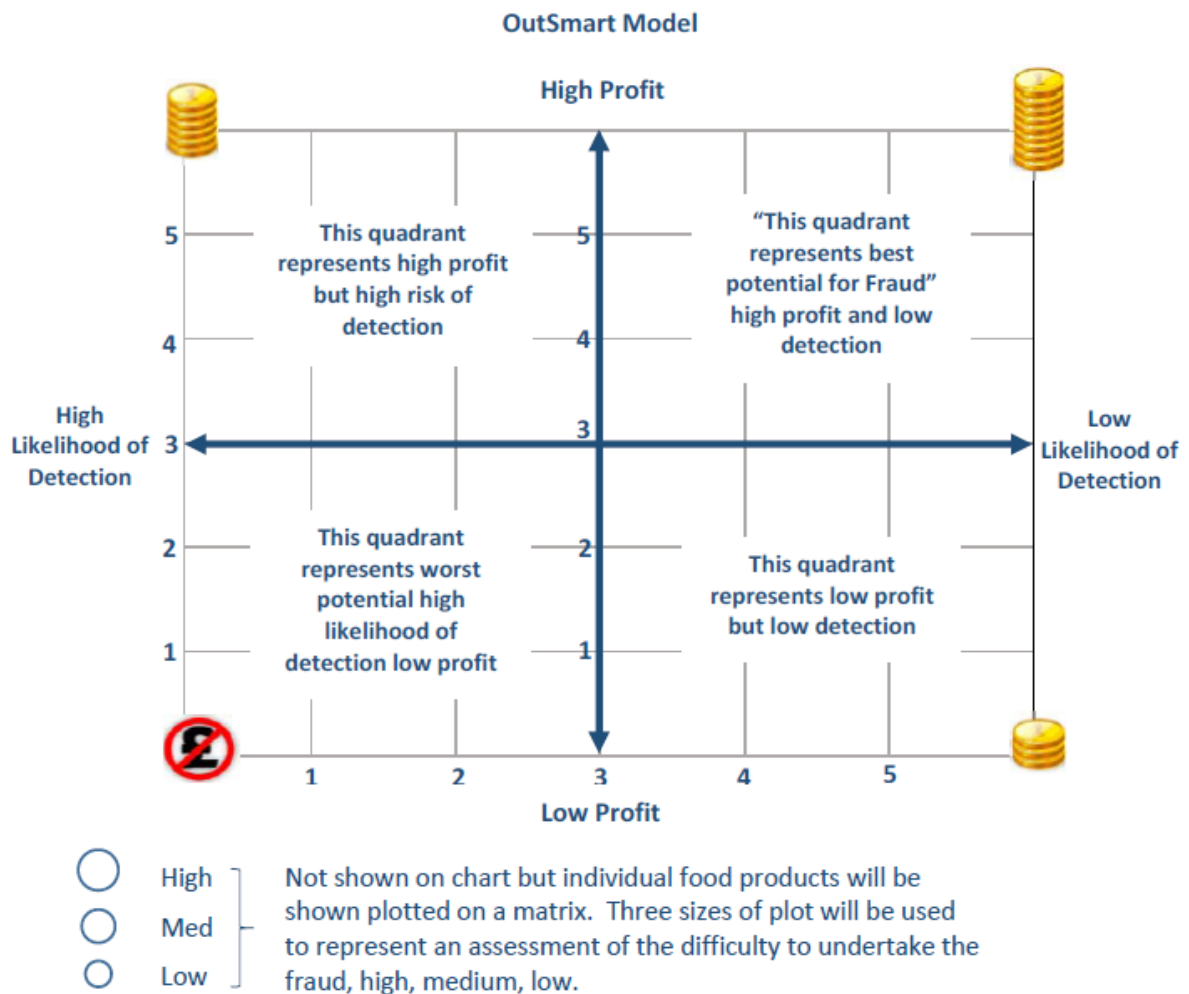
Categories falling into the top right quadrant (High Profit & low likelihood of Detection) are the most attractive to fraudsters – denoted graphically by the largest pile of coins.

Categories falling into the top left quadrant (High Profit & High likelihood of Detection) are attractive but carry a high risk of detection – denoted by the second largest pile of coins.

Categories falling into the bottom right quadrant (Low Profit & Low likelihood of Detection) – denoted by the smallest pile of coins.

Categories falling into the bottom left quadrant (Low Profit & High Likelihood of Detection), least desirable to the fraudster & lowest risk to the industry- denoted by a crossed-out £ sign.

Figure 19: Proposed Fraud Framework



Scale Derivation

1. Profit

Initially, the project team planned to examine the return on investment (ROI) to the criminal as a measure of profitability and financial attractiveness. This is a difficult concept to put into practice, and the literature sources state aspirations for measuring profitability and economic gain, rather than offering a model to do so. In order to measure profitability, information is needed about the investment made to carry out the adulteration, mis-labelling or substitution and about the process costs involved.

Another approach was to adapt target cost models to indicate where potential for economic gain exists. This type of model works backwards from market price to the target cost that the producer has to achieve in order to make a desired profit. The margins of retailers and intermediaries, as well as full cost of production and distribution at each stage are deducted to calculate the desired cost. The model highlights very clearly the motivation for producers and intermediaries to engage in economically motivated adulteration, particularly with the downward pressure on prices highlighted in the Elliott Report (2013).

However, this was complex for the initial static model in development. Therefore, a more basic approach was adopted to build up the concept of profit and then profitability from first principles.

The first step was to use publically available commodity data from indexmundi.com; meatprices.co.uk; indianspice.com and FT.com to derive a cost per kilogramme for each commodity (£/kg). This required adjustments to data which was quoted in different currencies and weights. The £/kg was then ranked from the highest (Saffron) to the lowest (Oats). This ranking demonstrated immediately the potential for profit between known fraudulent substitutions such as olive oil and peanut oil, or salmon and other fish.

Cost of Commodity and adulterant

Two key criteria were developed: cost of the commodity and cost of adulterant, using a reasonable division of the prices on the £/kg ranking.

Premium

The third criterion chosen was whether or not a premium was available for the product. The rationale is that the higher the potential mark up by the retailer or intermediary, the greater the margin for profit available to the criminal. The literature search shows that the foods most likely to be adulterated are premium products such as olive oil, honey, alcohol etc.

