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1 **Crime prevention in the food supply chain: addressing the pinch-points**

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10 **Abstract**

11 Food crime detection and prevention remains a challenge when whilst
12 opportunity for crime can be reduced by implementing certain measures;
13 addressing the potential perpetrators, their possible actions and criminal
14 behaviour (including their rationalisation and decision making) and the trade-
15 offs that can occur as a result of pressure in the food supply chain that
16 provide a motivation for such activity, still remains complex and difficult.
17 These factors have led, in this study, to the consideration of pinch points
18 within the food supply chain where crime could occur as a result of capability,
19 opportunity, motivation, rationalisation and supply chain pressure. Pinch
20 points can be addressed using the Food Crime Countermeasures Framework
21 (FCCF) conceptualised in this paper. The conventional anti-fraud measures:
22 detection, deterrence and prevention are essential to support food fraud risk
23 assessments, continuous interventions and response strategies. The
24 implementation of countermeasures that initially drive prevention and
25 deterrence and where required, detection, intervention and response form the
26 basis of the approach outlined in this paper.

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27

28 **Keywords:** continuous interventions; countermeasures; fraud; vulnerability

29

30

31 **1. Introduction**

32 Illegal activity in food supply chains is not only a discrete process
33 operating in parallel to legal activities and supply chains, instead such activity
34 can be embedded within authorised, licensed and permitted processes that
35 have particular elements of opacity (Gregson and Crang, 2017; Manning et al.
36 2017). Illicit behaviour is a contemporary and an ancient theme in food supply
37 chains both in terms of academic research, industry awareness and in
38 emergent food related organisational and supply chain literature. Since the
39 financial recession of 2007-08, McElwee et al. (2017) suggest that
40 contemporary evidence from official reports and the media shows an increase
41 in food related criminal activity including food adulteration, mislabeling of food,
42 sheep theft, and trading in illegal halal meat. Farm crime has been
43 considered in terms of criminal typology such as the urban marauder (Smith,
44 2010) exploiting often weak levels of security and police activity in rural areas,
45 organised criminal gangs (OCGs) that may involve a network of insider
46 groups (such as farmers) as well as external actors who can pass on the illicit
47 goods into wider markets and destinations (McElwee et al. 2017). However,
48 the strategic decision to engage in informal, and criminal acts for financial
49 gain may be motivated primarily by austerity and its impact on the food supply
50 chain and the need to be resilient or simply survive rather than motives of
51 profit maximization and greed (Smith et al. 2017). Farms are just one element

52 of the supply chain that encompasses multiple actors and stakeholders.

53 Organisations do not sit in isolation; they interact with external
54 influences in their wider environment (Winter et al. 2004). Primary producers
55 are actors that provide raw material, such as farms and aquaculture
56 secondary producers (manufacturers that enhance the value of raw materials,
57 wholesalers, distributors) and tertiary producers (retailers and food service)
58 see Closs and McGarrell (2004); Borghesi and Gaudenzi (2013). Supply
59 chains are socio-economic networks with inter-related strategies, activities,
60 dynamic components (the products, processes and technical knowledge
61 employed) and structural elements such the key actors involved including the
62 retailer, farmer, manufacturers processor, distributors and food service. Other
63 factors include stakeholders such as investors, shareholders, insurers,
64 certification bodies, governments, policy makers and regulators, civil society,
65 amongst others; the complexity of the relationships formed, the climate of the
66 relationships in terms of collaborative or conflicting characteristics, and the
67 type of goals each actor develops (Closs and McGarrell, 2004; Borghesi and
68 Gaudenzi, 2013). What factors have led to this reported rise in food related
69 criminal activity both at farm level and across the wider supply chain and how
70 is illicit behaviour rationalised from being the exception and becoming the
71 norm? Are the factors influenced by multiple trade-offs within the food supply
72 chain?

73 Trade-offs are said to be central to economics, because in a given
74 situation neither the decision-maker nor wider society can have everything
75 they want so they have to compromise in some way (Campbell and Kelly,

76 1994). A trade-off is a mediated form of decision-making that is often a
77 compromise, and this type of decision-making is ubiquitous at farm level when
78 land is managed with multiple strategic and operational objectives (Klapwijk et
79 al. 2014). Consumer trade-offs are often defined as being based on
80 willingness to trade some attributes e.g. quality or safety for others such as
81 price influencing marketing strategies, economic research and guiding public
82 policy i.e. trade-off as a means of mental exchange rate between discrete,
83 explicit attributes (Luce et al. 1999). Trade-offs therefore occur at multiple
84 levels in such network systems (Table 1).

