Managing Fraud in Food Supply Chains: The Case of Honey Laundering

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Abstract: Recent food fraud incidents have highlighted the need to manage fraud risks in food supply chains. However, there is little research on how to manage these risks. Our study helps to alleviate this issue by examining food fraud risk management in the Asia–Pacific honey supply chain. We conducted interviews about existing food fraud risk management practices. We then used the Gioia method to generate a framework of these management practices, which expanded the “Six Ts” framework by adding a seventh dimension of Tolerance to this extant framework. Next, we empirically examined this novel Seven Ts framework. We found that managers treat many of these risk management practice dimensions as substitutes rather than complements. Our findings and managerial guidance are practically relevant for food companies. Lastly, we believe that, by implementing some of these suggestions theoretically generated and empirically validated by our framework, food supply chains may become more sustainable.

Keywords: food fraud; food supply chain; risk mitigation; sustainable

1. Introduction

On the one hand, internationally sourcing food ingredients and products is beneficial because it may increase the availability and reduce the cost of food. On the other hand, the resulting agriculture food supply chains (FSCs) are typically long and complex [1]. As a result, global FSCs may present risks to consumers, as they may negatively affect food safety [1]. Thus, there is a need to examine how to sustainably access the benefits of globalization while managing these risks. Managing food safety issues has been researched extensively in the supply chain quality management (SCQM) literature (for recent reviews, see [2–4]). This literature assumes that food safety issues arise largely due to unintentional quality issues. Nonetheless, ensuring food safety is central to sustainable and high-quality FSCs [5]. However, there is a paucity of research that has examined how to manage the supply chain food safety issues that are due to quality issues that occur intentionally, otherwise known as food fraud.

Food fraud is “the act of defrauding buyers of food or ingredients for economic gain [6] (p. 2).” It includes “the deliberate and intentional substitution, addition, tampering or mis-representation of food, food ingredients or food packaging, labelling, product information or false or misleading statements made about a product [7] (p. 3).” Growing attention from egregious cases of food fraud has encouraged government regulation and industry to take the initiative to begin to address this problem [6]. For example, the Food Modernization Safety Act (FMSA) and Global Food Safety Initiative (GFSI) require firms to identify and mitigate food fraud risks [7,8]. Two interrelated issues contribute to a lack of practical guidance regarding how to address food fraud. First, compliance with FMSA and GFSI requirements has just taken effect in the last few years. Thus, best practices are still emerging and evolving. Second, an assessment of the causes of or vulnerability to food fraud incidents is still a fruitful area of research [9,10]. Therefore, there is an academic and a practical need to examine how to mitigate food fraud [9].
In this paper, we investigate the food fraud management practices instituted by firms in Asia–Pacific honey FSCs. We focus on honey FSCs because these are, anecdotally, a place where food fraud, which is our phenomenon of interest, is pervasive. We believe food fraud is pervasive in honey FSCs because insiders think it is common place and refer to it as honey laundering [11]. In addition, Honeygate, the largest food fraud incident in the history of the United States, occurred in a network of honey FSCs [11]. Lastly, honey is believed, by some estimates, to be among the top three foods that involve some form of fraud or adulteration in the world [11]. We focus on Asia–Pacific honey FSCs because the other major demand market, the European Union (EU), has the world’s strictest inspection regime. They look for added sugar, antibiotics, and the pollen signatures of the honey [12].

During our initial investigation of food fraud in honey, we discovered that, if the honey does not pass this strict inspection regime, then it is not allowed to be sold or used in food processing in the EU. Through our initial investigation, several industry experts that we spoke with indicated that any honey FSC fraud that may have been occurring in the EU may have shifted to other markets in the world to avoid detection, in order to preserve the profits of the honey launderers. Furthermore, managers have little incentive to take additional mitigation steps, because the EU commission coordinates and bears the majority of the cost for honey FSC inspections and actions [12]. Since the Asia–Pacific region is the largest demand and supply honey market in the world, and the responsibility of detecting and eliminating, or failing to do so, honey food fraud is often borne by the FSC, we decided to examine the management practices there.

We map these specific practices to higher-order constructs, as identified by the Six Ts framework [1], because of the equifinality or substitutability of specific practices. In other words, the SCQM outcome may be the same, but the path that leads to a specific outcome varies depending on a supply chain’s capabilities. For example, some suppliers may need relatively little training because they have developed capabilities through various quality certifications; thus, the focus may be on buyer–supplier integration the SCQM systems between firms. Alternatively, suppliers may require extensive supplier development (e.g., training) prior to effective SCQM integration. Conceptually, the Six Ts propose that Traceability, Transparency, Testability, Time, Trust, and Training practices may complement one another and improve food safety [1]. While the Six Ts may be aspirational regarding what managers should do to regarding aspects of SCQM, including food fraud, our study examines managerial practices relative to food fraud.

Managers may choose to tolerate or accept risks because of implementation costs [13]. Thus, we add the dimension of Tolerance to the existing Six Ts framework to create a new framework, the Seven Ts. Using our new framework, we argue that Tolerance, due to costs, may cause managers to treat the Seven Ts as substitutes rather than complements. Therefore, we hypothesize and test these competing perspectives. Our findings suggest that managers do tend to view this set of practices as substitutes or unrelated considerations. Our study contributes to the extant literature by extending the Six Ts framework and empirically testing the Seven Ts.