Sales Volume

The fourth criterion is currently sales volume, as a proxy for the amount that could be sold. This is problematic, because it is a relative figure that depends on whether a large amount can be sold through a retailer or through small shops or the Internet. The project team propose further refinement of this criterion to produce an economic measure of demand for the product. Other factors relating to volume are covered in the Ease/Difficulty dimension of the matrix, including access to a supply chain or market.

Table 9: Profit Metric and Criteria

Profit Indicative criteria					
		Cost of Commodity	Cost of Adulterant	Profit margin	Sales Volume
High	5	High raw commodity cost greater than £10/kg indicates profits more likely to be high	Low cost of raw commodity adulterant(s) <£0.5/kg indicates profits likely to be higher	Very high profit margin available greater than 50%: high premium product	Large number of potential outlets
	4	Medium-High raw commodity cost between £10/kg and £3/kg indicates profits more likely to be high	Medium-low range raw commodity cost between £0.5/kg and £1.50/kg indicates profits more likely to be moderate	High profit margin available between 10%-50%. Premium product.	
	3	Medium range raw commodity cost between £3/kg and £1.50/kg indicates profits more likely to be moderate	Medium range raw commodity cost £1.50/kg and £3/kg indicates profits more likely to be moderate	Moderate profit margin available around 10%: everyday item with some premium but main opportunity is to undercut market price.	
	2	Middle-low raw commodity cost between £1.50/kg and £0.50/kg indicates profits more likely to be high	Medium-High cost between £3/kg and £10/kg indicates that profits are likely to be low	Low profit margin available between 1%-10%. Everyday product with limited opportunity to undercut.	
Low	1	Low cost <£0.50/kg indicates that profits are likely to be low	High cost greater than £10/kg indicates that profits are likely to be low	Very low or no premium available: basic commodity	Few outlets

2. Likelihood of Detection

Eight criteria were identified on the strength of the information reviewed.

Previous/ reports /Incidents: Reports of EMA incidents in any category frequently recur at varying frequencies. This is often reflective of the fraudsters changing the nature of the adulterant, so avoiding detection. Once detected, the likelihood of subsequent detection is increased through routine testing and surveillance by industry and regulators such that that particular adulterant is no longer attractive, until industry focus and attention is distracted.

The pattern within the scale currently defined provides a starting point for the model. It should become clearer now that fraud has attracted much more attention from the industry and databases have recently been set up to allow analysis of the data not previously possible.

Purchasing/Trading Specification: Since the Fraudsters intentionally set out to avoid detection, the likelihood of detection is inverse to the sophistication of the specification.

Testing Frequency: The less often testing is carried out, the less likely the detection.

Supply Chain Complexity: The complexity of the global supply network has increased the vulnerability to fraud. The more complex the supply chain the easier it is for the fraudster to avoid detection.

Supply Chain Integrity/Assurance: It is easiest to perpetrate a crime in businesses that have the least level of assurance. There is currently little if any difference in risk to the fraudster as a consequence of assurance since fraud controls are only now being introduced through GFSI following the Horsemeat crisis. The current shift towards unannounced audits may help to put paid to some localised fraud in the interim.

Test Efficacy: Fraud is often revealed with the introduction of new technology (e.g. Isotope testing of origin), the nature of the adulterant is also changed to avoid the detection method used (e.g. melamine in milk) or the target of the test is removed (e.g. Filtering honey). This scale is reflective of the available tests to detect the nature of the intended fraud.

Health Hazard: Fraudsters do not intend to cause harm since this would provide an alert and increase the likelihood of detection.

Deterrent: Soft penalties for food fraud make it an attractive alternative to criminals compared to other types of crime. The penalty of being caught will however be a part of the decision making process.

Table 10: Detection Metrics and Criteria

Detection Indicative Criteria									
		1	2	3	4	5	6	7	8
		Previous Reports/ Incidents	Purchasing/ Trading Specification	Testing Frequency	Supply Chain Complexity	Supply Chain Integrity/ Assurance	Test Efficacy	Health Hazard	Deterrant
Highly Likely	1	Current	Fingerprint/DNA/ Isotope	Positive release on intake at Manufacture	Direct Supply	Audited (Fraud); Governance	3 out of 3 Low cost /effective/ frequent	Immediate- Severe (Death)	Life imprisonment
	2	Year Ago	Independent CoA	Routine	Multiple Supply-Tier	Audited (Compliance - Unannounced)	2 out of 3 of above	Immediate - Likely to trigger surveillance	Imprisonment
	3	1-5 Years Ago	Indicator/Protein/ CoC	Import Checks	Trader	Audited (Compliance- Announced)	1 out of 3 of above	Medium Term	Substantial Fine
	4	5-10 Years Ago	Organoleptic	Surveillance Programme/Infrequent	Commodity n-tier	Licensed	Below Detection limit	Long term- Non traceable	Moderate Fine
Low Likelihood	5	Never	Volume/Weight	None/ Unavailable	Co-operative/ Bulk Storage	Unlicensed	Unavailable/ Never done	None	Bad publicity

3. Difficulty

Four criteria were identified from the literature review and analysis of the databases.

Physical State: Liquid adulteration with liquid is common and physically the easiest to perform. Grinding of e.g. spices into powders makes it easier to carry out and less likely to be spotted. Recent experiences highlight the higher risk from frozen materials where blocks are less likely to be scrutinised than chilled. Entire items are least likely as a target (e.g. Fish are filleted; Fruit is pulped or juiced).

Availability of adulterants/ substitutes: The nature of the adulterant depends on how available it is locally and its relative cost hence profit. This can range from addition of freely available materials e.g. water & organic matter, to relatively cheaper substitutes (e.g. industrial salt, alternative juices, oils & fish/meat species) and non-food chemical availability & cost (e.g. fake eggs & rice; melamine purchase restricted).

Ease of adulteration/substitution: Many incidents occur prior to packaging of any description in bulk form due to dilution & mixing. Thereafter re-labelling requires little effort & investment, followed by freezing which requires more specialist equipment and re-packing (often in conjunction with re-labelling and/or freezing) become sequentially more difficult/ less attractive to the fraudster

Labelling/Tamper-proofing: Many incidents occur prior to packaging of any description in bulk form. The difficulty thereafter increases progressively with respect to packaging type, contents / quantity & integrity.