85 **Take in Table 1**

86 Protected values are those values that prove resistant to trade-offs with
87 other values, particularly economic values (Baron and Spranca, 1997).
88 However, research on trade-offs especially with multiple attribute and/or
89 collective decision-making has considered other attribute trades such as time
90 versus cost trade-offs (Feng et al. 1997); time-cost-quality trade-offs
91 (Monghasemi et al., 2015); speed versus accuracy trade-offs (Häubl and Trifts
92 2000; Franks et al. 2003; Dane and Pratt, 2007); accuracy versus effort (or
93 energy) trade-offs (Johnson and Payne, 1985, Bettman et al. 1990; Häubl and
94 Trifts, 2000; Boulis et al. 2003; Gigerenzer and Gaissnaier, 2011); accuracy
95 and informativeness trade-offs i.e. accepting errors in return for securing more
96 informative judgments (Yaniv and Foster, 1995); cost versus risk trade-offs
97 (Kerstholt, 1994); and benefit versus harm as a trade-off (O'Connor et al.
98 2003).

99 Time pressure is a frequent element of trade-off. Time pressure is
100 driven by deadlines when the time available may be perceived as too short to

101 make a decision and multiple studies have investigated this phenomenon
102 (Huber and Kunz, 2007). Time pressure, for example may lead to a negative
103 emotional response (Maule et al. 2000) which then affects decision-making.
104 Luce et al. (1999: 144) define emotional trade-off difficulty as “the level of
105 subjective threat a decision-maker associates with an explicit trade-off
106 between two attributes. Thus positive (benefit) and negative emotion (fear,
107 harm, anxiety, threat, challenge, concern) and specific emotional goals (such
108 as protecting self-esteem, maintaining a moral value or ideal) have an impact
109 on both cognitive appraisal and decision-making. Therefore, trade-offs that
110 can occur are multiple, complex and interwoven and the compromise between
111 legality and illegality is only one of multiple decisions that supply chain actors
112 have to take.

113 Decision-making behaviour is affected by these dynamic aspects of a
114 given task environment such as time pressure, feedback on the effect of own
115 actions, uncertainty and also a trade-off between cost and risk (Kerstholt,
116 1994). As a result, humans adapt their decision-making behaviour to a given
117 situation or environment often seeking to reduce the amount of associated
118 cognitive effort required (Shugan, 1980; Häubl and Trifts 2000) either as a
119 conscious response or as an unconscious cognitive strategy. Thus it could be
120 posited that decision-making is a situated event influenced by a number of
121 factors. Prendergast (2002) suggests that the trade-off of risk versus
122 incentive is influenced by how risk is determined e.g. risk as measured by
123 volatility or variance of returns by the executive, whereas for farmers it is the
124 variance of profits or variance of yield in a given crop cycle.

125 In this context a *food crime* threat can be considered to be an agent
126 that arises from fraud, or perpetrators taking advantage of the market
127 opportunities to substitute or deceive as a result of weather events, harvest
128 failure etc. that can cause loss or harm to individuals and/or organisations.
129 Profit maximisation in the agricultural sector is contextualized by
130 characteristics of constant uncertainty and risk of failure due to weather,
131 animal disease etc. and many farming organizations have limited
132 opportunities in terms of growth orientation and business expansion (Smith et
133 al. 2017). So what are the pinch points in the supply chain that give rise to the
134 environment where crime could occur?

135 **2. Pinch Points**

136 The term “pinch-point” has been used to describe physical points or
137 locations (Makwasha and Turner, 2013); the weakest necessary conditions for
138 the problems to persist (Read and Tilley, 2000); strategic points in the supply
139 chain (Christopher and Peck, 2004); and points of intervention (Weisel, 2003)
140 such as where external pressure can be applied e.g. regulatory pressure or
141 stimulus (Yakovleva and Flynn, 2004) or to disrupt criminal activity (Chon,
142 2016). Pinch-point mapping involves identifying potential bottlenecks and
143 threats and manipulating and managing those points in order to ensure
144 effective control of resources in order to meet demand (Pil and Holweg,
145 2006). Moreto and Clarke (2013) in their research on transnational illegal
146 markets in endangered species highlight that crime is situational and by
147 directing preventive measures at pinch-points then this will deliver the best
148 results in reducing the potential for criminal activity. Further they argue
149 different crimes will have different pinch-points. In summary, a pinch-point is

150 the location at which intervention might be expected to have the longest term
151 of action and the widest impact (Read and Tilley, 2000) and in the context of
152 food crime the point where interventions take place that will have the longest
153 and widest impact. In terms of types of crime associated with the food chain
154 this paper is considering inter-food supply chain i.e. between one discrete
155 food supply chain and another, the legal and the illicit and intra food supply
156 chain criminal activity i.e. criminal activity within an otherwise seemingly
157 legitimate food supply chain. To provide clarity the following definitions from
158 Closs and McGarrell (2004, p8) are used:

- 159 • *A supply chain* is the combination of organisations and service
160 providers that manage the raw material sourcing, manufacturing, and
161 delivery of goods from the source of the commodities to the ultimate
162 users.
- 163 • *Supply chain management* is the inter- and intra- organisational
164 coordination of the sourcing, production, inventory management,
165 transportation, and storage functions with the objective of meeting the
166 service requirements of consumers or users at the minimum cost.
167 Pinch-points can be created by supply chain pressure (Manning et al.
168 2017).