The results of our study are particularly timely and practically relevant because the management of Asia–Pacific FSCs is becoming increasingly important. Currently, Asia has a food supply deficit, as it needs to import over 200 million tons of food a year [14]. The countries in the Pacific region make up the majority of the exports that fill this current supply deficit [14]. It is predicted that Asian demand for food will roughly double from its current level by 2030, driven by population growth and changing consumer preferences [15]. At the same time, Asian food supply markets are expected to be more open to increased food price competition [15]. Increased investment in infrastructure such as the One Belt, One Road initiative [16], or trade liberalization [17] may further increase trade across the Asia–Pacific region. With the future growth of Asian food demand and current supply constraints, the management of Asia–Pacific FSCs will become more important over time. Yet, with this increase in trade and economic opportunity, there may also be a corresponding increase in the incentive to commit food fraud. Thus, Asia–Pacific FSCs are an ideal environment...
for studying food fraud phenomena. At the same time, we argue that, by better managing food fraud, which can negatively affect supply, these FSCs may become more sustainable.

To the best of our knowledge, no SCQM study has addressed the challenges associated with the increasing opportunities or incentives for FSC fraud. This FSC food fraud would endanger food safety and could further exacerbate already tenuous Asia-Pacific relationships. For example, the 2009 tainted milk scandal, where at least 6 children died and 300,000 were made ill, was a Chinese domestic issue [6]. It is not hard to imagine the potential ramifications of a similar international incident. Therefore, we believe our study practically contributes by examining how firms manage their FSCs in order to detect food fraud in a timely manner or prevent food fraud from harming consumers. More broadly, we believe our study adds to the nascent literature on how FSC mechanisms may contribute to creating sustainable food supply chains [5,18].

The remainder of this paper is organized as follows. In the next section, we review the relevant literature and generate a set of competing hypotheses. After that, we discuss our research design, methodology, sample frame, and data collection protocol. Next, we present the analysis of our data and report our results. We conclude our paper with a discussion of our results relative to the extant literature, as well as what our results mean for managers, academics, and policymakers.

2. Literature Review and Hypotheses

In this section, we discuss the Six Ts framework of supply chain quality management [1]. We also develop logic for extending this framework by including a seventh dimension of Tolerance.

The Six T’s framework describes six complementary dimensions of SCQM. They are: (1) Traceability, which is “the ability to track a product’s flow or attributes throughout the production process and supply chain [1] (p. 23).” (2) Transparency, which is the sharing of product information throughout the supply chain. (3) Testability, which is the ability to detect a non-conforming product. (4) Time, which is “the duration of specific processes [1] (p. 23).” (5) Trust, which is the ability to rely on another supply chain party to honor their commitments. (6) Training, which is the “systematic process of developing knowledge, skills and attitudes regarding international standards of quality, food safety and best practices [1] (p. 23).” Traceability and Transparency are robustness factors that enable quality in supply chains. They do so by allowing for root cause analyses of quality issues [1]. Testability and Time are complicating factors that may impede the quality in supply chains if not managed. Difficulty in testing for quality issues or long lead times between when a quality issue occurs and when it is found may exacerbate the ability to find and correct the root causes of quality problems [1]. Trust and Training are enabling factors that help to increase quality through the dissemination of quality process improvement knowledge throughout supply chains [1].

Some food fraud research has addressed the components of the Six Ts framework. For example, Robson et al. (2021) conducted a review of food fraud mitigation guides [19]. They found that Transparency and Testing are commonly suggested as the main sources of food fraud mitigation [19]. While not explicitly mentioned in their work, one might argue that there are elements that implicate Trust or Traceability, as defined above, as being used for mitigation. Nonetheless, neither Time nor Trust were implicated.

Similarly, Brooks et al. (2021) conducted a review of food fraud in FSCs, with an emphasis on how COVID-19 and Brexit may have been affecting the incident rate of the fraud [20]. They argued that existing challenges with Testability and Traceability were exacerbated by both COVID-19 and Brexit [20]. They provided specific recommendations about how specific traceability systems and analytic techniques used to detect food fraud may be used to mitigate food fraud from occurring in FSCs [20]. The other four components of the Six Ts framework were not mentioned.

Duan et al. (2020) conducted a content analysis of Blockchain (BC) technology adoption in FSCs [21]. They argued and found that Transparency and Traceability have been
indicated as reasons to adopt BC technology in FSCs [21]. Additionally, they argued that an added benefit of adoption is that food safety will be enhanced and food fraud will be mitigated [21]. However, they also indicated that the literature has identified some challenges to this adoption. While not explicitly mentioned in their work, one might argue that they indicated Training or Trust, as defined above, as being challenges to blockchains being adopted. Yet, their content analysis did not indicate Time or Testability as a either a benefit or challenge.

Danese and Mocellin (2021) examined five companies using BC technology to prevent counterfeiting [22]. They provided guidance on how to build a downstream or upstream BC system to enhance Transparency and Traceability, in order to mitigate counterfeiting. While addressing how to design a BC system to mitigate the risk of counterfeiting is practically relevant [22], counterfeiting is only one type of food fraud [6,9,10]. It is worth mentioning that our study contributes to this literature by examining the other potential factors in mitigating food fraud, as identified by the Six Ts framework. However, it also contributes by examining all the management practices of all types of food fraud that were perceived by honey FSC managers to exist.

