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Quality risk and responsive actions in sourcing/procurement: an empirical study of food fraud cases in the UK

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ABSTRACT

It is never an easy task to govern contemporary food systems and prevent contaminated foods from reaching further down the chains. This study aims to investigate how UK managers in food supply chains have perceived food fraud risk in their supply chain and to identify what their actions could be in response to the threat of food fraud. The study adopts the psychometric paradigm approach to measure risk perception and uses the data collected from 113 UK food practitioners to identify the determinants of their responsive actions. The results highlight that most managers have perceived high uncertainty in the food supply chain and considered the disruption of information flow as a major concern in dealing with food fraud. Therefore, this study suggests that putting effort into practices to improve supply chain visibility and facilitate the flow of information are weighted as important in the food fraud mitigation journey. Policy makers should also make better use of the current quality assurance schemes for proactive food quality control and fraud prevention; government agencies should improve the risk communication systems for trustworthy information dissemination.

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Supply chain risk; risk perception; food fraud

1. Introduction

Despite the fact that new technologies and a more compliant law enforcement system have been developed, managing the provision of food safety remains a challenge. In particular, the food quality problem has been and is a continuing issue due to the complexity of long and globalised supply chains. The recent regulatory changes due to Brexit and the ongoing effects of Covid-19 have also left the UK food supply chain more vulnerable to food fraud (Djekic et al. 2021; Yu et al. 2021).

According to Tse and Tan (2011, 141), supply chains are exposed to 'inherent quality problems (e.g. raw materials/ingredients/production/logistics/packaging) in any of the members to trigger a cascading effect that spreads through a multi-tier supply network'. In a food supply chain, a dishonest act or omission in the production or supply of food to deceive consumers for economic gain has been named as 'food fraud' (Elliott 2014). Compare with ordinary food safety issues caused by 'an unintentional act with unintentional harm' (Spink and Moyer 2011, 157), risks from deliberate food fraud scandals can cause more serious impacts on the downstream food companies and be more harmful to the general public (Schaefer, Scheitrum, and Nes 2018).

Food fraud has now been considered as 'a serious organised crime' (Swinford 2014), 'an urgent global policy issue' (Spink et al. 2019), and 'a major concern for the food

industry, consumers and governments' (Guntzburger et al. 2020). It encompasses an inventory of activities to substitute, add, tamper or misrepresent and mislead about the food, food ingredients or packaging (Van der Meulen et al. 2015). Despite new efforts in testing and a higher level of safety regulations (McPhee-Knowles 2015), current methods for managing food fraud are still drastically challenged (Brooks et al. 2021). It is always difficult to govern contemporary food provisioning (Spink et al. 2017) and prevent fraudulent food products from reaching further down chains (Koubová, Samková, and Hasonová 2018). Additionally, if a deliberate action was involved, plus the length and complexity of the supply chains, it is difficult to mitigate the problems and reduce the impacts (Bouzemrak et al. 2018). A knock-on effect can impact the entire food supply chain, and quickly spread to the downstream industry practitioners (e.g. farms, slaughterhouses and food processing companies) and customers (Schaefer, Scheitrum, and Nes 2018) to cause financial and health related damages (Havinga 2010; Levy and Kerschke-Risch 2020). Furthermore, the contaminants within food fraud are usually unconventional (e.g. access to advanced bio-technology) (Maloni and Brown 2006), but most quality assurance systems are not designed to look for an infinite number of contaminants (Spink et al. 2017). Inevitably the food supply chain is generally vulnerable to food fraud issues (Silvis et al. 2017).

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Recent studies have indicated that the food industry is lacking clear food fraud risk prevention guidance and effective mitigation strategies, and the development of food fraud policy is still in early stages (Robson et al. 2021; Brooks et al. 2021). Therefore, protecting the integrity of the food chain is still an emerging topic (Black, Chevallier, and Elliott 2016) and further steps are urgently needed for continuous policy development (Spink et al. 2019). Several food fraud studies exist on the impact on large enterprises and SMEs (Mensah and Julien 2011), and try to develop systems and guidelines to detect, screen and report food fraud (Guntzburger et al. 2020; Minnens, Lucas Luijckx, and Verbeke 2019).

However, food fraud risk is situational and should be characterised by the wider environment in which not only the food production takes place but also other operations (e.g. packaging, transportation and trade) within the supply chain (Manning 2016). This study extends the existing research on food fraud risk management and aims to investigate how the UK food supply chain managers have perceived food fraud risks, supply chain trust and the reasons behind their *ex-post* actions in response to the threat of the food fraud incidents. The uniqueness of this study lies in the use of Slovic's (1987, 2000) original psychometric paradigm to study UK food supply chain managers' risk perception and empirical data to establish determinants of their response. Therefore, this paper has the following three research questions:

RQ1: What is UK food supply chain managers' risk perception of food fraud?

RQ2: What are their *ex-post* actions in response to food fraud?