169 In a given food supply chain there are normative, coercive and mimetic
170 pressures from respectively lobby groups, consumer, criminal groups,
171 coercive and political pressures from government, buyers and sellers etc.
172 (Kilbourne et al., 2002), and mimetic pressures (economic), which emerge
173 from horizontal competition (Aerts et al., 2006; Zhu et al., 2005; Sarkis et al.,
174 2010) that operate at individual levels primary, secondary, tertiary production

175 and also at the interfaces between levels. Pressure can be specifically
176 exerted where there is an asymmetry in supply chain power between two or
177 more actors/stakeholders. Wolf and Hermanson (2004) argue that pressure is
178 one element of the “fraud diamond” model, the other three elements being
179 capability, opportunity and motivation. Indeed, trading in an environment
180 where there are differentiated global standards for animal welfare,
181 environmental protection and worker welfare standards can lead to trade-offs.

182 Borghesi and Gaudenzi (2013) considered four types of supply chain
183 risk: market risk, process risk, supplier risk and environmental risk as well as
184 the risks associated with transparency and information visibility. For a retailer,
185 the degree of risk associated with a given actor is mediated by whether the
186 actor has a given monopoly in terms of their products or service or
187 alternatively whether the actor e.g. a farmer can be easily substituted.
188 Traditional supply chain response to managing and mitigating risk include
189 using insurance, greater information sharing or outsourcing risk to other
190 supply chain actors (Olson and Wu, 2011). Therefore, driven by shareholder
191 or insurer demands to quantify, manage and where possible mitigate their
192 market, process, supplier and environmental risk profile, retailers,
193 manufacturers or food service may adopt a systems based approach to risk.

194 There are multiple pressure factors that can drive illicit activity in food
195 supply chains including rapid development of systems, logistics and
196 technology, asymmetry in information flow, data swamping and opacity;
197 market competition and resource scarcity, inadequate policy and market
198 governance, lack of regulatory and market sanctions, isomorphism, and
199 ultimately low probability of discovery (Charlebois et al., 2016; Manning et al.,

200 2016; Manning, 2016; Marvin et al., 2016; Manning et al. 2017). This pressure
201 can create a series of pinch-points of informal: formal and visible: invisible
202 supply chain risk interface(s) where differentiation in actor and stakeholder
203 approaches, goals and objectives leads to trade-offs and thus gives rise to
204 illicit behaviour. Taking a transactional approach and simply developing formal
205 risk prevention strategies (countermeasures or preventive measures) is not
206 enough to address the challenge if illicit behaviour and so pressure,
207 opportunity. Capability, motivation, rationalisation, the derived value
208 propositions, and regulatory and market incentives for illicit behaviour also
209 need to be considered when developing crime prevention strategies (Manning
210 et al. 2016; Manning et al. 2017).

211 The actualization of this pressure, capability, opportunity and
212 motivation dynamic can be seen through the lens of recent global food
213 scandals such as the 2014 European horsemeat scandal; the 2017 meat
214 fraud scandal in Brazil (Manning et al. 2017), and the 2017 fipronil in eggs
215 and composite products scandal in Europe. The lack of early and harmonised
216 regulatory intervention in the fipronil scandal has resulted in an incident that
217 has affected 56 countries (RASFF Portal, 2018; RASFF 2018). Manning et al.
218 (2017:19) outline a number of contextual factors that show the complexity of
219 the socio-economic aspects of illicit behaviour such as resource allocation
220 and ownership, power relations, greed, economic inferiority, need and
221 pressure, and argue that the existing model of the two-dimensional fraud
222 diamond is actually three dimensional and multifaceted when the socio-
223 economic dynamics of supply chain pressure are also considered.

224

225 **3. Locating and situating food crime prevention**

226 Supply chain power is driven by the degree of power localisation or
227 conversely distribution and each actor's relative control of or access to
228 resources and capital assets. Thus the risk of illicit behaviour is situational
229 and is framed as has just been described by power structures and other
230 socio-economic factors. Successful modes of food crime in terms of the
231 degree of financial gain, or their impact in the case of food defense, reflect on
232 the quality of execution and at what point, or even if, detection actually occurs.
233 The use of a pre-requisite program to minimise and where possible eliminate
234 the likelihood of an *unintentional* food safety incident is well established in the
235 food supply chain through the hazard analysis critical control point (HACCP)
236 approach. The alternative i.e. the development of a countermeasures program
237 to minimise or where possible eliminate the likelihood of a food crime threat is
238 less well determined.