Zhang et al. (2023) used an evolutionary game theory model to examine how to mitigate honey adulteration in Chinese private and government FSCs [23]. They found that the managers of companies have an incentive to not adulterate their honey-based products because they are able charge a price premium for their product [23]. However, the non-adulterated honey producer’s ability to charge a premium depends on companies that adulterate their honey products being caught and penalized for such adulteration [23]. Local governments have the responsibility of catching and penalizing any adulteration [23]. As such, their study focused on Testability and Trust, but did not address the other dimensions of the Six Ts framework.

To the best of our knowledge, no empirical research has tested all the proposed dimensions of the Six Ts framework and how they may complement or substitute one another in order to mitigate food fraud. This is a gap in the extant literature. This gap is surprising, given the number of citations that the research has and that the motivating example for this research, which was the product recall of pet food products containing melamine, was food fraud. Our study hopes to contribute to the aforementioned food fraud and SCQM literature by filling this gap.

However, we believe this gap or the lack of research could be due to the Six Ts framework being incomplete. Specifically, it is missing the critical insight that mitigation practices may not always be implemented because of cost [13]. Instead, managers may choose to accept or tolerate risks because they believe that the expense of the risk mitigation practices may exceed the profit made in any given transaction [13]. Integrating this insight into the framework, which we henceforth refer to as Tolerance, creates a seventh T. However, this insight also suggests that managers may not view the original Six Ts as complements. This is because, in practice, when costs are considered, mitigating activities may be substitutes for Tolerance. Similarly, managers may make trade-offs among robustness factors, as well as complicating and enabling factors. Because the Six Ts framework [1] argues that the aforementioned factors should be complements, while the Tolerance logic [13] suggests that they may be substitutes, we propose competing hypotheses. In each pair of competing hypotheses, the first hypothesis suggests a complementary relationship between the robustness factors, complicating factors, and enabling factors, while the alternative hypothesis suggests that they are substitutes. Our hypotheses are:

**H1a–d.** The robustness factors of Traceability and Transparency will be positively related to the complicating factors of Testability and Time.

**H1a.** Traceability will be positively related to Testability.

**H1b.** Traceability will be positively related to Time.

**H1c.** Transparency will be positively related to Testability.
H1d. Transparency will be positively related to Time.
H1e–h. The robustness factors of Traceability and Transparency will be negatively related to the complicating factors of Testability and Time.
H1e. Traceability will be negatively related to Testability.
H1f. Traceability will be negatively related to Time.
H1g. Transparency will be negatively related to Testability.
H1h. Transparency will be negatively related to Time.

H2a–d. The robustness factors of Traceability and Transparency will be positively related to the enabling factors of Trust and Training.
H2a. Traceability will be positively related to Trust.
H2b. Traceability will be positively related to Training.
H2c. Transparency will be positively related to Trust.
H2d. Transparency will be positively related to Training.

H2e–h. The robustness factors of Traceability and Transparency will be negatively related to the enabling factors of Trust and Training
H2e. Traceability will be negatively related to Trust.
H2f. Traceability will be negatively related to Training.
H2g. Transparency will be negatively related to Trust.
H2h. Transparency will be negatively related to Training.

H3a,b. The complicating factors of Testability and Time will be positively related to the enabling factors of Trust and Training.
H3a. Testability will be positively related to Trust.
H3b. Testability will be positively related to Training.
H3c. Time will be positively related to Trust.
H3d. Time will be positively related to Training.

H3e–h. The complicating factors of Testability and Time will be negatively related to the enabling factors of Trust and Training.
H3e. Testability will be negatively related to Trust.
H3f. Testability will be negatively related to Training.
H3g. Time will be negatively related to Trust.
H3h. Time will be negatively related to Training.

We also include a second set of hypotheses that include Tolerance, the seventh T, and its relationship with the relationships between the robustness, complicating, and enabling factors. Using the same logic as above, we believe there may be either a complementary or a substitutionary relationship between these factors. Thus, we hypothesize:

H4a,b. Tolerance will be positively related to the robustness factors of Traceability and Transparency.
H4a. Tolerance will be positively related to Traceability.
H4b. Tolerance will be positively related to Transparency.
H4c,d. Tolerance will be negatively related to the robustness factors of Traceability and Transparency.
H4c. Tolerance will be negatively related to Traceability.
H4d. Tolerance will be negatively related to Transparency.

H5a,b. Tolerance will be positively related to the complicating factors of Testability and Time.

H5a. Tolerance will be positively related to Testability.

H5b. Tolerance will be positively related to Time.

H5c,d. Tolerance will be negatively related to the complicating factors of Testability and Time.

H5c. Tolerance will be negatively related to Testability.

H5d. Tolerance will be negatively related to Time.

H6a,b. Tolerance will be positively related to the enabling factors of Trust and Training.

H6a. Tolerance will be positively related to Trust.

H6b. Tolerance will be positively related to Training.

H6c,d. Tolerance will be negatively related to the enabling factors of Trust and Training.

H6c. Tolerance will be negatively related to Trust.

H6d. Tolerance will be negatively related to Training.