Table 11: Difficulty Metrics and criteria

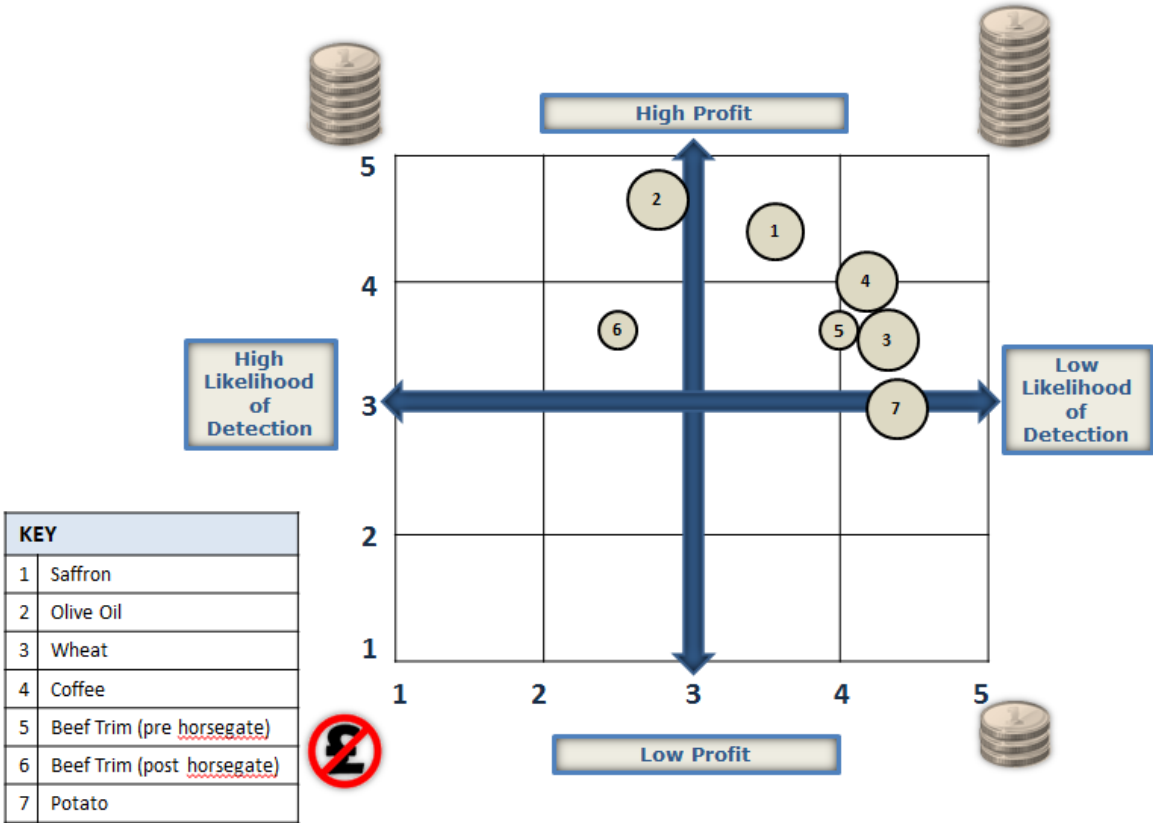
Difficulty Indicative Criteria					
Difficulty		Physical State	Availability of adulterants/substitutes	Ease of adulteration/substitution	Labelling/Tamper Proofing
High	5	Entire	Restricted/ Technically complex	Complex Processing	Retail Pack
	4	Heterogeneous/Solid chilled	Available (Expensive)	Re-pack	Barcode
	3	Solid/ Frozen	Available (At a cost)	Freezing	Integral/Tamper proof
	2	Powder	Widely Available	Labelling	Sticker/ Removable
Low	1	Liquid	Freely	Dilution/Mixing	Bulk/ None

Validation

A number of food items selected for their differing properties and involvement in previous incidents were ran through the model. Initial calculation based on average prices and margins does place items close to where expected in the literature and in the perceptions survey.

However, the concern is that there are very few items where an economic return could not be made through fraudulent means. This suggests that either we need to weight the criteria and that even very basic commodities such as root crops or cereals could be subject to adulteration.

Figure 20: Model Validation



Phase 4: Organisational Validation

The review also explored how the model once created could be used in practice and how information might be shared between industry and regulators whilst maintaining confidentiality as appropriate.

A presentation was given by the “NSF Fraud Protection Model” team members of the background and development of the project to date at the user group meeting. Attendees were provided with hand outs of the ‘gut feel’ output from the industry survey and model framework and associated criteria for profit, detection and difficulty.

Industry representatives were asked collectively and individually for their reaction to the framework and their comments have been collated and summarised below:

Meeting Feedback Summary

The model as presented was considered to be reflective of current Best Practice adopted amongst the attendees. User group felt adoption of the model would be beneficial as a systematic mechanism, particularly for businesses beyond the reach of the major retailers for example for SMEs that can’t afford the resource and expertise that retailers have access to.

The overriding message from the group was the need for a dynamic picture and customisation for business needs.

Post - Meeting feedback summary

A feedback form was circulated after the meeting requesting recommendations for improvement and commentary on the model metrics, additional criteria, data source recommendations, ideas for dynamic improvements.

Further comments were obtained from 1:1 meetings with representatives of three leading supermarket retailers.

Responses were analysed and investigated by the group and enhancements identified for further exploration as part of the “NSF Fraud Protection Model” development.

Phase 5: Proposal for Development of “NSF Fraud Protection Model”

Revised and Final Metrics

The three tables below set out the revised and final metrics for the developed model.