239 In the wake of the 2013 Horsemeat Scandal, the Elliott Review
240 determined that a national food crime prevention framework was essential to
241 prevent a future food crime incident (Elliott Review, 2014). Countermeasures
242 that address food crime vulnerability include detection, deterrence and
243 prevention and disruption (Spink et al. 2015; Spink et al. 2016; Soon and
244 Manning, 2017). Detection measures can identify the activities associated
245 with food crime, whilst deterrence includes the measures that focus on a
246 specific type of attacker and their activities. Deterrence can therefore be
247 described as the inhibition of opportunity and perpetrator activity as a result of
248 concern over the personal consequences to themselves as a result of taking
249 an action or the maintenance of appropriate preventive measures, or

250 countermeasures that will discourage their activity (e.g. concern that the
251 attack will fail). Prevention in this context concerns the resources employed to
252 minimise the potential for a food crime incident to occur and ensure disruption
253 mechanisms to address any activity if it occurs. Preventive measures,
254 deterrence and/or a lack of motivation to conduct food crime will also have
255 influence. Spink et al. (2017) recommended that in order to address the root
256 cause of food fraud – food science and technology should encompass social
257 science, business and understanding of criminology.

258 Manning and Soon (2016) compared and contrasted six existing food
259 crime risk assessment (FCRA) models in terms of their aims, mechanisms of
260 operation and practicalities of use. The risk assessment models were: threat
261 analysis critical control point (TACCP), vulnerability assessment and critical
262 control point (VACCP), the CARVER+SHOCK tool, the food protection risk
263 matrix (Spink and Moyer, 2011), and the United States Pharmacopeial (USP)
264 preventive food fraud management system.

265 The ability to quantify the likelihood of a threat or vulnerability in a
266 given situation is influenced by the degree of adoption of countermeasures
267 and their effectiveness (Manning and Soon, 2016). Thus whilst FCRA is
268 obviously of value, that preventive benefit to organizations is limited especially
269 with regard to emerging or new threats if the risk assessment phase does not
270 translate into an effective, and dynamic food crime countermeasures
271 framework (FCCF). The development of the FCCF is essential to embed
272 preventive measures, identify relevant sources of intelligence on changing
273 status of risk, detect illicit activity, and ensure timely and appropriate
274 responsive action and a countermeasures' continuous improvement strategy.

275 Therefore, three factors: detection, deterrence and prevention can be drawn
276 together at regulatory, supply chain or individual business level to underpin a
277 FCCF of integrated risk assessment and implementation of countermeasures
278 that initially drive prevention and deterrence and where required, detection,
279 intervention and response (Figure 1).

280 **Take in Figure 1**

281 Horizon scanning can be described as a systematic way of considering
282 evidence about future trends and scenarios in order to determine whether an
283 organization is adequately prepared for potential threats and has
284 implemented, or can readily adopt, means for their appropriate
285 countermeasure control. Effective horizon scanning is a foundation for a
286 FCCF i.e. considering intelligence from a range of sources, be it economic,
287 social or environmental, in order to effectively map possible criminal scenarios
288 associated with the materials and products that the organisation procures,
289 produces and sells, in order to accurately identify the potential threat, the
290 controls required and the mechanisms for updating such assessments if the
291 evidence (intelligence) changes in the future. During the mapping process
292 weak areas, pinch-points or *hotspots* that are vulnerable to food crime at
293 specific stages in food supply chains or networks can be determined.
294 Detection, mapping and prevention activities can only be developed to
295 address known issues or activities, making TACCP and VACCP of limited
296 value with regard to emerging crime risk or entrepreneurial, enterprising,
297 situational crime risk that is reactive, responsive and specific to an
298 organisation, the products it produces and the associated supply chain (Soon
299 and Manning, 2017).

300 Those individuals or teams developing FCCF (often termed *defenders*)
301 need to recognise that the adoption of universal, general countermeasures
302 based on historic threats as a 'catch all approach' to preventing and where
303 required managing food crime is of limited value in addressing illicit behaviour
304 that is caused by supply chain pressure as the drivers of illicit behaviour and
305 associated opportunity, rationalisation, capability and motivation, and derived
306 value proposition are situational and transitory.

307 Situational crime risk and the means to predict its occurrence been
308 explored within criminology and contemporary food literature (Manning and
309 Soon, 2016; McGloin et al. 2011; Perline and Goldschmidt, 2004). Situational
310 crime risk factors include factors such as supply chain pressure, power
311 asymmetry, type of corporate culture, the work environment and can have a
312 multiple, compounding impact (Perline and Goldschmidt, 2004; Carson and
313 Bull, 2003). Situational crime risk can be mitigated by strengthening
314 environmental resilience (Clapton, 2014) especially by increasing the
315 associated personal risks and difficulties associated with the crime and
316 alternatively reducing the potential personal rewards of committing a crime
317 (Spink and Moyer, 2011; Clarke, 1995).