3. Research Design and Methodology

We conducted our semi-structured interview investigation in Asia–Pacific honey FSCs for several reasons. First, in these FSCs, food fraud is perceived to be a large and credible risk, such that the industry refers to the issue as “honey laundering”. Global production and consumption numbers suggest that this perception is valid; the global production of honey was approximately 1.9 million tons, but the global consumption was 2.0 million tons [14]. While this result could be the result of an error in how the FAO collects these data, our interviews of practitioners suggested that honey laundering may be endemic.

Second, the Asia–Pacific region plays an outsized role in honey FSCs. Eight of the top ten honey-producing nations, including Canada, China, Turkey, Iran, Mexico, India, Russia, and the United States, are in the Asia–Pacific Region [14]. Four of the top ten honey-exporting nations, including China, India, New Zealand, and Vietnam, are in the Asia–Pacific Region [14]. Four of the top ten honey-importing nations, including China, Japan, Saudi Arabia, and the United States, are in the Asia–Pacific Region [14].

Third, Asia–Pacific honey FSCs are heterogeneous (see Figures 1 and 2 for examples), which enables the observation of variability in honey-laundering management practices. These FSCs are heterogeneous because the price and uses for honey vary widely. For example, the price of bulk honey may be from several to tens of United States Dollars (USD) per kilogram (kg). Yet, specialty honeys such as Manuka (Australia/New Zealand), Royal Sidr (Yemen), or Elvish (Turkey) may be from one thousand to several million USD/kg. Similarly, honey may vary in use as an ingredient or may be a standalone product. Furthermore, both ingredients and standalone products can be processed into multiple variations (e.g., pure, organic, raw, or unfiltered).

Figure 1. Simple food supply chain (specialty product).
Figure 2. Simple food supply chain (specialty product).

Figure 2. Complex food supply chain (commoditized product).

3.1. Sample

To create our sample, we contacted firms by e-mail or telephone that had experienced honey laundering between 2008 and 2018, as indicated by either the Food Adulteration Incidents Registry or Factiva. Of those contacted, five indicated interest and consented to participating in our study. Due to the global pandemic, our initial interviews of these companies were conducted in English via video conferencing using the questions developed from the key literature themes, as indicated in Appendix A. At the end of the interviews, we asked these companies, if they felt comfortable, to indicate the organizations within their supply chains, either upstream or downstream, who might be interested in participating in our study. As a result, an additional twenty-one firms participated. In total, twenty-six firms participated, including five bee farmers, four aggregators, four brokers, two trading companies, two processors, five food manufacturers, two distributors, and two retailers, across seven countries, including Australia, Canada, China (Hong Kong), Mexico, New Zealand, Turkey, and the United States. The forty-three interviewees from these companies were in charge of the detection, prevention, or response to honey laundering. Their job titles included: Owner, Chief Operating Officer, Chief Supply Chain Officer, Buyer, Logistics Manager, Purchasing Agent, Operations Manager, Quality Manager, and Supply Chain Manager. The unit of analysis was the company’s response to managing food fraud in their supply chain. The company sizes ranged from two to several hundred thousand employees, and the revenues from tens of thousands to billions of U.S. dollars.

3.2. Analytical Approach

The interviews were conducted with key informants who were intimately involved with the food fraud detection, investigation, and prevention process, which is consistent with other FSC qualitative studies of difficult-to-observe phenomena [3,24]. The interviews were between 40 and 100 min in length and were conducted using a semi-structured interview approach. First, the research team asked the scripted questions (See Appendix A) and recorded their responses. Next, the interviewees were allowed to give additional information regarding their food fraud practices, which, in some cases resulted in unscripted questions and discussions. The interviewees were asked to rank order their food fraud practices from most important (10) to least important (1). We concluded the interview by asking if the interviewee knew anyone in their firm or outside their organization who might know more about their or any honey FSC’s food fraud practices. As a result, we conducted
seventeen additional interviews with managers from the same firm and nine with different firms in the same honey FSC. Nonetheless, all were working to address the problem of honey laundering. After the interviews were completed, the interview recordings were transcribed and validated, and then the recordings were destroyed to ensure confidentiality. We validated the data from the interviews using a process described by Manuj and Pollen (2012) [25]. We analyzed these data both within and across the cases using the Gioia method [26]. We started by coding the transcripts to the first-order themes with the help of NVivo. We then developed our second-order themes based on the interviews and the extant literature [26]. Finally, we mapped the second-order themes to our proposed Seven T’s framework. Lastly, we returned to a few of the interviewees with our proposed framework to externally evaluate its validity and completeness [25]. Figure 3 shows the result.