Table 12: Final Profit Metrics

Profit Indicative criteria					
		Cost of Commodity	Cost of Adulterant	Profit margin	Sales Volume
High	5	High raw commodity cost greater than £10/kg indicates profits more likely to be high	Low cost of raw commodity adulterant(s) <£0.5/kg indicates profits likely to be higher	Very high profit margin available greater than 50%: high premium product	Large number of potential outlets
	4	Medium-High raw commodity cost between £10/kg and £3/kg indicates profits more likely to be high	Medium-low range raw commodity cost between £0.5/kg and £1.50/kg indicates profits more likely to be moderate	High profit margin available between 10%-50%. Premium product.	
	3	Medium range raw commodity cost between £3/kg and £1.50/kg indicates profits more likely to be moderate	Medium range raw commodity cost £1.50/kg and £3/kg indicates profits more likely to be moderate	Moderate profit margin available around 10%: everyday item with some premium but main opportunity is to undercut market price.	
	2	Middle-low raw commodity cost between £1.50/kg and £0.50/kg indicates profits more likely to be high	Medium-High cost between £3/kg and £10/kg indicates that profits are likely to be low	Low profit margin available between 1%-10%. Everyday product with limited opportunity to undercut.	
Low	1	Low cost <£0.50/kg indicates that profits are likely to be low	High cost greater than £10/kg indicates that profits are likely to be low	Very low or no premium available: basic commodity	Few outlets

Table 13: Final Detection Metrics

Detection Indicative Criteria								
	1	2	3	4	5	6	7	
	Previous Reports/ Incidents	Purchasing/ Trading Specification	Testing Frequency	Supply Chain Complexity	Supply Chain Integrity/ Assurance	Test Efficacy	Cost of Test	
Highly Likely	1	Current	Fingerprint/DNA/ Isotope	Positive release on intake at Manufacture	Direct Supply	Audited (Fraud); Governance	Effective	£
	2	Year Ago	Independent CoA	Routine	Multiple Supply-Tier	Audited (Compliance - Unannounced)	Targeted quantifiable	££
	3	1-5 Years Ago	Indicator/Protein/ CoC	Import Checks	Trader	Audited (Compliance- Announced)	Available Low Detection Limit	£££
	4	5-10 Years Ago	Organoleptic	Surveillance Programme/ Infrequent	Commodity n-tier	Licensed	Available High Detection limit	££££
Low Likelihood	5	Never	Volume/Weight	None/ Unavailable	Co-operative/ Bulk Storage	Unlicensed	Unavailable	£££££

Table 14: Final Difficulty Metrics

Difficulty Indicative Criteria				
Difficulty	Physical State	Availability of adulterants/ substitutes	Ease of adulteration/ substitution	Labelling/ Tamper Proofing
High	5 Entire	Restricted/ Technically complex	Complex Processing	Retail Pack
	4 Heterogeneous/ Solid chilled	Available (Expensive)	Re-pack	Barcode
	3 Solid/ Frozen	Available (At a cost)	Freezing	Integral/ Tamper proof
	2 Powder	Widely Available	Labelling	Sticker/ Removable
Low	1 Liquid	Freely	Dilution/ Mixing	Bulk/ None

Model Key Criteria Improvements

- **Profit**

Other criteria could be included and assessed, such as increased/decreased cost of processing as a result of the adulteration ranging from 5 adding water / cheap relabeling and so most attractive to the criminal through to 1 involving significant investment and so unattractive. However, this is skewed by the presence of money laundering among organised criminals: the investment in the factory or its processes may be due to money laundering and therefore, the return on operating cost or investment is less an issue.

Further work to develop this initial phase of the model would include:

- Building economic criteria for supply and demand based on production figures. Indicators of where deficits in premium commodities appear and where surpluses of cheaper substitutes appear would allow us to measure the opportunity existing for the criminal (which would give a red flag for retailers and others). However, these need to be understood on a commodity by commodity basis to allow for storage.
- Building criteria for fluctuations in price and significant movements in price indices based on economic data. These can be affected by food speculation and care needs to be taken in their use, particularly for volatile items.
- Considering weighting the averages.

It is proposed to use the University of Portsmouth access to Bloomberg to widen the number of commodities examined and to test the feasibility of easily extracting economic data. Publically available economic data is highly aggregated and lags behind in terms of availability. Therefore, we need to search for a cost effective way of making the data available through a dynamic model.

- **Detection**

- **Reported/Previous Incidents.**

- Fraud history is relevant and supported by the literature review and industry feedback general confidence was obtained that the outer score points were appropriate. However further evidence is required to ensure 2-4 are suitably placed, due to the immaturity of fraud incident collation and focus the data is not available to make any further changes at this stage and to answer the question posed at the user group 'Is it a straight line relationship as incidents may cause copycats and perversity?'

- **Test efficacy:** It is recommended that the metric should be split into 2 maintaining efficacy with carrying criteria ranging from not available through to specific/effective testing. Test cost to be introduced as the feedback from the user group provided confirmation that the cost of testing is inversely proportionate to the amount of testing conducted.

- **Testing frequency:** It is recommended to remove unavailable from Score 5 as a duplication of the test efficacy criterion.

- **Deterrent and Health Hazard:** These were considered to be precursors to the decision to perpetrate a fraud hence were removed from the final proposed model. The impact of the fraud on health to consumer should be considered as an additional metric for future development.

- **Difficulty**

No changes were identified that required amendments to the initially proposed criteria and metrics.

The “NSF Fraud Protection Model” model aims to provide a proactive approach to the potential for fraud. The scope of this project was to produce a static model and the project team have done this.

How to use the model

We anticipate that small food safety and integrity teams situated in food businesses, trade associations and possibly regulators can use the model to assess the **relative susceptibility** of a range of food products to fraudulent attack. This in turn helps focus limited resource on intervention methods such as enhanced testing and auditing.

The project team themselves found the most useful way to apply the model was to form a small group with as broad technical and product expertise as possible to then assess products individually reaching a team consensus on scoring the three assessment criteria. Ideally we recommend a team including:

- A Product category specialist who understand the relevant food technologies
- An individual with forensic or laboratory expertise who understand testing
- Financial knowledge of the products (Category buyers would be ideal)
- A facilitator with broad industry experience

In our experience the project team select categories of food and collectively and quickly came to conclusions as to how to position them on the model.

We anticipate that assessing most foods for the purpose of initial plotting on the framework would take around 15 minutes per item allowing 4 per hour sometimes a little more when there is rapid agreement. Realistically 4 persons working in 3 hour blocks of time each day using a paper based static method could assess 50-60 products a week. Within a month a major retailer should be able to “map” the relative risk of fraudulent attack against the majority of products already identified as susceptible on the basis of past attacks plus a substantial number of others i.e. from the NCFPD and USP databases.

This is a time commitment that could be reduced by companies agreeing to share lists although this would have to be facilitated in a secure environment, perhaps through a trade association since there is obviously some risk that effectively mapping relative susceptibility to fraud could be abused if the information falls into the wrong hands.

Eventually we see a library of mapped susceptibility being produced which is revisited and updated as circumstances change for example price or detection

methods. This could be shared amongst buying and technical teams to heighten awareness of fraud potential and to better direct preventive intervention.