RQ3: What are the latent determinants to take these actions?

The rest of the paper is organised as follows: Section 2 reviews relevant literature on risk and risk perception, supply chain risk management and managing food fraud. Sections 3 presents the research setting and methodology. Section 4 explains and analyses the results and provides discussions. Finally, in Sections 5 and 6 the conclusions and recommendations are presented.

2. Theoretical background

2.1. Risk and risk perception

Risk is a widespread and multi-perspective term (Harland, Brenchley, and Walker 2003). Although it has been frequently used and relatively easy to understand (Morgan, Henrion, and Small 1990), the term is still vague (Peck 2006) and several conceptualisations can be found across different disciplines (Manuj and Mentzer 2008). Past literature has mostly defined risk as a chance of danger, linked it to fear (Heckmann, Comes, and Nickel 2015), and regarded it as a chance of undesired outcomes (March and Shapira 1987) or hazard to cause different types of losses (Mitchell 1995). Risk is also viewed as opportunity (fear of missing the boat) (Nabi and Liñán 2013) and has the potential for financial gain (Hung and Ryu 2008), if proactive actions are taken to reduce ambiguity and uncertainty (Acedo and Florin 2007).

Risk has a heterogeneous nature (Heckmann, Comes, and Nickel 2015) and is defined by two important components (Ellram, Tate, and Billington 2004; Davis 1993): 'uncertainty and exposure' (Holton 2004, 24). Risk can be viewed, in quantitative terms, as 'the chance of a defined hazard occurring' (Royal Society 1992, 4) but measured quantitatively (Fox-Glassman and Weber 2016) by the probability of happening (Ghadge, Dani, and Kalawsky 2012; Vorst et al. 1998) and the magnitude of an adverse effect (Adams 1995; O'Callaghan, Reid, and Copeland 2006). Risk can also be perceived as a socially or culturally constructed phenomenon (Olteidal et al. 2004). It concerns how one feels and experiences a potential hazard situation and therefore the perception of risk can be linked to many factors (Olteidal et al. 2004), such as the source and characteristics of the hazard (Slovic and Weber 2002), the possible impacts (Hallikas et al. 2004) and the control mechanism (Walker, Bisset, and Adam 2007). This suggests that the judgements of risk are related to cognitive processes (Olteidal et al. 2004), and hence understanding the perception of risk can give insights about efficient countermeasures (Tse and Zhang 2017; Slovic 1987) and to support the risk management decision-making (Hung and Ryu 2008).

In relation to supply chain management, stakeholders' cognitive stance with the supply chain uncertainties could influence the demands for risk management and actions aimed at reducing the risk (Kraude et al. 2018). Based on the supply chain managers' perceptions of risk, a number of measures for supply chain uncertainties have been developed (Zsidisin, Panelli, and Upton 2000; Zhu, Krikke, and Caniels 2017), such as using various supply chain constructs (i.e. physical, financial, informational, relational and innovational) (Cavinato 2004), supply chain focuses (e.g. single firm, entire value chain and materials) (Hofmann, Schleper, and Blome 2018), and supply chain positions (e.g. supply and demand) (Johnson 2001) to prioritise risks (e.g. using a hybrid model) (Qazi et al. 2017; Nakandala, Lau, and Zhao 2017) and categorise risk sources (e.g. external, internal and network-related risks) (Jüttner, Peck, and Christopher 2003) and for resilience (Behzadi et al. 2018). Therefore, supply chain managers' tacit knowledge and experiences could help to develop control mechanisms and reduce possible impacts.

2.2. Supply chain risk management

A modern supply chain has a high uncertainty inherent in its nature (Rao and Goldsby 2009; Tang 2006) and contains a multi-dimensional construct (Zsidisin 2003; Cheng and Kam 2008). In order to stay internationally competitive, it is a trend for companies to depend more on the vast and increasingly complex supply chain partners and adopt sophisticated operations strategies like lean management (Asbjørnslett 2009; Munir et al. 2020); inevitably they become more vulnerable and subject to unexpected disruptions (Svensson 2000; Yu and Abdul Rehman Khan 2021). Particularly in Europe, companies have increasingly globalised their supply chains and become dependent more on international suppliers, and thus could be exposed to more potential risks (Rikama et al. 2013; McPhee-Knowles 2015).

Therefore, a core task in supply chain management is to effectively remove glitches and minimise risks (Childerhouse and Towill 2003). Supply chain risk management has become increasingly popular in recent years (Wagner and Bode 2008; Ho et al. 2015) and attracted growing research interest (Jüttner, Peck, and Christopher 2003; Jüttner 2005).