<table>
<thead>
<tr>
<th>1st Order Concepts</th>
<th>2nd Order Themes</th>
<th>Dimensions of the 7 T’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixing or comingling of product in a batch</td>
<td>Transformation of original food product</td>
<td>Traceability</td>
</tr>
<tr>
<td>Use as an ingredient in a recipe</td>
<td>Product identification</td>
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<td>Breaking of bulk</td>
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<td>Co-packing</td>
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<td>Distribution or dispersion of product</td>
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<td>Clarity of product origin</td>
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<tr>
<td>Documentation on when and how product is processed</td>
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<td>Results of any prior quality control tests</td>
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<td>Willingness to work together to solve supply problems</td>
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<td>Change management</td>
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<td>Strategy sharing</td>
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<td>Bills of lading</td>
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<td>Certification of analysis</td>
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<td>Certification of credence attributes</td>
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<td>Import/export documents</td>
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<tr>
<td>Laboratory testing for credence attributes</td>
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<td>Laboratory testing for contaminants or dilution</td>
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<td>Laboratory testing for origin</td>
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<td>Transit length or duration</td>
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<td>Buying direct or minimizing number of entities involved</td>
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<td>Buying in-season</td>
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<td>fraud</td>
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<td>Supplier certification</td>
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<td>Supplier-led testing</td>
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<td>Vertical integration</td>
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<td>Switching suppliers</td>
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<td>Independent verification of facts provided</td>
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<tr>
<td>Hazard analysis</td>
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<td>Risk-based prevention and quality control monitoring</td>
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<td>Corrective action</td>
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<td>Recordkeeping and information sharing procedures</td>
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<td>Learning about customer requirements</td>
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<td>Channel management</td>
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<tr>
<td>Co-investigation customer complaints or quality issues</td>
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<tr>
<td>Likelihood of a specific form of food fraud unknown</td>
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<td></td>
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<tr>
<td>Creative and adaptive nature of food fraud</td>
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<tr>
<td>How do I know with certainty a quality issue is fraud instead of an unintentional quality error?</td>
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<tr>
<td>Increased cost of implementing preventative controls</td>
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<tr>
<td>Customers unwilling to pay to prevent fraud</td>
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<tr>
<td>Profit margin or firm’s ability to stay in business</td>
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</tbody>
</table>

**Figure 3.** Data structure.
4. Results

We evaluated our hypotheses using Kendall’s Tau, because of the rank-ordered structure of the data and our sample size suggests caution regarding parametric assumptions. All the rank-ordered data were analyzed as originally indicated by the interviewees, except for the second-order theme of lack of trust, for which we reversed the code. Our results are reported in Table 1.

Table 1. Kendall’s Tau results.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Traceability</td>
<td>7.63</td>
<td>1.52</td>
<td></td>
<td></td>
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<tr>
<td>2. Transparency</td>
<td>2.96</td>
<td>1.26</td>
<td>0.36 *</td>
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<tr>
<td>3. Testability</td>
<td>7.74</td>
<td>1.70</td>
<td>−0.26 **</td>
<td>−0.34 *</td>
<td></td>
<td></td>
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<tr>
<td>4. Time</td>
<td>2.52</td>
<td>1.59</td>
<td>0.11</td>
<td>−0.14</td>
<td>0.32 *</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5. Trust</td>
<td>5.96</td>
<td>1.83</td>
<td>−0.15</td>
<td>0.13</td>
<td>−0.24 **</td>
<td>−0.25 **</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Training</td>
<td>3.85</td>
<td>1.38</td>
<td>−0.11</td>
<td>−0.23 **</td>
<td>−0.25 **</td>
<td>−0.11</td>
<td>−0.21 ***</td>
<td></td>
</tr>
<tr>
<td>7. Tolerance</td>
<td>8.56</td>
<td>1.01</td>
<td>0.23 **</td>
<td>0.25 **</td>
<td>−0.28 **</td>
<td>−0.20 ***</td>
<td>0.16</td>
<td>0.24 **</td>
</tr>
</tbody>
</table>

* p < 0.01, ** p < 0.05, and *** p < 0.10.

The results showed that the robustness factors of Traceability and Transparency were negatively related to the complicating factors of Testability (τ = −0.26, p = 0.03; τ = −0.34, p < 0.01), but not statistically significantly related to Time (τ = 0.11, p = 0.78; τ = −0.14, p = 0.15). These findings support H1e and H1g, but fail to support H1a–d, H1f, or H1h. Additionally, we found that these robustness factors were not related to the complicating factor of Trust (τ = −0.15, p = 0.14; τ = 0.13, p = 0.18). Traceability was not statistically significantly related to Training (τ = −0.11, p = 0.21), but the results suggested a negative association of Transparency to Training (τ = −0.23, p = 0.04). These findings partially support H2h, but provide no support for H2a–g. Further, the results indicated that the complicating factors of Testability and Time were negatively related to the enabling factor of Trust (τ = −0.24, p = 0.04; τ = −0.25, p = 0.03). Training was negatively related to Testability (τ = −0.25, p = 0.03), but not statistically significantly related to Time (τ = −0.11, p = 0.22). These findings support H3e–g, but fail to provide support for H3a–d and H3h. In summary, our findings suggested that the robustness factors, complicating factors, and enabling factors of the Six Ts framework are used as substitutes in practice.

Our findings regarding Tolerance suggested a complex story. We found that Tolerance was positively related to the robustness factors of Traceability and Transparency (τ = 0.23, p = 0.05; τ = 0.25, p = 0.03). This supports H4a-b, but not the competing hypotheses of H4c-d. Conversely, we found that Tolerance was negatively related to the complicating factors of Testability and Time (τ = −0.28, p = 0.02; τ = −0.20, p = 0.07). This supports H4c,d, but not the competing hypotheses of H4a-b. Finally, we found that Tolerance was not significantly related to the enabling factor of Trust (τ = 0.16, p = 0.12), but was positively related to Training (τ = 0.24, p = 0.04). These findings support H6d, but fail to support H6a-c. Together, these findings suggest that Tolerance may be used in practice as a complement to Traceability, Transparency, and Training, and that Tolerance may be a substitute for Testability and Time.