318 The concept of crime prevention through environmental design is nothing
319 new as the design of physical space has long been identified as being
320 important in understanding and mitigating criminal behaviour (Newman,
321 1972). Newman proposed that defensible space can be created when the
322 physical space is structured in a way that reinforces the social structure that
323 defends itself i.e. a farm or factory design could in itself help or hinder the
324 social culture of the organisation in which people work and their psychological

325 engagement with the space itself. Appropriate countermeasures that are
326 based on the concept of defensible space can be adopted in a preventive
327 approach to crime in the food supply chain. Newman (1972) identified four
328 themes of defensible space and these have been adapted in this conceptual
329 research to considerations of a food factory environment:

- 330 • **Territoriality** – creating a sense of legitimate and illegitimate access to
331 space i.e. identifying the legitimate allocation of space to those who are
332 approved to work in the area and those who should not have access.
333 Protocols that address territoriality will assure that appropriate people
334 are in a given space, colour coded protective clothing by location will
335 create a visual territoriality that should prove a deterrent to illicit
336 individuals entering that space;
- 337 • **Natural surveillance** – designing the physical space in a way that
338 assists legitimate users to observe the behaviours of both employees
339 and visitors e.g. temporary workers, service engineers, contract
340 cleaners etc.
- 341 • **Image** – a sense that the physical space within the factory and
342 externally is well cared for and developing preventive measures that
343 reduce the visual appearance that areas of the farm, distribution centre
344 or manufacturing site are remote, little used, or not regularly visited;
345 and
- 346 • **Milieu** – which, in the context of a food supply chain, describes the
347 image, natural surveillance and territoriality of other businesses that
348 interface with the organization's space. Is there a sense, for example,

349 that other businesses in the supply chain are not addressing defensive
350 space and undertake opaque practices or lack transparency?

351 The example given here is one of defensive space in the physical context.

352 The other area of defensive space is more ethereal, such as data storage,
353 data exchange and cyber-related space. *Cybersecurity* can be described as
354 the countermeasures taken to protect a computer system and associated
355 storage clouds or individual appliance against an intentional malicious target
356 attack and/or unauthorised access and unintentional or accidental access.

357 Cybersecurity countermeasures include, but are not limited to, developing
358 cybersecurity policies and procedures, undertaking focused FCRA, adopting
359 training and awareness sessions for staff commensurate with an individual
360 staff member's responsibilities and developing soft or hard controls such as
361 specific software, firewalls, technologies etc. that can protect the
362 organisation's cyber environment and their electronic assets (Manning,
363 forthcoming).

364 However, preventive environmental design to mitigate food crime risk is
365 of limited benefit if there is high-level insider complicity i.e. the involvement of
366 the business owner, management or employees in criminal activity in illegal
367 practices such as covert operations by running out of hours processing known
368 only to a select few. Therefore, consideration of the impact of the processing
369 environment and the wider supply chain environment is of value, but it cannot
370 address all potential threats and is not as a result a zero risk approach.

371 However the theory of defensive space does lend itself to adoption within an
372 overarching FCCF.

373 Spink et al. (2015) define *hurdles* in the context of food crime
374 prevention approaches. Hurdles are the transactional, formal system
375 components that reduce opportunity for food crime by either assisting
376 detection or proving to be a deterrent (Spink et al. 2015). These would include
377 on-line monitoring and verification activities in the wider supply chain such as
378 audits and product sampling. Thus a *hurdle gap* can be described as a
379 vulnerability to food crime where such mitigation activities are not in place, or
380 alternatively are in place, but are not effective. *Guardians* are the individuals
381 operating at national, supply chain or individual business levels (Spink et al.
382 2015) that have the knowledge, skills and understanding to implement a
383 FCCF, but vulnerability can still occur even in the presence of a capable
384 guardian.

385 **4. Crime vulnerability – crime prevention weak spots**

386 Crime vulnerability is the extent to which an individual, organisation,
387 supply chain or national food system is at risk from, or susceptible to, attack,
388 emotional injury or physical harm, or damage from intentional illicit activity
389 (Manning and Soon, 2016). Vulnerability can be assessed, using input from
390 legal, intelligence, medical, scientific, economic, and political sources, to
391 determine the scientific, economic, political, and social circumstances of a
392 country in order to quantify the degree of threat and to set priorities for
393 resources (Manning et al. 2005; WHO, 2002). Vulnerability ranking is not
394 static and needs to be routinely reassessed to ensure that the ranking and
395 prioritisation of risk remains appropriate and that suitable countermeasure(s)
396 continue to be in place (Manning and Soon, 2016; Manning et al. 2017).