Additional potential for Development

The originally proposed framework whilst modified has remained essentially intact in terms of its key metrics and visual design. However, stakeholder consultation particularly with industry representatives has identified and clarified several potential broad areas for enhancement and innovation. These are:

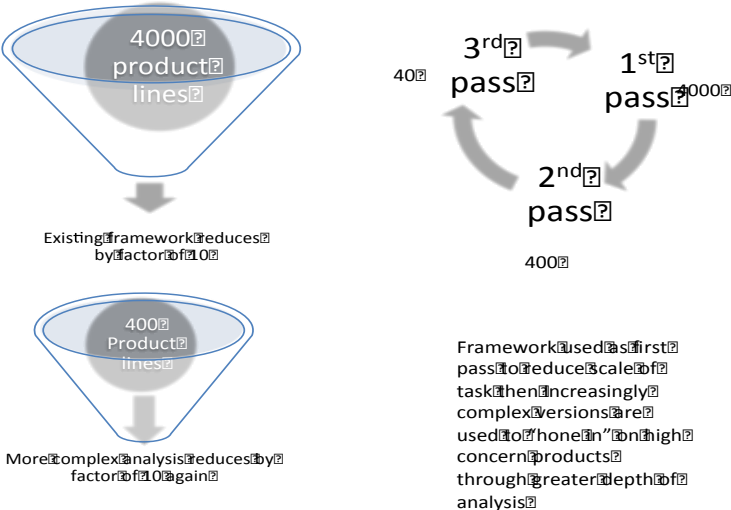
Enhancing the metrics

1. By increasing the complexity of the model and or the proposed measurement indices to take account of a wider set of factors that may influence decisions to commit fraud. However this has a downside since complexity will tend to make practical use, particularly by industry less likely as it increases costs and slows reaction time. However, converting the paper based framework to an online intranet enabled version would speed use and facilitate sharing within an organisation.

Using Information Technology

One proposal to tackle this problem is to create a layered approach with the complexity of analysis increasing as the sample size decreases as shown in Figure 21 below.

Figure 21 Layered process to manage analysis volume



2. By using information technology to enhance the frameworks ability to respond in real time to changing market conditions for example price or trading volumes and to make data entry and assessments easier through automated processes. For example scoring.

Integration with other Tools

Enhancements associated with the use of technology both to input data in real time particularly trading data in terms of volume and price would be very helpful but also using technology to automate and simplify the input process and underlying framework metrics for example using touch screen or tablet style applications.

3. By integrating the framework with other tools identified as part of the project research to provide a comprehensive “dashboard” that predicts, tracks and detects food fraud at the earliest opportunity.

Further enhancement could be achieved through the creation of and linking up of a whole series of integrated assessment models, intelligence gathering and platforms for deciding potential impact and appropriate intervention subsequent to identifying a product is particularly vulnerable or relatively attractive to fraudsters.

Potential Adulterants - Link to adulterant used is required as food safety risk may be introduced at this stage e.g. Allergen, Carcinogen e.g. Sudan I, Other severe health hazard e.g. Melamine. The adulterant used by the fraudster is key to each of the metrics proposed within the model, we therefore propose that further work is conducted to identify adulterants previously used vs product commodities and importantly highlight potential unknown adulterants. We are aware of useful sources of information to assist with this task namely USP database and NCFPD Susceptibility database which identify items likely to be targeted.

“NSF Fraud Protection Model” International Collaborative Intelligent Platform

The current “NSF Fraud Protection Model” uses a simple chart for visual impact, would be developed to include indicators relating to changes in supply and demand for both products and substitutes. In its dynamic form, the model would draw on risk data from the network analysis tools to highlight specific changing areas of concern to the industry, in order to shift from reactive to preventative action.

Technology

Two methods and software types have been identified – Gap Minder & Predictive Analytics – that would potentially enable the framework to become a dynamic platform capable of delivering near real-time intelligence on areas at highest risk food fraud at different points in time.

Gapminder is a freely available model which demonstrates changes between data over periods of time. It is demonstrated by Professor Hans Rosling on <http://www.gapminder.org/>.

Predictive Analytics/Big Data

A network analytical tool has been developed by the project team members from Kingston University ([Nepusz, Petroczi & Naughton](#), 2009), for monitoring global food

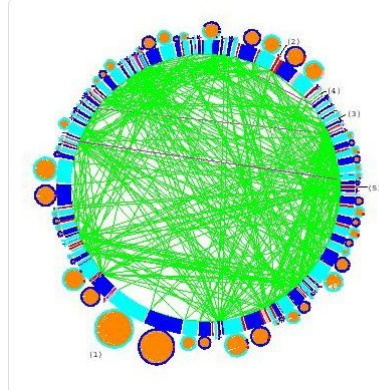
safety using RASFF data.

Indeed, industries with a full-time focus on fraud (e.g. Banking, Insurance, healthcare) have already adopted next generation solutions for predictive analytics.

This solves the 'big data' challenge, provides visibility & Intelligence and facilitates the paradigm shift from post-incident forensics to proactive and predictive fraud prevention

[Data Science Central](#) is an online resource for big data practitioners. From Analytics to Data Integration to Visualization, Data Science Central provides a community experience that includes a robust editorial platform, social interaction, forum-based technical support, the latest in technology, tools and trends. A specialist section on [forensic and fraud analytics](#) provides a useful resource.

Figure 22: Forensic & Fraud Analytics Tool



One of the key features of network analysis is that this will allow harvesting and processing the data instantaneously. In other words, there is not the same need for standardised data as there is in certain economic models, although there may be some scope to homogenise data. This gives network analysis a significant time advantage over other predictive models.