5. Discussion and Implications

The FMSA [8] and GFSI [7] require companies to consider Hazard Analysis and Risk Based Controls (HARPC) to prevent SCQM issues, including food fraud. How food fraud should be managed is an ongoing and practical discussion for FSC managers. To address this issue, we mapped the case study interview data to the Seven Ts framework for SCQM. We then empirically tested whether the managers viewed the robustness, complicating, and enabling factors identified in this framework as complements or substitutes. In doing so, we simultaneously addressed the need to begin empirically testing the Seven Ts framework [1], while examining how to mitigate food fraud [9]. Our findings contribute to this discussion.
and provide managerial implications in several ways. In addition, our study has several implications for SCQM and food fraud research. We discuss these in the sub-sections below.

5.1. Managerial Implications

Our study offers several important managerial implications. Specifically, our first managerial implication is that our study suggests that, practically, managers may not see the original Seven Ts as complements. This is because, when costs are considered, Tolerance may be a substitute for mitigation. In addition, the reliance on Trust suggests that these costs of mitigation are likely to be substantial. However, not a single FSC manager in our sample mentioned cost-sharing (or profit-sharing) contracts (cf. [27]). This lack of discussion about cost sharing as a form of FSC fraud management is surprising, because our findings suggest that cost appears to be a significant driver of FSC fraud management practice adoption. As such, we recommend that FSC managers consider cost-sharing contracts, as they may help to reduce the impact of information asymmetries on unintentional conformance quality issues, as suggested by existing research [27]. This logic also applies to food fraud. However, even with cost-sharing contracts, the food fraud prevention costs may be larger than the costs of transactions [13]. If that is the case, we recommend that managers pursue voluntary standard certifications such as GFSI [7]. These voluntary certifications tend to allow FSC companies to charge a premium price for taking actions to increase their food safety, including controlling food fraud. It is plausible that regulation may eventually close markets to FSC managers that do not act proactively.

Our second managerial implication is that the robustness factor of Traceability appears to be used primarily as a tool to facilitate the product recall of non-conforming goods. While compliance tends to be a driver of FSC investments that facilitate Traceability [3,24,28], there may be additional benefits that FSC managers do not currently utilize, which also are aided by the incorporation of FSC Transparency. For example, these factors may enable root cause analyses and organizational learning to prevent future quality problems [29]. Furthermore, Traceability may increase the speed and efficacy of FSC decisions [2], as well as result in potential cost savings by doing so [24]. Finally, Traceability may encourage collaboration, cooperation, or incentive alignment among FSC entities [1]. In the very least, it may enable the use of mechanisms that do so [27].

Our third managerial implication is that managers frequently rely on the validity of quality tests, typically provided by a supplier, otherwise known as Testability. This is somewhat surprising, given that the FSC managers consistently expressed the sentiment that food fraud is challenging to manage because it is widespread, conducted by actors both within and outside of the supply chain, and can take many different forms. Of the different types of food fraud, document fraud, including the falsification of test results, may be one of the more prevalent forms of food fraud [30,31]. As a result, reliance on supplier-provided test results may be inadequate. We therefore recommend the random validation of supplier test results by the buying firm. In contrast, we recommend targeted sampling techniques to manage specific food fraud risks. For example, a testing regime may allow for discrimination between trusted and non-trusted suppliers. While relying on testing alone for food safety has limitations [32], following our recommendations, managers may prevent a product recall and its associated costs [24].

Our last managerial implication is that, by preventing food fraud, we believe managers may increase the ecological, economic, and social sustainability of FSCs, which customers and stakeholders demand [5]. This is because these preventative measures act as deterrents to offset any economically motivated bad actors by increasing the costs to hide their fraud or reducing the profits from fraudulent food being detected. In other words, we believe these may make FSCs less vulnerable to fraud [30]. Ecological sustainability is increased by finding fraud or even simply searching for food fraud. Typically, fraudulent food is seized, destroyed, or otherwise made not useable by consumers. As such, all ecological damage created through growing, processing, storing, and transporting the fraudulent food is not offset by the social benefits of it being consumed. Similarly, the FSC may
become more economically sustainable for legitimate suppliers of food, as fraud tends to bring down market prices [9,23,31]. At the same time, the entire FSC may become more economically sustainable, as these preventative practices may prevent costly food recalls from happening [24]. These FSC costs are ultimately borne by customers. Finally, the FSC will likely be safer by preventing food fraud from reaching consumers [4,30].

Taken together, our managerial implications suggest that managers should experiment with different FSC preventative mechanisms. Our findings suggest that FSC managers tend to use few Time-, Transparency-, and Training-based practices. Yet, there may be ways to control food fraud using these underutilized dimensions of the Seven Ts framework. For example, one company in our sample indicated the use of Time to reduce the opportunity for food fraud to occur within their supply chain by expediting the shipment of their products. Similarly, firms may be able to charge a premium by providing Transparency and ensuring the credence attributes of FSC products. Transparency may be particularly valued in Asian markets, where food fraud is perceived by consumers to be a credible threat based on historical events [1]. Finally, the Training of customers to detect and report food fraud, in many instances, may be the first step in helping to investigate the origins and extent of the fraud [1]. All three of these working in tandem may be important in managing food fraud in newer business models such as sustainable FSCs.