Managing supply chain risk is a complex task (Heckmann, Comes, and Nickel 2015) and requires a multifaceted approach (Fan and Stevenson 2018). Risks could be caused by many sources along the supply chain (Jüttner, Peck, and Christopher 2003) affecting an entity (Ghadge, Dani, and Kalawsky 2012) of the chain parties (Oehmen et al. 2009). Common supply chain risks have been identified and classified differently (Baryannis et al. 2019; Hudnurkar et al. 2017). Past research has placed emphasis on the pathway (Fan and Stevenson 2018) to categorise the risk types (e.g. man-made, natural disasters) in different supply chain scopes (e.g. supply, demand, product flow risks) (Ho et al. 2015) and sourcing suppliers (e.g. internal and external) (Heckmann, Comes, and Nickel 2015).

Various strategies have been suggested for risk mitigations (Kilubi 2016; Tsai and Lasminar 2021), such as reactive strategies (e.g. risk-hedging, dual sourcing) to deal with supply-side and internal risks (Trkman and McCormack 2009) and proactive strategies (e.g. redundancy inventory, postponement and joint planning) for demand-side and external risks (Yang and Yang 2010; Kilubi 2016). However, these strategies are mostly firm-centric internal practices (Munir et al. 2020), they could be less effective on risks caused by intentional deception. As the chains become longer (Rong, Akkerman, and Grunow 2011) and more diverse (Ritchie and Brindley 2007; Ghadge, Dani, and Kalawsky 2012), risks may be concealed through collusion among different chain parties. These risks are even harder to detect and hence can be further stretched and escalated (Diabat, Govindan, and Panicker 2012) to be transmitted unnoticed between the supply chain partners (Yan et al. 2020). Both practitioners and academics have been calling for a more coordinated approach that encompasses all supply chain parties (Zsidisin and Ritchie 2008) to reduce supply chain vulnerability as a whole (Jüttner, Peck, and Christopher 2003; Munir et al. 2020). This study responds to the calls and refines the definition of supply chain risk management based on Ho et al. (2015) and Fan and Stevenson (2018) to best reflect the characteristics of fraud and the adverse influence on any part of a supply chain. Therefore, the definition is:

An inter-organisational collaborative endeavour utilising tools, techniques and strategies to identify, evaluate, mitigate and monitor unexpected macro and micro level events or conditions, which are deliberately concealed to deceive any part of a supply chain.

2.3. Managing food fraud

The food supply chain plays a crucial role in the food industry, for instance, it has a substantial contribution to the revenue in the European Community (e.g. the food processing industry is the biggest branch of EU industry and representing a large proportion of total industrial Gross Value Added)

(EU Agricultural Markets Briefs 2021) and employs millions of employees (Manzini and Accorsi 2013). Food supply chain management is a subset under the broad topic of supply chain management, it is dedicated to manage food or food ingredients to move along the supply chain from the farm gate or commodity suppliers to the consumers (King and Phumpiu 1996). Food is a critical product to human beings (Khan et al. 2021). Its production contains a wide range of processes which require considerable expense and technical input (Stringer and Hall 2007). It therefore carries high price tags, has large profit potential (Silvis et al. 2017) and creates an appealing crime opportunity for fraudsters and attracts great risk (Septiani et al. 2016).

The quality risk problem in the food supply chain has received a great deal of attention in the last decade (Bigliardi and Bottani 2010; Behzadi et al. 2018) and has remained as a current issue (Nakandala, Lau, and Zhao 2017; Yan et al. 2020; Ma et al. 2021). Controlling quality and safety is of the utmost importance in the food industry (Beske, Land, and Seuring 2014). Consumers are now more informed about food quality issues (Guntzburger et al. 2020) and have high expectations for food quality attributes such as integrity (Rong, Akkerman, and Grunow 2011) and safety (Beske, Land, and Seuring 2014; Olsson and Skjöldebrand 2008), but even with more stringent regulations and closer monitoring (Bigliardi and Bottani 2010), there are still considerable quality threats in the food supply chain (Aruoma 2006). As the food industry relies more on outsourcing and transport (e.g. dynamic networks of interconnected firms and organisations) (Christopher and Peck 2004), the food quality risks are still rising rapidly (Ali et al. 2017) and their impact has also increasingly extended (Olsson and Skjöldebrand 2008).

Quality risk in food supply chains may be largely divided into two categories: food safety issues and food fraud (Tse and Tan 2011). As mentioned earlier, food safety issues are accidental (Manning and Soon 2016) and caused by unintentional acts (Spink and Moyer 2011), which can be regarded as natural disasters, quality issues, technological accidents or infectious disease (Leat and Revoredo-Giha 2013). Substantial research has been devoted to identifying ways to prevent (*ex-ante* practices), or isolate (in process practices) this type of issue (Kurniawan et al. 2017; Petersen and Lemke 2015; Kathryn, Ward, and Hill 2014). On the other hand, food fraud is deliberate and intentional deception for unfair and unlawful gain (van Ruth, Huisman, and Luning 2017) which makes it difficult to forecast and uniquely complex to prevent *ex-ante* (Moyer, DeVries, and Spink 2017).