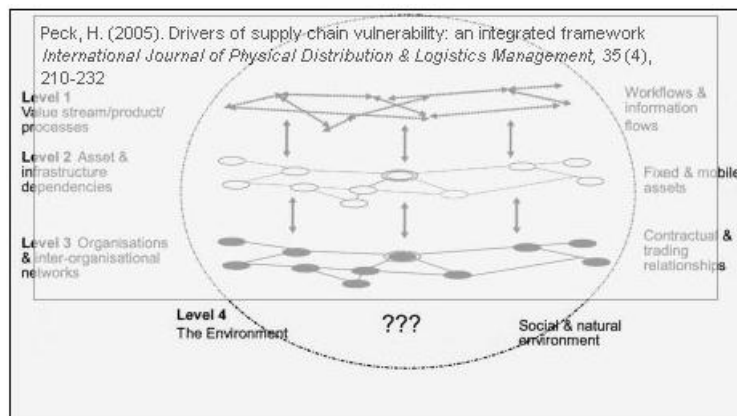
Macro-level Data

To develop the “NSF Fraud Protection Model” further, indicators relating to the macro-level environment of the food supply chain need to be incorporated. Supply chains need macro-level environmental information to develop fraud risk management tools. Different authors see potential in the use of global economic data in creating predictive models for food fraud. However, the majority of economic databases both lag current events and are highly aggregated. This makes it difficult to see where immediate issues of supply and demand which drive both pressures and opportunities for food fraud arise. We conclude that web-crawlers, data mining and network analysis drawing information on weather, disease, market prices, etc would provide a much more immediate picture of upcoming supply and demand issues. In the fast moving field of data mining, advances can be expected on a monthly basis and thus, a fluid approach is a necessity. For this reason an open ended coverage is warranted for these final sections.

Although different researchers foresee the potential of data analysis, the problems involved in collecting, analysing and presenting macro-level data have not been fully resolved nor made widely available.

Peck (2005) emphasises that a resilient network involves much more than the design and management of robust supply chain processes. It is important to recognize that by taking actions to reduce risk at one point within the four levels, at the same time the risk profile for the other levels is changed, including players and stakeholders not thought of in the initial risk assessment. Supply chains are dynamic and constantly evolving, and so is supply chain risk. Achieving supply chain resilience is a constant battle and a never-ending process.

Figure 23: Supply Chain Vulnerability 4-level model framework (Peck, 2005)



This is described by Jan Husdal as an excellent tool for explaining the scope and dynamic nature of supply chain risk (Available at:

<http://www.husdal.com/2008/08/25/drivers-of-supply-chain-vulnerability/>)

In essence, in order to develop the “NSF Fraud Protection Model”, links with Level 4 data sources are required. These represent a broad macroeconomic perspective, political, economic, social, legal and technological factors. Disruptions or sudden changes in these factors are more often than not beyond the control of an individual company.

Specifically in relation to food fraud, this is supported by [Everstine, Kircher & Cunningham \(2013\)](#) who advise that early warning analysis should take advantage of multiple data sources. This has the potential to alert us to elevated risk of EMA in certain food products for relatively few resources. The development of data management technologies in which the food and agriculture stakeholders can regularly and proactively share real-time information across the globe is key to identifying risks and initiating the appropriate response to mitigate adverse consequences.

However, there are problems with accessing this level of data. Economic databases, by their nature, are highly aggregated and can lag real-time information by up to two years. There are economic models that predict criminal activity and risk in food supply chains. However, there is a strong argument for using data analytics rather than economic prediction models.

Two key drivers should be considered when developing the “NSF Fraud Protection Model” through to implementation.

The first is the disaggregated and heterogeneous nature of food fraud data. To overcome this challenge, new technologies must be capable of harvesting data from multiple sources with minimum delay. Furthermore, the data must be processed in a way that routine assessment is possible on very new or even live datasets taken from a wide range of sources. It is imperative that the data can be digested in silico to provide user friendly outputs at the decision level.

Network analysis has strong potential to deliver on this requirement as has already been demonstrated in the food safety arena (e.g. [Nepusz, Petroczi & Naughton, 2009; 2012](#)). Several organisations have incorporated Network Analysis into their anti-crime activities, including police forces {e.g. <http://ai.arizona.edu/research/coplinc/crimenet.asp>}. The science underpinning Network Analysis is developing rapidly and future advances will bring the technology even closer to regulatory requirements.

The second driver is the residual need for human decision making. Although machine learning is developing, it has yet to be adopted in stand alone format in food fraud. In the recent authoritative report by the European Food Safety Authority EMRISK Unit (EFSA, 2012), there is a report on a pilot study with well thought considerations of the balance between data acquisition and judgement calls. In this exemplar study the necessity to have i) data rigour and availability, along with ii) appropriately judged decision steps is key. The former can be provided by Network Analysis and the latter can be underpinned by “NSF Fraud Protection Model” to assist in decision making. A key aspect of the EFSA EMRISK report is the resource required per detection. Clearly, this will be a key challenge in times of limited resource.

Fraud Intelligence Sharing

Data sharing between stakeholders within the food industry is also currently a major stumbling block in the way of progress with shared intelligence considered to be the '[biggest nut to crack](#)'.

Integrity and security of DNA testing data shared between industry stakeholders during the horsemeat crisis was questionable, using spreadsheets and e-mails. More robust and secure methods are required.

Other industries have overcome conflicts and shared intelligence is custom and practice e.g. STEADES for IATA (Aviation); ECAIRS for Transport; SMIS for the UK Rail Sector; NRLS for the UK NHS Health Sector. The aviation model was identified in the GMA Report (2010) as a foundation to build upon.

Mechanisms for optimising data sharing between stakeholders and maximising security from fraudsters needs to be fully considered within the scope of “NSF Fraud Protection Model” development. The following provide background on the potentials and pitfalls of intelligence sharing:

In the post- horsemeat review by Prof. Pat Troop a failure in current intelligence in ‘joining the dots’ was identified.

[http://www.meatinfo.co.uk/news/fullstory.php/aid/15704/Horsemeat: FSA must improve intelligence, says expert.html?utm_source=newsletter_weekly&utm_medium=email&utm_campaign=Newsletter%2BWeekly%2BIssue%2B241](http://www.meatinfo.co.uk/news/fullstory.php/aid/15704/Horsemeat:_FSA_must_improve_intelligence,_says_expert.html?utm_source=newsletter_weekly&utm_medium=email&utm_campaign=Newsletter%2BWeekly%2BIssue%2B241)

FSA Intelligence sources were identified through interview with the FSA which identified the organisational relationships for data inputs as illustrated in the schema provided (See Figure 2).

Limitations on the FSAs Memex Patriarch system were reported in 2011.

http://www.foodmanufacture.co.uk/Food-Safety/Intelligent-software-won-t-predict-next-Sudan-1-experts-warn-FSA/?c=3eYffeo0PvoBLDnqPwxXug%3D%3D&utm_source=newsletter_daily&utm_medium=email&utm_campaign=Newsletter%2BDaily. Further details of the Memex system are available at : <http://www.itproportal.com/2007/04/19/memex-launches-new-intelligence-management-tools/>

The FSA has recently commissioned research on data mapping with Leatherhead Food Research (due in March). This should facilitate development of the proposed “NSF Fraud Protection Model” Intelligence Platform

<http://www.thegrocer.co.uk/fmcg/fsa-data-project-takes-the-fight-to-horsemeat-style-food-fraud/353620.article>.