5.2. Research Implications

Modern FSCs are often global and complex, rendering the SCQM within these supply chains extremely challenging [1]. While SCQM is important for creating sustainable FSCs [5], the existing SCQM research informs supply chain managers on how to manage unintentional FSC quality problems [2–4,24], but managers have little guidance about how to manage intentional FSC quality problems or food fraud. Our research begins to give guidance on how to manage food fraud. We found that managers tend to rely on Traceability, Testability, and Trust practices to manage food fraud, while rarely prioritizing Transparency, Time, or Training practices. This is surprising, because existing research suggests that synergies, in theory, may exist among these various categories of practices. However, our research suggests that, due to resource constraints, these practices are used as substitutes. Our research does not negate the Six Ts framework, but contributes to the extent theoretical framework by expanding it to include this practical consideration. In fact, in our expanded Seven Ts framework, we empirically found that Tolerance is the most consistently employed SCQM practice.

These findings have several implications for research. First, while prior research has evaluated the potential benefits of implementing specific categories of SCQM practices such as Traceability [2,3,28], little of this research has estimated the costs or cost savings of these practices. This is an important research direction, because FSC managers need to know both to conduct cost–benefit analyses of various practices [24]. In general, the cost of preventing poor-quality products from reaching the end customer has been consistently estimated to be less than the cost of external failures that reach the customer [33]. It is important, however, to recognize that the costs of internal or external failures could be borne by different entities within a supply chain. To our knowledge, no research has yet addressed how to share these costs, or, alternatively, the cost savings from preventing food fraud in the supply chain.

Second, even though our study found that managers generally view the Seven Ts as substitutes, it is possible that there may be contingent relationships among the Seven Ts. For example, Competitive Progression Theory suggests that the order of capability development may determine if practices are complements or substitutes [34]. In other words, we believe that there may be contingent relationships among the Seven Ts. Based on prior research [4,5,9,18,24,31], we believe these contingent relationships could affect the sustainability of FSCs. As such, future research should not overlook the possibility that some combinations of these Seven Ts may act as complements, whereas others act as substitutes.
Finally, the implementation of food fraud prevention is still in its early stages and is not yet mature [7,8]. Our examination of the relationship among the Seven Ts may help to implement food fraud prevention. Nonetheless, managers’ views and practices may evolve as learning occurs. While the extant quality management literature has addressed how practices are updated over time [35] and how learning occurs within, as well as across, firms [28], there is a need to describe these phenomena within the context of food fraud, because such fraud occurs with intent to deceive. Thus, it may be more difficult to detect and learn from fraud using conventional SCQM practices.

5.3. Policy Implications

There are policy implications of our research. Our first set of policy implications is for supply chain policymakers. Food fraud is either discovered or goes unnoticed. In the case where it is discovered, which often is accompanied by product recall, the economic consequences of this discovery leave lasting economic consequences for the supply chain members [2,3]. We also argue that, ecologically, food fraud is wasteful, because the environmental impact, which is often negative, of creating, harvesting, processing, and transporting the food is realized, but the nutrition from the food is not. For example, carbon dioxide associated with these activities is created, but none of the benefits from human consumption are realized. In the case where it goes unnoticed, public health or social wellbeing are negatively impacted [30]. As such, we argue, based on prior research [5], that food fraud, which is a quality issue, is inherently a sustainability issue. As such, supply chain policymakers interested in creating a more sustainable supply chain, such as large companies that can dictate the adoption of policies, should consider the following recommendations. They could consider contracting to share product recall costs across all members and provide quality improvement incentives [27]. In addition, they may consider, in terms of changing supply chain governance [18], encouraging sustainability. Lastly, in addition to acting with their own firm, they may encourage the managers of other firms in their supply chain to adopt the SCQM practices indicated in the managerial implication section of our research.

Our second set of policy implications is for lawmakers. We argue that there may be incentives for lawmakers to encourage policies to reduce food fraud, because major food fraud events could hurt social stability. For example, the widespread pet food recalls in 2007 [1] may have temporarily harmed the international relations between the U.S. and China. In another example, the infant formula scandal in 2008 in China [4] may have temporarily disrupted the social harmony there. Both of these events had negative financial consequences for FSCs. They reduced international pet food trade [1] and caused an immediate reduction in willingness to buy domestically sourced baby formula [4], respectively. In both situations, there was an FSC demand and supply in balance created by these events. At best, we are certain that tax revenues are harmed, at least temporarily, by food fraud events. At worst, some FSC firms can be affected by stranded assets. Lastly, more safe and affordable food may be an outcome of preventing food fraud [9,10]. Taken together, these indicate that policymakers have strong incentives to encourage the adoption of SCQM practices, as indicated in the managerial implication section of our research. They may conduct this in several ways. The first way they might conduct this is by mandating through law that the firms within their jurisdiction adopt any or all of the identified SCQM practices (cf. [23]). However, we believe that any mandate alone may fail. They may fail because the mandate would not cover most of the SCQM practices suggested by our analysis of the Seven Ts framework. For example, we believe the EU mandate of Testability, but not other elements of SCQM practices, has shown limited success in preventing actors in FSCs from attempting to honey launder [12]. Additionally, our study of Tolerance indicated that, often, SQCM practices were perceived as having higher production costs. This leads to the logical conclusion that FSCs that implement SCQM practices may be perceived as less competitive than other FSCs not under the same mandate. This is because, in FSCs, it is most common that the primary focus is on production efficiency or costs,
rather than ecologically or socially responsible concerns. We found that this was true, even though the firms were aware that, by addressing ecologically or socially responsible concerns, their FSC or firm may be able to charge a price premium. We found that, often, this price premium and the resulting revenue were not perceived to be larger than the costs. We found those few firms that eschewed Tolerance on a regular basis usually did so for sustainability being the ethical thing to do or brand image concerns. As such, we argue that mandates should be pursued only with collaborations with other jurisdictions on a shared, mandated standard of FSC SCQM practices or for FSC subsidies to adopt SCQM practices. Collaborations with other jurisdictions to create a shared, mandated standard ensures that every individual FSC plays by the same rules, would incur similar costs, or have similar reductions in their production efficiencies introduced by these. Regularly, collaborations fail to include all jurisdictions. We recommend FSC subsidies for when every jurisdiction does not play by the same rules. The exact nature of these subsidies, we leave to future research.