Furthermore, the food supply chain is increasingly lacking information exchange and knowledge sharing (due to a low trust level) (Soon et al. 2019; Yang et al. 2019), *ex-ante* preventive measures (e.g. a data-driven type control system) and firm-centric internal practices would become less effective to pinpoint the weaker spots and control the fraud drivers (Yan et al. 2020). The importance of *ex-post* measures and supply chain integration for managing food supply chain risks has been increasingly recognised in the recent literature (Feng et al. 2014). Several past studies have investigated the *ex-post* methods to examine various control behaviour and reactions

to food fraud, but the results are still fragmented, and they are drawn mainly from the consumers' perspectives (e.g. Kendall et al. 2018; Saeri et al. 2014; Carfora et al. 2019). Counter measures to tackle food fraud are the responsibility of all supply chain stakeholders. As Guntzburger et al. (2020) suggested, there is a growing demand not only from consumers for a 'food fraud-free' product, but also from other food supply chain stakeholders for a better food fraud management system to reduce their burden and rebuild customer trust. Also, recent studies have indicated that there is a disagreement on the perception of food fraud risks (Silvis et al. 2017; Soon et al. 2019) among the supply chain partners (Djekic et al. 2018), hence their *ex-post* methods and strategies to handle and manage fraud could also be affected. Therefore, this study follows this path to further explore how supply chain trust affects risk perceptions and predict supply chain stakeholders' *ex-post* actions in response to food fraud.

3. Methodology

3.1. Study design and data collection

This study aimed to investigate UK food supply chain managers' risk perception and behavioural responses towards the threat of fraudulent incidents. A questionnaire was designed to identify subjects related to managers' perceived risk on

food fraud. Logistic regression was employed to test the relationships between their perceptions, trust and potential responsive actions.

The study adopted constructs from Slovic's (1987) original Perception of Risk Paradigm to measure risk perceptions. This is a popular Paradigm to reflect risk characteristics (Fischhoff et al. 1978; Slovic and Weber 2002; Han et al. 2021) and has been adopted in many recent risk management studies to gauge risk perception and predict responsive behaviour and actions (Kummeneje and Rundmo 2020; Van Schaik et al. 2017; Fox-Glassman and Weber 2016). The paradigm has the constructs to measure risk controllability, dread, severity of consequences, voluntariness, being known to the exposed, immediacy of effect, and risk newness (Table 1).

The constructs to measure food supply chain managers' trust in supply chain stakeholders and their responsive actions were based on Feng et al.'s (2010, 2014) risk responsive conceptual model. They included questions, on a five-point Likert-style scale, to measure to what extent they trusted their supply chain stakeholders (e.g. trust in suppliers) and questions to provide information about their responsive actions (Table 2).

The questions related to supply chain managers' potential response actions were self-developed based on a study by Feng et al. (2010), in which the authors used short questions to measure respondents' potential response actions towards

Table 1. Constructs to measure risk perception (Slovic 1987; Fischhoff et al. 1978).

Risk perception	Description
Controllability	Please rate to what extent you can, by management skill or personal diligence, avoid company interest harm, if exposed to the risk. (1 = Controllable; 7 = Uncontrollable)
Dread	Is this a risk that you have learned to manage and can think about reasonably calmly, or is it one concerning which managers have great dread – on the level of a gut reaction? (1 = Not Dread; 7 = Dread)
Severity	Please rate how likely it is that the consequence will be fatal when the risk is realised in the form of a sales volume/company interest harm. (1 = Consequence not fatal; 7 = Consequence fatal)
Voluntariness	Please rate to what extent this risk is faced voluntarily. (1 = Voluntary; 7 = Involuntary)
Known to exposed	Please rate to what extent the risks are known precisely by the managers who face those risks. (1 = Known precisely; 7 = Not known)
Immediacy	Please rate to what extent the risk of harm to sales volume/company interest is immediate – or such mishap is likely to occur at some later time. (1 = Effect immediate; 7 = Effect delayed)
Newness	Please rate to what extent this quality risk is old and familiar or new and novel. (1 = Old; 7 = New)

Table 2. The constructs to measure trust in supply chain stakeholders.