397 Food criminals are clandestine, stealthy, and actively seek to avoid
398 detection (Spink, 2011). According to the Centre for the Protection of National
399 Infrastructure (CPNI, 2013), the majority of insider criminal activity in
400 organizations was carried out by permanent staff (88%), with only 7% of
401 cases involved contractors and 5% involved agency or temporary staff.
402 Individuals who had worked for their organization for less than 5 years
403 represented 60% of cases and 49% of cases were by perpetrators aged
404 between 31 and 45. More males (82%) were involved in insider activity
405 compared to females (18%). These data were derived from 120 UK-based
406 insider cases from both public and private organizations from a range of
407 industry sectors, not just food, where financial gain was the single most
408 common primary motivation (47%), ideology (20%), desire for recognition
409 (14%) and loyalty to friends, family or country (14%). This literature and other
410 sources lends itself to categorising food criminal according to type (see
411 Manning et al. 2016; PAS, 96: 2017; Spink and Moyer, 2013) and by
412 inference developing appropriate preventive strategies.

413 McElwee et al. (2017) argue that in order to mitigate the potential for
414 food crime in the supply chain two approaches can be followed: firstly to
415 design food supply chains with built in risk-tolerance to crime and secondly to
416 have appropriate strategies in place to contain the damage once an
417 undesirable event has been identified. The magnitude of food crime risk (and
418 to whom) will depend on the likelihood and severity of each type of incident
419 and the degree of implementation of preventive and mitigation measures
420 which can also be affected by the efficacy of guardians and hurdles (Spink et
421 al. 2015). Thus as previously outlined in this paper there is no silver bullet of

422 solutions to address food crime instead holistic, focused and product and
423 process specific crime prevention strategies need to be adopted.

424 **5. Crime prevention strategies**

425 Countermeasures are intended to reduce criminal opportunity in food supply
426 chains (Spink et al. 2015). The implementation of countermeasures will not
427 only have a preventive aspect in terms of preventing an incident and also
428 more unlikely in the first place, but should an incident occur appropriate
429 countermeasures will lessen the impact of an incident (Mitenus et al. 2014).
430 Regulators seek to reduce illegal activities either through punitive command
431 and control measures, prosecution and detection systems or alternatively via
432 preventative or deterrence measures such as awareness education and
433 enterprise support (Smith et al. 2017). Supply chain approaches need to drive
434 a crime prevention strategy based on reduced opacity and more transparency
435 and access to information in the supply chain. Supplier monitoring protocols
436 need to include not only product related procurement activities but also
437 standard reference checks, financial status checks, and consideration of the
438 supplier's surge capacity and flexibility i.e. the ability to deliver increased
439 quantities at short notice, if required (Beil, 2009). A financial status check can
440 be incorporated into a suppliers' ranking and performance weighting and the
441 scoring system that can highlight and reflect financial risk associated with a
442 given supply base. This data will support FCRA that focuses on identifying
443 the suppliers who could be subject to the supply chain pressures described
444 earlier in this paper e.g. failed harvest, volatility in commodity price etc. and as
445 a result be more likely to undertake illicit activities. These "high-risk" suppliers
446 can then be tracked and monitored. Whilst price is one of the most important

447 factors used in supplier selection, but it is critical to ensure that the objectivity
448 of assessing product integrity and food crime risk is not lost in a purely risk:
449 financial reward; time versus accuracy trade-off.

450 Forensic accounting has been adopted as a food crime
451 countermeasure especially to identify “false” suppliers (Power, 2013).
452 Traceability tests and second party and third party supply chain audits will
453 provide more information for focused forensic accounting and combined
454 audits can be developed (Figure 2).

455 Take in Figure 2

456 Indeed, it was a recommendation of the Elliott Review (2014) that the United
457 Kingdom (UK) government should “*support the work of standards owners in*
458 *developing additional audit modules for food fraud prevention and detection*
459 *incorporating forensic accountancy and mass balance checks.*” Traceability
460 protocols adopt as a minimum the regulatory one step backward and one step
461 forward tracking and trace principle (EU Regulation No. 178/2002) or market
462 protocols can require traceability throughout from field to fork and the reverse
463 too in a given supply chain. However, with multiple ingredients used to make
464 composite products, and lengthy and complex food supply chains traceability
465 can prove difficult in practice. Additionally, if an individual business within the
466 supply chain deliberately and unanimously decides to behave illicitly, they can
467 choose to circumvent orthodox supply chain traceability countermeasures,
468 controls and monitoring. Therefore the value of developing a FCCF with
469 regard to traceability is the socio-economic aspect of the promoting food
470 integrity and developing an open transparent supply network. Procedural
471 controls for traceability in themselves are not enough to ensure consistent

472 compliance and prevent the opportunity for illicit activity. Further actions are
473 needed including an effective verification (or surveillance) programme that
474 ensures that the controls are in place and adequate.

475 The process of food production involves discrete production stages from farm
476 to fork i.e. during growing, harvesting / slaughtering / catching of primary
477 products, primary processing, secondary processing of food / food
478 ingredients, packaging, labeling, storage and dispatch all pinch-points where
479 food crime activities could occur. At the manufacturing stage specifically,
480 countermeasures need to be adopted to address the process vulnerabilities
481 that can provide opportunity for food crime earlier in the supply chain.