A cloud-based fraud framework for predictive fraud detection in the US Federal Subsidy arena gives a useful insight into what an intelligent fraud framework that ‘connects the dots’ looks like

http://www.sas.com/resources/whitepaper/wp_41905.pdf

Insurance industry models

There is potential to build the “NSF Fraud Protection Model” so that it would be available for insurance companies to use in house as well as there being a more public face. Like RASFF, there could be a hidden component for sensitive data.

The “NSF Fraud Protection Model” could be linked to other commercial risk assessment models for example the NOVI product recall system provided by AIG insurance

NOVISM estimates the financial impact of a product recall caused by an accidental product contamination.

The confidential NOVISM Estimate is the largest probable loss arising from an accidental product contamination that occurs during production at the plant level, assuming failures of critical control points in the sourcing or manufacturing of the company’s product. In insurance terms, the NOVISM Estimate is also known as a Probable Maximum Recall Loss. It includes the value of contaminated products, recall expenses, destruction costs and lost profit associated with the contaminated products.

An industry survey carried out in 2012 through a strategic collaboration between Campden-BRI and JLT Insurance ([New World New Risks, 2013](#)) provides an insight into the industries perception of current and future risks in the food sector.

It provides insight and highly comprehensive and graphical representation of direct commercial impacts such as the volatility of commodity prices, and the associated industry impacts. Therefore, we will investigate this further as it parallels the work which needs to be done to incorporate price indices and risk in to the profit axis of “NSF Fraud Protection Model”.

Some [insurance companies](#) have adopted predictive analytics for fraudulent claims. Opportunities should be explored to investigate sharing of intelligence with them.

This could also provide an incentive for data and intelligence sharing by the industry, since recall insurance for horsemeat fraud in the absence of a food safety risk was not covered. Adoption of “NSF Fraud Protection Model” into business as usual could reduce their insurance risks and premiums.

Potential sources of data

Potential sources of data and intelligence which can feed into a dynamic “NSF Fraud Protection Model” platform have been identified. Further work on the “NSF Fraud Protection Model” would involve more in-depth analysis and testing of the different sources of information, and the indicators that provide the more robust analyses.

The [Sigma Vulnerabilities in the Food Chain- A Stakeholder’s Guide \(2009\)](#) provides guidance on data that provides sensitivity to early warnings and other signals, including recall notices and alerts from national databases; alert internet services and daily press in order to identify emerging hazards; latest scientific literature or other internet information through general search. Various internet links are provided as accessed at the time of publication in their Annex 1. Development of “NSF Fraud Protection Model” will achieve this consistently and systematically at an industry level, otherwise out of reach at an individual business level.

[Everstine, Kircher & Cunningham \(2013\)](#) describe various data sources, compiled and analyzed to detect a signal, can serve as a trigger for decision makers to take action.

The USP (US Pharmacopoeia) & NCFPD (National Collaboratory on Food Protection and Defense) food fraud databases are described which have been reviewed within objective 2 to build the model framework. A dynamic interface with these tools should be sought.

In addition, this article describes additional data sources such as weather information, global trade data, pricing indexes, policy changes, and indications of political and civil unrest, whereby algorithms can be built that can assist in identifying the environments where food fraud is likely to occur or may already be in the system.

Other NCFPD technology solutions, known as the FIDES and EMA projects are also described: These support data fusion, analytics, and dissemination within and across organizations to help identify and warn of food threats such as EMA, provide risk

management assessments, and provide decision makers tools to make informed assessments and decisions.

Development of “NSF Fraud Protection Model” should build on existing knowledge from these initiatives in order to build a global solution to reflect the challenges of the global supply network.

Everstine et al., (2013) identified a number of incidents where food fraud detection has or could have been made earlier through pursuit of tax and other financial data. The use of non-traditional data sources for detection are described, such as tax records, below-market pricing, rapid increases in supplies and sales or known imbalances in quantities between primary production and final distribution. The potential for the use of import & trade data, economic production data and market pricing data to provide an early indication are also described.

However, tax and financial data are not publicly available sources of information. To be able to facilitate this approach, there would need to be a significant degree of information sharing within supply chains: this degree of information sharing is very unusual in food supply chains. Import and other economic trade and production data suffer from time lags in their publication. However, market movement and pricing data has more immediacy.

Individual tools identified in objectives 2 & 4 would also be included as appropriate:

Price Indices- Economy Watch <http://www.economywatch.com/economic-statistics/price-index-indicators/>

Global Risks- World Check – Thomson Reuters <http://www.world-check.com/our-services>

Corruption Perceptions Index
http://www.transparency.org/whatwedo/pub/corruption_perceptions_index_2012

BrandView <http://www.brandview.com/>

However, the issue with these tools is that they are not easily accessible, are selective and in some cases, highly aggregated. Whilst price indices movements could be incorporated into the profitability criteria for “NSF Fraud Protection Model”, other risk indices are not specific enough to highlight commodities or localities where alerts are required.

Integration of “NSF Fraud Protection Model” framework with Horizon Scanning tools

Drawing in intelligence from the existing horizon scanning tools identified is also an imperative. The arena of horizon scanning in food safety is developing with multiple stakeholders producing a range of approaches depending on specific needs (as outlined, in part, above). It is expected that the necessary drivers of this process will increase over the coming years. In parallel, and somewhat less developed, new approaches to horizon scanning in food fraud are underdevelopment – including “NSF Fraud Protection Model”. Thus, it is a timely stage for co-development of models and strategies with a focus on food fraud alongside commensurate developments in food safety.

Social networks/Infodemiology

‘Infodemiology’ as it develops the analysis of information distributed on the internet could help minimise the impact of incidents in the future.

It has been reasonably well described in the context of food safety:

Frank Yiannias reported at the [GFSI Conference 2012](#) that infodemiology is emerging as a powerful tool in controlling the spread of foodborne illness. ‘I believe food safety is at a crossroads’. One example of infodemiology is [Pulse Net](#) which analyses DNA subtypes of various pathogens identified in laboratories across the US. It is claimed that PulseNet would have avoided the 2008 Salmonella outbreak from peanuts which resulted in more than 700 reported illnesses and 9 deaths.