Trust in stakeholders	Description
Supplier trust	Do you trust the product information (such as ingredients) provided by suppliers? (1 = Do Not Trust; 5 = Fully Trust)
Food fraud – long term	Food fraud in the supply chain is a long-term issue (1 = Strongly Disagree; 5 = Strongly Agree)
Food fraud – random act	Food fraud is the result of organised activities (i.e. food crime), rather than random acts by a few people. (1 = Strongly Disagree; 5 = Strongly Agree)
Trust in FSA 1	The regulations for dealing with food fraud are well developed in the UK. (1 = Strongly Disagree; 5 = Strongly Agree)
Trust in FSA 2	The FSA's regulation and supervision of food fraud is sufficient. (1 = Strongly Disagree; 5 = Strongly Agree)
Trust in FSA 3	The FSA is well prepared for any food fraud problems (1 = Strongly Disagree; 5 = Strongly Agree)
Trust in food industry 1	The food fraud products are produced by only a small percentage of food companies, and most food companies are trustworthy. (1 = Strongly Disagree; 5 = Strongly Agree)
Trust in food industry 2	Those food products that are not indicated by FSA announcement or the Rapid Alert System for Food and Feed (RASFF) are safe and reliable. (1 = Strongly Disagree; 5 = Strongly Agree)
Trust in food industry 3	Most food products in the market are safe and reliable (1 = Strongly Disagree; 5 = Strongly Agree)
Trust in food company 1	The food processing companies are innocent. Purchasing adulterated ingredients is done by individual employees in the procurement departments of the companies. (1 = Strongly Disagree; 5 = Strongly Agree)
Trust in food company 2	The relevant food processing companies are innocent. They purchased adulterated ingredients from suppliers/dealers without knowing they were adulterated. (1 = Strongly Disagree; 5 = Strongly Agree)
Trust in food company 3	The relevant food processing companies have dealt with fraud promptly and effectively (1 = Strongly Disagree; 5 = Strongly Agree)

the food fraud incidents. The questions in this study include consulting actions (e.g. consult government agency), quality assurance (e.g. dispose of all raw materials/ingredients from the suspected country of origin), supplier management (e.g. ask supplier to provide extra evidence to guarantee the product integrity), and information disclosure (e.g. releasing supply chain information to gain the client company/consumer's confidence).

The questionnaire was pilot tested before sending out to supply chain managers who were in the food industry and familiar with the procurements of supply materials. A merged contact list was used in this research (a combined contact database purchased from D&B and Global Marketing Institute, a marketing consultancy firm). Two emails were sent to each potential informant, including a pre-notice letter that introduced the research background and an official letter with a survey link. The questionnaire data were collected via SurveyMonkey.

Non-response bias (Armstrong and Overton 1977) was examined to compare the early and late arriving responses (Swafford, Ghosh, and Murthy 2006). The authors adopted the chi-square test to assess the differences between first wave and second wave respondents regarding company size, annual sales and gender. The non-significant results of the chi-square test indicate that non-response bias was not a threat to our sample.

3.2. Descriptive statistics and correlations

In total, 140 responses were received after a three-month data collection period. Removing 27 uncompleted responses, 113 copies of the questionnaire were retained for the data

Table 3. Demographic Information $n = 113$.

Characteristics	% of respondent
Gender	
Male	52.5
Female	47.8
Company size	
Fewer than 50 employees	40.70
50–250 Employees	15.90
250–500 Employees	12.40
Over 500 Employees	31.00
Annual sales	
Under £50 million	54
Over £50 million–£100 million	13.30
Over £100 million–£250 million	13.30
Over £250 million–£500 million	2.70
Over £500 million–£1 billion	12.40
Over £1 billion	4.40

Table 4. Correlation table of risk perception dimensions.

	1. Controllability	2. Dread	3. Severity	4. Voluntariness	5. Known to those exposed	6. Immediacy	7. Newness
1	1						
2	0.195*	1					
3	0.042	0.429**	1				
4	0.384**	0.030	0.016	1			
5	0.258**	0.129	−0.038	0.475**	1		
6	0.190*	0.162	−0.011	0.293**	0.545**	1	
7	0.087	0.414**	0.249**	0.013	0.068	0.190*	1
Mean	3.32	4.34	4.36	4.26	3.90	3.30	3.93
Std. deviations	1.720	1.813	1.747	1.814	1.850	1.804	1.732

*Correlation is significant at the 0.05 level.

**Correlation is significant at the 0.01 level.

analysis. Table 3 reports the demographic information of the valid respondents.

Table 4 presents the descriptive statistics and bivariate correlations of the risk perception constructs. The overall average value of risk perception was below the midpoint of four (mean = 3.869). They included controllability (mean = 3.366), fatal (mean = 3.811), knowledge (mean = 3.933) and immediacy (mean = 3.348). However, the managers perceived other risk measures in relatively high levels: such as dread (mean = 4.44) and voluntariness (mean = 4.146), the newness (mean = 4.034) was also scored above average.

Table 5 presents the results of the factor analysis and reliability test of the three trust factors. Bartlett's test of sphericity is significant and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is high. The result of the factor analysis is robust (to explain 74.994% of total variance) and reveals three factors, namely Trust in FSA, Trust in Food Industry and Trust in Food Company. The internal consistency of these three factors is high (i.e. Cronbach's α is larger than 0.7).

Regarding the responsive actions, the managers were asked the following question: 'If you heard news about another firm in your industrial area suffering from adulteration of materials, what would be your response actions?' The top ten answers were presented in Table 6, and the first four response actions were supported by more than 50% of the participants. They are: RA1 Releasing Supply Chain Information, RA2 Check Suspected Suppliers, RA3 Check FSA Website and RA4 Consult Government Agencies.

Table 5. Factor analysis and reliability test results.