482 During processing, itself potential deliberate contamination of food
483 products or tampering with processes can be minimised via limited
484 accessibility through engineering design and consideration as to the
485 accessibility of production equipment and where needed re-engineering of
486 equipment to prevent access e.g. covered conveyors, use of sight glasses,
487 zoning (place) and creating a buddy-system to limit lone workers at high-risk
488 processes such as use of expensive ingredients, or for recipe use where such
489 information is deemed confidential. Tracer ingredients can be added to high
490 value food so that potential counterfeit product can be readily identified in
491 production and post packing. Further supply chain preventive
492 countermeasures include numbered and tamper-proof seals on delivery
493 vehicles and bulk storage silos, stock control measures such as computerised
494 fill level equipment which relay the information back to central computerised
495 systems, reduced electronic access to specific physical zones which are
496 deemed high-risk via fingerprint technology, codes and passwords (PAS 96,

497 2017) password protection of computer terminals and electronic process
498 management systems etc.

499 Appropriate assessment measures that demonstrate whether the
500 FCCF is effective include substitution profit assessments, suppliers' ranking
501 and ongoing performance monitoring, risk rating of likelihood of perpetrators
502 to conduct activities, assessments to determine the likelihood of detection,
503 severity or impact of practices, consideration of the effectiveness of
504 preventive countermeasures and other factors that influence the risk of food
505 crime such as history of occurrences, seasonality, and market prices. The
506 formal FCCF systems that are in place being visible and auditable provide
507 objective evidence to internal and external stakeholders of the organization's
508 commitment to combatting food crime (Power, 2013). However this approach
509 does not, according to Power, build the soft knowledge required in terms of
510 inspector skills and knowledge to interpret audit results, thus a new type of
511 balanced score card of soft, culture-based risk factors also needs to be
512 developed. This development is worthy of further study and empirical
513 research.

514 Assessing the efficacy of the FCCF encompasses both the technical
515 areas of responsibility within the food supply chain as equally as the
516 administrative areas of responsibility, so food auditors (food crime / fraud
517 assessors) need to work hand in hand with appropriately trained accountants,
518 purchase ledger administrators etc. Via processes such as forensic
519 accounting, the consistency of records and documentation can be assessed
520 and activities such as mass balance testing for batches and production runs
521 allow unusual and inappropriate trends to be identified. Market knowledge is

522 essential to undertake this assessment effectively especially as described in
523 this paper the risk is situational and dynamic.

524 Verification through documentation review and classical food supply chain
525 auditing provides the food crime auditor with a range of evidence or audit
526 observations, which can be both qualitative, e.g. interviews, observations and
527 records or quantitative based on measurement and test. System failure can
528 occur through people (human failure), process and place (design) which
529 provides opportunity for perpetrators to commit food crime so verification
530 activities need to include all of these areas in their scope.

531

532 **6. Conclusion**

533 Pinch points are not dissimilar to vulnerability points. Identification of pinch
534 points and applying intervention strategies within the food supply chain – will
535 provide positive impact in reducing food crime. One way to address the pinch
536 point is via the Food Crime Countermeasures Framework (FCCF). In addition
537 to the conventional deterrence, detection and prevention methods, the FCCF
538 emphasizes a circular or a feedback mechanism to ensure continuous
539 interventions are successfully implemented. The countermeasures cover a
540 range of potential pinch points and vulnerabilities or can be targeted
541 measures that act against unique risks and perpetrators.

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544 **7. References**

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809 **Table 1. Types of Trade-off (Adapted from Klapwijk et al. 2014)**

Trade off	Examples
Field level	Production yields versus nitrate/phosphate leaching and water quality
Enterprise level (crop or animal)	Grain versus crop residue Milk versus meat production
Farm/agricultural system level	Cropping plans/enterprise mix Diversification Maximising short-term versus long-term return
Landscape level (agricultural system versus spatial, environmental or socio-cultural objectives)	Land use and ecosystem services Water use
Supply chain	Specification versus food waste Cost versus risk