Infodemiology could also be used to track patterns in internet users searching for similar foodborne illness-related terms on search engines, or Twitter users discussing their symptoms via tweets ([Newkirk et al., 2012](#)). There are three main advantages to the use of social media – timeliness, representativeness and self-identification of outbreaks. Incorporation of existing social media into a public health surveillance system certainly has the potential to enhance early outbreak detection.

FSIS (US Food Safety Inspection Service) have introduced a system of state-specific [food safety Twitter feeds](#) to help US consumers identify affected products to restrict the impact of foodborne outbreaks.

Conclusion

The research team see the “NSF Fraud Protection Model” model being used in two principal ways. Firstly to validate and reassure product and category teams in the technical functions of food companies and also industry regulators that their focus on fraud detection in terms of product category is appropriately targeted. The model in its current format will bring some structure to what is currently almost entirely based on “gut feel” and experience of past experience/incidents. Secondly the model has a predictive quality allowing these same individuals to explore “what if” scenarios as trading or market conditions change or when they consider new suppliers and new products.

From the research undertaken it is clear that whilst the global food industry and its regulators around the world are increasingly concerned at the nature and extent of food fraud the current control measures in place need enhancement with only 19% of respondents to our survey including fraud within their risk assessment, only 9% monitoring available intelligence on fraud and none using price information to alert concern.

Survey participants also demonstrated either large gaps in their knowledge of fraud or an unwillingness to share information.

Whilst anecdotally companies claim to have considered fraud we found little hard evidence or examples of either a systematic or commonly agreed approach to the identification and control of the potential vulnerability of specific products to fraud. It is therefore not surprising that we found broad and enthusiastic support for the principal of a consistent and structured approach to assessing fraud vulnerability.

We are aware that in its current stage of development the “NSF Fraud Protection Model” model is at an early stage and we have discussed various potential enhancements with stakeholders and in this report. However, we have also been very mindful of the need for simplicity and ease of use. A medium to large supermarket will have product ranges running into the thousands and of course many of these products will contain multiple ingredients from multiple locations around the world. A simple Pizza has been shown to include 35 ingredients from 60 countries on 5 continents. The complexity of the modern supply network is a major barrier to effective risk assessment but all the more reason to attempt some form of rational categorization of those products or to identify in advance ingredients that are most vulnerable to fraud.

However, we see the most important next step as enhanced testing of the “NSF Fraud Protection Model” model against known incidents and to build a larger data set of mapped products. We are in discussion with a major international retailer to undertake this work. It is to be hoped that given the scale of the task the industry will work collaboratively within its own ranks and with regulators to develop a better

understanding of fraud risk and the appropriate controls and interventions to minimise impact and the potential for harm.

The original model itself stood up satisfactorily to various tests and comparisons with known incidents and the stakeholders own perceptions of high and low risk categories/products although it was necessary to amend the original choice of horizontal axis as research indicated the likelihood of detection was more important to the fraudster than ease of perpetrating the fraud.

We are confident that we have developed a useful framework and the basis for further enhancement that will with support and investment eventually lead to a dynamic tool collecting key data in near real time that will help identify and detect fraud allowing timely and appropriate monitoring and intervention.

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User Group attendees

Representatives from most sections of industry were present including supermarket retailers, quick service chain restaurants, manufacturing , business management consultants, DEFRA and the FSA.

Industry stakeholders that responded to the survey

Sectors Surveyed	Number of Respondents
Manufacturer	16
Food Service	8
Certification Body	3
Trader	3
Wholesale	2
Importer/exporter	2
Enforcement	2
Consultant	2
Retailer	1
Government Agency	1

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Annexes/Appendices

Appendix 1: NSF Fraud Protection Model: Framework Elaboration

Appendix 2: Industry Interview Responses

Appendix 3: Survey Questions

Appendix 4: Survey Circulation List

Appendix 5: Survey Participant Information

Appendix 6: Fraud Database Review

Appendix 7: Literature & Internet Survey

Glossary

Adulterant The undesirable substance in a fraudulent food or food ingredient.

Boston Consulting Group (BCG) Matrix This is a chart that was created by the Boston Consulting Group in 1970 to help corporations to analyse their business units and is used as an analytical tool in brand marketing, product management, strategic management, and portfolio analysis. Quadrants on the matrix are described as stars (high growth, high market share), cash cows (low growth, high market share) dogs (low growth, low market share) and (high growth, low market share). Further information is available at:

http://www.valuebasedmanagement.net/methods_bcgmatrix.html)

British Retail Consortium (BRC)

Economically Motivated Adulteration (EMA) The fraudulent addition of non-authentic substances or removal or replacement of authentic substances without the purchaser's knowledge for economic gain of the seller. It is also referred to as food fraud, economic adulteration, intentional adulteration or food counterfeiting.

Fraudster The perpetrator of fraud

Global Food Safety Initiative (GFSI)

Grocery Manufacturers Association (GMA)

IATA International Airline Association

Locus The position marking the intersection of the model axes

MARCI (Mitigate, Assure, Redeploy and Cumulative Impact) Chart The MARCI chart plots risks along the two axes of impact and vulnerability, and indicates each risk's speed of onset by the size of the data points. This is particularly useful when the primary purpose of the prioritization exercise is for risk response: risks plotting the farthest in the upper right quadrant represent the highest impact and vulnerability and would benefit the most from additional management effectiveness in managing the risks.

NCFPD National Collaboratory on Food Protection and Defense

NRLS National Reporting and Learning System A central database of patient safety incident reports

RASFF Rapid Alert System for Food and Feed

SEDEX Supplier Ethical Data Exchange SEDEX provides a secure, online database which allows members to store, share and report on information on four key areas: Labour Standards, Health & Safety, The Environment & Business Ethics. <http://www.sedexglobal.com>

SMIS Safety Management Information System UK rail industry network national database for the recording of safety related events. Its use is mandatory for all Infrastructure Managers and Railway Undertakings operating on Network Rail managed infrastructure. The collection of safety related data and turning it into intelligence and risk information assists the industry in analysing risk, predicting trends and focussing on major areas of safety concern. It is key to successful management, planning and decision making within the industry.

STEADES Safety Trend Analysis and Data Exchange Database of aviation incident reports for global safety performance improvement.

USP – US Pharmacopoeia