	Mean	Std. deviation	Factor loadings
Trust in FSA 1	3.52	.955	.736
Trust in FSA 2	3.23	.935	.811
Trust in FSA 3	3.27	1.037	.844
Percentage of variance 49.613			
Eigenvalue 4.465			
Cronbach's α .823			
Trust in food industry 1	3.78	.799	.796
Trust in food industry 2	3.38	.900	.643
Trust in food industry 3	3.89	.806	.893
Percentage of variance 15.541			
Eigenvalue 1.399			
Cronbach's α .769			
Trust in food company 1	2.96	.999	.870
Trust in food company 2	3.10	.982	.848
Trust in food company 3	3.42	1.100	.673
Percentage of variance 9.841			
Eigenvalue .886			
Cronbach's α .776			

Bartlett's test of sphericity chi-square = 477.143 ($p < 0.001$), KMO = .841. Method: Principal components, total variance explained 74.994%.

3.3. Results and analysis

Logistic regression is a common statistical analysis to test relationships between one categorical dependent variable and one or more categorical or continuous predictor variables (Peng, Lee, and Ingersoll 2002). The analysis was used in this study to investigate the relationships between managers' risk perception, trust in stakeholders and behavioural responses towards the threat of the fraudulent incidents in the food supply chain. Four logistic regression models were developed. Risk perception and trust measures were chosen as the independent variables, whereas the four responsive actions RA1–RA4 were used as the predictor variables (Table 7).

For the first responsive action (RA1), three significant predictors were found: they were Trust in FSA 1 (Wald Static = 5.124, $p < 0.01$) and Trust in Food Industry 1 (Wald Static = 0.3847, $p < 0.05$). Both of them were positively associated with the RA1 to release supply chain information, whereas Newness (the quality risk is new and novel, Wald Static = 3.481, $p < 0.05$) was a significant, but negative predictor in the model.

For the second responsive action (RA2), two significant predictors were found. They were both positive predictors: FSA 1 (Wald Static = 4.783, $p < 0.01$) and Trust in Food Industry 1 (Wald Static = 2.733, $p < 0.01$). They were positively associated with RA2 to check suspected suppliers.

For the third responsive action (RA3), the logistic regression model revealed two significant determinants. Among them Severity (Wald Static = 4.009, $p < 0.05$) was a positive determinant, whereas Newness (Wald Static = 7.606, $p < 0.01$) was a negative determinant of this responsive action to check the FSA website.

Regarding the fourth responsive action (RA4), the logistic regression results suggested that Supplier Trust (Wald Static = 3.260, $p < 0.05$) was a positive predictor, whilst Food Fraud – Organised (Wald Static = 3.167, $p < 0.05$) and Trust in Food Company 1 (Wald Static = 6.788, $p < 0.01$) were negative predictors of the responsive action of consulting government agencies.

4. Discussion

4.1. Releasing supply chain information (RA1) and check suspected suppliers (RA2)

The result shows that releasing supply chain information is the most selected action when facing food fraud (see Table 6). Although this action is thought to be helpful to develop mutual trust and develop supply chain integration (van Ruth, Huisman, and Luning 2017), this is not a favourable action by many supply chain managers in normal circumstances (Chen

Table 6. Description of the top 10 response actions.

Response actions	Percentage
RA1. Releasing Supply Chain Information	70.8
RA2. Check Suspected Suppliers	64.6
RA3. Check FSA Website	54.9
RA4. Consult Government Agencies	52.5
RA5. Read/listen to news coverage	48.2
RA6. Revisit previous quality/testing reports	30.77
RA7. Quarantine all raw materials/ingredients from the suspected country of origin	25.00
RA8. Dispose of all raw materials/ingredients from the suspected country of origin	24.04
RA9. Employ third party inspectors to guarantee product integrity	11.54
RA10. Seek advice from lawyers to clarify the responsibility for this kind of scandal	9.62

Table 7. Results of the logistic regression models.