6. Conclusions and Limitations

Our study makes several contributions to both academic knowledge and the practical management of FSCs. First, we illustrated how food fraud is managed by building on the extant SCQM literature that has focused on food safety [1–4]. As such, our study fills a gap in the literature by being among the first to empirically examine how an FSC might mitigate food fraud [9]. Second, as our empirical results suggested, the tolerance of and trust in other supply chain entities appear to be the dominate manners of food fraud management. This is contrary to what is suggested by the extant Six Ts theoretical framework, but reflects current practice. We contribute by extending this framework to include Tolerance. Overall, and practically, these findings suggest that managers need to focus their efforts on how to encourage FSC participants to help prevent food fraud. These efforts may involve incentives or contracts, whose specific functional form we leave to future research. Finally, we provide a starting point for FSC managers who are seeking information about best practices and how to comply with recent FMSA and GFSI food fraud requirements.

Our study is subject to several limitations, which provides opportunities for future research. First, we limited our investigation to Asia–Pacific honey FSCs. While this focus may limit its generalizability, our study practically contributes by providing a starting point for the managers of other FSCs in the management of food fraud. This is important, because food fraud may be difficult to identify due to the difference between unintentional quality failures and deliberate food fraud [6,31]. For example, the Peanut Corporation of America’s (PCA) series of food product recalls in 2009 were initially attributed to a failure in the PCA’s quality management system (QMS) to detect the presence of salmonella during production. Upon further investigation, the PCA’s QMS was working, but the managers intentionally distributed the unsafe product in order to profit [6]. In other cases, food fraud may mimic a desirable characteristic of food and the evidence of the adulteration is destroyed during the consumption process. For example, the pet food recalls in 2009 contained melamine, which mimics protein [1].

Our second limitation is that we did not investigate the role of any aspect of social identity theory (i.e., culture, in-group/out-group dynamics, etc.) in the nature of food fraud vulnerability and, subsequently, preventative management practices. Despite our sample of twenty-seven firms across eight countries, we did not have a large enough sample to distinguish the best management practices considering the aspects of social identity theory. Nonetheless, it may be possible that any aspect of social identity theory could affect food fraud or its management.

Finally, we implicitly studied practices that managers perceived as effective against food fraud. While some research supports the reliability and validity of perceived measures of performance [36], we have no definitive proof that such measures are objectively better. To measure the objective efficacy, we would need to observe the inputs and outcomes of
food fraud practices at every stage in a particular FSC and across multiple different FSCs. Given the illicit nature of and intentional guile associated with food fraud, this would be difficult to accomplish. Future research may be able to expand upon this work to address some of these limitations.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** This study was exempt under category 2. Nonetheless, we followed exempt study procedures and best practices. Interviews were based on participants personal knowledge of activities at each case study organization. Each interview was conducted with conditions of anonymity and that statements were not made on behalf of the case study organization.

**Informed Consent Statement:** All interviewees gave their voluntary and informed consent for inclusion before they participated.

**Data Availability Statement:** The summarized data presented in this study are available in Table 1 and Figure 3. To create a sample similar to our researchers may search for food fraud incidents using the Food Adulteration Incidents Registry or Factiva. Due to the need to maintain anonymity, after interviews were completed, the interview recordings were transcribed, and the recordings were destroyed. Further, to maintain anonymity, each transcript has an anonymized and generic name used to describe their organization, downstream, or upstream organizations based on where they were located in the chain. Similarly, any person’s name was replaced with John Doe and a number. The resulting generic and anonymized transcripts are available upon request from the corresponding author, but are not publicly available in order to minimize the risk of identifying interviewees or organizations discussed in the interviews.

**Conflicts of Interest:** The author declares no conflict of interest.

**Appendix A**

**Interview protocol**

1. What are the current activities that you are doing to manage, prevent or mitigate food fraud? What are you considering or planning to do in the future?
2. What role do your suppliers (or their suppliers) play in managing, preventing, or mitigating food fraud? What are your suppliers’ (or their suppliers) current activities? What are their future activities?
3. What role do your downstream entities, such as manufacturers, distributors, and retailers, etc. play in managing, preventing, or mitigating food fraud? What are their current activities? What are their future activities?
4. What company or supply chain activities inhibit or impede food fraud?
5. What company or supply chain activities support or encourage food fraud?
6. What role do financial resources or implementation costs play in your food fraud management choices?
7. Is there any additional information that you would like to share with us?

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