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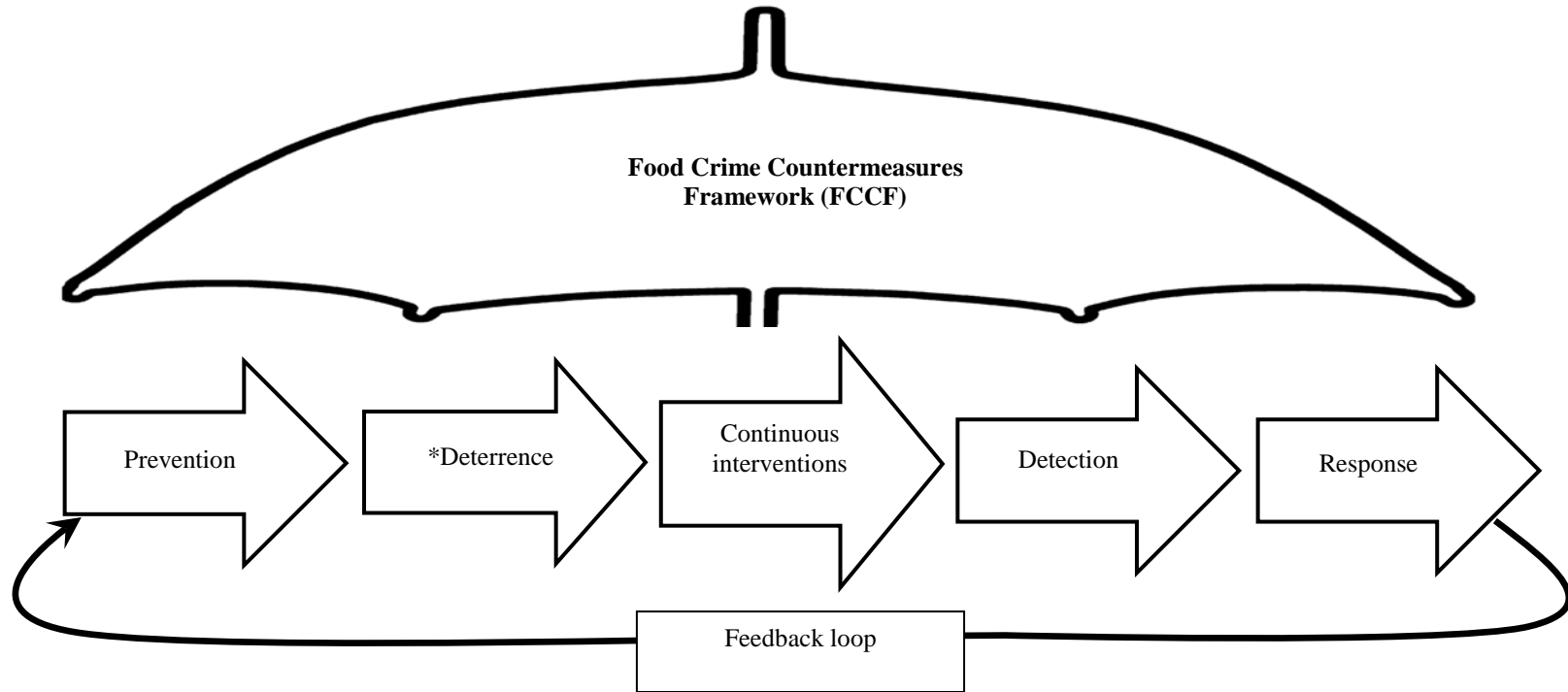


FIGURE 1. Steps in developing a food crime countermeasures framework (FCCF). *Via food crime risk assessment (FCRA), known threats may be prevented, deterred or detected. Via continuous interventions including horizon scanning, existing and emerging threats may be identified or detected and appropriate actions (response) can be taken.

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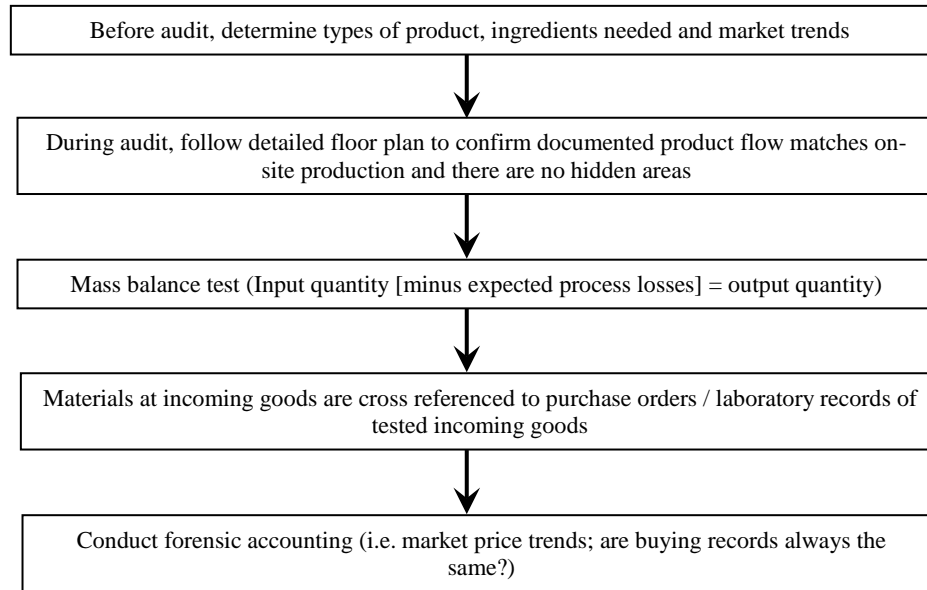


FIGURE 2. Forensic accounting and food crime prevention audits (adapted from Jack, 2015; NSF 2014)