Variable	RA 1		RA 2		RA 3		RA 4		Wald
	β	Wald	β	Wald	β	Wald	β	Wald	
Supplier trust	-.141	.176	-.142	.213	-.214	.414	.637*	3.620	
Food fraud – long term	.206	.377	.153	.278	.156	.280	.134	.222	
Food fraud – random act	-.135	.122	.374	1.717	-.216	.496	-.572*	3.167	
Trust in FSA	.299*	6.195	.659*	3.513	.415	1.403	-.081	0.57	
Trust in FSA 1	1.048*	5.124	.829*	4.783	.468	1.624	-.203	.277	
Trust in FSA 2	-.006	.000	-.295	.675	.479	1.540	.175	.211	
Trust in FSA 3	.346	1.824	-.102	.190	.106	.195	-.116	.254	
Trust in food industry	0.161	1.593	.164	1.965	.068	.345	0.80	0.466	
Trust in food industry 1	.780*	3.847	.589*	2.733	.094	.074	.091	.069	
Trust in food industry 2	-.125	.091	-.798	5.122	-.323	.707	.152	.167	
Trust in food industry 3	.093	.112	.435	2.671	.403	2.286	.405	.268	
Trust in food company	-3.34	3.627	-.276*	4.191	-.160	1.236	-.401**	7.725	
Trust in food company 1	.348	.668	-.126	.125	-.221	.339	-.968**	6.788	
Trust in food company 2	-.532	1.426	-.244	.486	.071	.035	.038	.012	
Trust in food company 3	.230	.892	-.390	.234	-.062	.079	-.116	.254	
Controllability	-.188	.727	.096	.430	-.032	.033	.179	1.055	
Dread	.123	.267	.017	.013	-.221	.997	.172	.751	
Severity	.089	.130	.033	.052	.469*	4.009	-.146	.488	
Voluntariness	-.451	2.788	-.009	.003	-.103	.237	.217	1.177	
Known to exposed	.402	2.167	-.158	.968	.207	.896	-.317	2.028	
Immediacy	.166	.522	-.047	.109	-.189	.886	.089	.193	
Newness	-.492*	3.481	.059	.129	-.675**	7.606	-.359	2.507	
R ² (Cox and Snell)	0.297		0.276		0.226		0.226		

Note: (*) $p < 0.05$; (**) $p < 0.01$.

The bold values are not significant values, they are only highlighted as they are over 50%.

2003; Sahay 2003). This action could actually weaken the supply chain control (Li et al. 2006), leak important knowledge (Li and Lin 2006) and eventually reduce competitive advantages (Li 2002). However, it seems that the action becomes preferable when facing a fraudulent risk in the supply chain. Releasing the information can be viewed as an effective way to clear customers' doubts and help to restore consumer confidence. It could help to control rumours and speculations and increase brand awareness (Ma et al. 2021). This move might also put pressure on competitors to release their supply chain information, especially when the fraudulent incident was thought to be caused by the rival companies. Furthermore, as the finding shows, the regulations to manage food fraud management are a positive predictor. It indicates that if the regulations for dealing with food fraud are well developed, the managers are more likely to release their supply chain information. According to Cai et al. (2010) and Lane (1997), higher institutional forces (e.g. laws and policies) can result in greater trust and collaboration in the supply chain, which can help to trace and identify the source of the fraud.

The result has further suggested that supply chain managers would prefer to disclose supply chain information when they perceive the fraud is not new. There are two possible reasons: first, they trust their suppliers and believe that the problem is from other supply chains. Second, repeating risks could be relatively easier to manage, particularly if there are resources and support (e.g. the Food Fraud Database) readily available. Therefore, releasing the information should have positive impacts and help to regain consumer confidence.

This study also finds that the action to check for suspected suppliers is rated second by the participant managers (see Table 6). This finding suggests that if the supply chain managers are confident with their own supply chains and trust most of their suppliers, they are more likely to look for the suspected suppliers (from other supply chains). The finding confirms that supply chain trust is pivotal across all areas of the supply chain when facing fraud or issues of traceability. It also confirms that a high level of supply chain confidence and a sceptical mind-set are important to combat fraud in supply chains (Marks 2013).

4.2. Check FSA website (RA3)

Checking the FSA Website is the third favourable responsive action (see Table 6). The FSA Website is an official government website to provide a wide range of information on food safety issues and food fraud alerts in a quick manner. It also offers guidance on improving food chain safety and managing food crimes. Many have used it (e.g. the food fraud database) as a reference tool to handle repeating food fraud and take remedial actions (Spink et al. 2019; Elliott 2014).

In fact, the same information about the emerging food safety issues and food fraud alerts can also be obtained from the Government Agency (Spink et al. 2019), but the supply chain managers in this study have preferred to use the FSA Website, particularly when the fraud is not new and severe.

It could suggest that easy accessibility and timely information are the important features of the FSA Website when dealing with food fraud. According to Tse and Zhang (2017), the government agency has been mainly used as a platform to report food problems and crimes (e.g. the UK Food Crime Confidential Hotline).

4.3. Consult government agency (RA4)

The result reveals that consulting government agencies is rated as another most selected action (see Table 6). Compared with using the FSA website, consulting a government agency can be a more interactive way to obtain the general information about the fraudulent incident and seek official advice. The result suggests that such an action is a necessity, as many supply chain parties are highly vulnerable due to information asymmetry (Tse et al. 2021) and the highly opportunistic nature of food fraud (Fawcett, Magnan, and McCarter 2008; Ireland and Webb 2007). Without any doubt, the managers will have to look for reliable sources to counter check the supply chain information and look for tarnished suppliers. Furthermore, the randomness in the fraud pattern may increase the difficulty for the managers to obtain trustworthy information from the supply chain. Therefore, consulting government agencies could be a desired action when managers perceive the food fraud issue was just a random act rather than an organised crime activity.

The study also finds that managers are more likely to consult a government agency if the food fraud is performed by a group of people. It suggests that if the food fraud is organised, the documents/certification related to the food information might be forged as a package and hidden in a company, it would be difficult to identify and trace. Therefore, consulting government agencies has become indispensable and a key imperative to obtain truthful and authoritative information.

5. Conclusions

This study adopts Slovic's (1987) original Perception of Risk Paradigm and follows some existing works' (Kendall et al. 2018; Carfora et al. 2019; Feng et al. 2014) suggestions to further investigate how UK food supply chain managers have perceived fraudulent risks, supply chain trust and the reasons behind their *ex-post* actions in response to the threat of food fraud incidents. From the results, releasing supply chain information, checking suspected suppliers, consulting government agencies and checking FSA websites are the top responsive actions. The results highlight that most managers have perceived high uncertainty in the food supply chains and considered disruption of information flow as a major concern in dealing with food fraud. The results suggest that the problem of low visibility and high uncertainty of the existing food supply chain was serious, as more than half of the responding managers had no other choice but to obtain trustworthy information from official sources. Therefore, putting effort into uncertainty-handling practices to improve supply chain visibility and facilitate the information flow

should be an important beginning for the food fraud management journey.

The study also follows Spink et al. (2019) to analyse the supply chain trust, control behaviour and *ex-post* actions. The results suggest that the trust within the food supply chain has remained low and highlight the important role of government and institutional forces to manage food fraud. When facing the threat of food fraud, most supply chain managers would prefer to consult the government agency and use the FSA websites to obtain information about the emerging food safety issues and food fraud alerts. It shows that the responsibility for preventing and controlling food fraud still falls on the government departments, agencies, and local authorities. The results also highlight the need for better and cross-border policies to tackle and prevent food fraud, hence, to increase the supply chain trust and integration.

The authors have carefully developed the following recommendations for food industry policy makers and practitioners. Policy makers should make better use of the current *ex-ante* quality assurance schemes and legislation, ensure more food supply chain organisations adopt and follow the proactive food quality control and fraud prevention systems, these include the food fraud prevention ISO standards and the inter-organisational systems for good agricultural practices (e.g. GLOBALG.A.P. Certification). Government agencies from different countries should increase their incorporation and exchange intelligence (e.g. The EU Food Fraud Network) to prevent fraud and develop guidelines to manage the long and international food supply chains. Policy makers should also consider expanding the use of the current channels for *ex-post* risk communication, such as to improve the current tracking system (e.g. RASFF). They need to work with other media organisations to increase information coverage and develop infrastructure to disseminate truthful information. This is an important step to disseminate trustworthy information, stop the fraudsters concealing information and spreading false information.

The study also finds that the end-to-end trust level within the food supply chain is still low, and this could increase the cost to prevent and manage food fraud. Therefore, food supply chain practitioners should look for *ex-ante* methods to increase mutual trust and integration to ensure the flow of information, such as simplifying the supply chain and localising suppliers (Childerhouse and Towill 2003). The integrated supply chains can also moderate the opportunistic behaviour and reduce the extent of information asymmetry thereby preventing the fraud in the long-term. In addition, the practitioners can also take *ex-post* actions to minimise the food fraud damages. They need to stay up to date with other supply chain members to ensure information gathered about the fraudulent incidents is accurate and verified. They also need to increase the chain transparency and release information about the fraudulent incidents to offer a clearer picture to restore consumer confidence.

In short, it is impossible to completely eliminate all frauds from a supply chain, but they can be reduced or neutralised by better preparation. This study has provided a discussion

related to the management of food supply chain risks. It tries to understand rationales behind the *ex-post* actions when a fraud is discovered. It assists practitioners and frontline managers to create better knowledge on managing food fraud. Organisations can benefit in many ways, including better resource allocation to support front-line managers and a preparation for supply chain quality and integrity recovery. For policy makers and government agencies, this study highlights the importance of having effective quality assurance schemes and legislation. A more effective platform for trustworthy information dissemination should also be made available on a timely basis to share intelligence on managing food fraud and control rumours spreading.

6. Limitations and future research

The results of this study have some limitations, which open the door for future research.

The first limitation observed is that the study has employed Slovic's (1987) original Perception of Risk Paradigm to measure risk perceptions. Future research may compare and further explore other risk perception models (e.g. Munir et al. 2020) in explaining food fraud across the food supply chain. Second, the study suffers from typical empirical survey design. It only uses data from the UK food supply chain, the findings therefore may have impacts on the generalisability. Future work should include supply chain data from other countries and industries to help generalise the results. Third, only food supply chain managers data are included in this study. However, the responses and perceptions of risk are purposely captured to address the existing research gaps. Finally, the anti-fraud process within the food supply chain requires continued efforts (Brooks et al. 2021), future studies should therefore carry on identifying methods to increase food integrity and food supply chain resilience, as high incentives may admittedly make food fraud hard to prevent.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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