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# **Farmers' decision making on livestock trading practices: cowshed culture and behavioural triggers amongst New Zealand dairy farmers**

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13   **Keywords: culture, livestock trading, livestock disease, middle-man, stock agent, behaviour,**  
14   **behavioural change, qualitative interview**

15

16   **Abstract**

17   Studies of farmers' failure to implement biosecurity practices frequently frame their behaviour as a  
18   lack of intention. More recent studies have argued that farmers' behaviours should be conceptualised  
19   as emergent from farming experiences rather than a direct consequence of specific intentions. Drawing  
20   on the concepts of 'cowshed' culture and the 'Trigger Change Model', we explore how farmers'  
21   livestock purchasing behaviour is shaped by farms' natural and physical environments and identify  
22   what triggers behavioural change amongst farmers. Using bovine tuberculosis (bTB) in New Zealand  
23   as a case example, qualitative research was conducted with 15 New Zealand dairy producers with  
24   varying bTB experiences. We show how farmer's livestock purchasing behavior evolve with culture  
25   under a given farm environment. However, established cultures may be disrupted by various triggers  
26   such as disease outbreaks, introductions of animals with undesired characteristics, and farm relocation.  
27   While dealing with economic and socio-emotional impacts posed by triggers, farmers reorganise their  
28   culture and trading behaviours, which may involve holistic biosecurity strategies. Nevertheless, we  
29   also show that these triggers instigate only small behavioural changes for some farmers, suggesting the  
30   role of the trigger is likely to be context-dependent. Using voluntary disease control schemes such as  
31   providing disease status of source farms has attracted a great interest as a driver of behavioural change.  
32   One hopes such schemes are easily integrated into an existing farm practice, however, we speculate  
33   such an integration is challenging for many farmers due to path-dependency. We therefore argue that  
34   these schemes may fail to bring their intended behavioural changes without a greater understanding on  
35   how different types of triggers work in different situations. We need a paradigm shift in how we frame  
36   farmer's livestock trading practices: we may not able to answer our questions about farm biosecurity  
37   if we continue to approaching these questions solely from a biosecurity point of view.

38

39    **1      Introduction**

40    Theoretical and empirical research studies have shown that farmers' practices play a substantial role  
41    in determining how livestock diseases spread within and between farms (1–4). In particular, farmers'  
42    livestock trading behaviour can be responsible for the geographical spread or translocation of disease  
43    (5,6). Previous studies suggested that regional or national-level livestock movement patterns are  
44    sensitive to externalities such as an imposition of new legislation and global milk price (4,7–9).  
45    However, despite epidemiologists' use of social network analysis to understand the temporal and  
46    spatial variability of movement patterns (10), there is surprisingly little research that seeks to  
47    understand how and why individual farmers make livestock trading decisions (11). This paper seeks  
48    to address this gap.

49    Literature on livestock trading practice almost exclusively frames farmer behaviour from a  
50    biosecurity perspective. Given that livestock trading is one of primary reasons of introducing a  
51    disease onto a farm, it is natural that this framing is popular. Under this framing, various practices  
52    associated with livestock trading have been previously studied including: maintain a closed herd  
53    (12,13), verify disease status of purchasing animals (14–16), and consider disease risk status of  
54    source farms and regions (10,17). Other studies suggested that farmers perceive these practices  
55    effective but often impractical (51), which may partially explain why farmers do not often employ  
56    these measures. These studies often use behaviouralist approaches that focus on the motives, values  
57    and attitudes that determine farmers' decisions. Quantitative methodologies associated with  
58    psychological behavioural theories such as the Theory of Reasoned Action (TORA) or Theory of  
59    Planned Behaviour (TPB) (18,19) have been widely used in studies of farmer behaviour (20–22),  
60    allowing policy makers to hone key messages to farmers in order to change their behaviour (23).  
61    However, Burton (2004) cites a range of conceptual and methodological problems associated with  
62    their (mis)use in agricultural behaviour studies (24), including: failure to take into account the  
63    influence of significant others by conflating subjective norms with attitudes; failure to take into  
64    account specific contexts or the 'compatibility principle' when analysing the influence of others  
65    (25,26); and the time and resources to capture appropriate data (27).

66    More recent studies have suggested that other factors beyond farmers' attitudes towards biosecurity,  
67    contribute to livestock trading behaviours. For example, some studies indicate that farmers' physical  
68    and environmental conditions play an important role in shaping their behaviours (28) whilst others  
69    demonstrate how social, physical and biological factors collectively influence farmers' behaviour  
70    (29). These approaches emphasise how farmers' behaviour is not a result of specific intentions, but  
71    emerges from deeply embedded, path-dependent and location specific farming cultures, or what  
72    Burton et al. (29) call 'cowshed' cultures. Sutherland et al. further proposed the 'Trigger Change  
73    Model' to explain a mechanism by which a major change occurs in such culturally-embedded farm  
74    practices (30).

75    Using data from qualitative interviews on 15 dairy producers in New Zealand, and drawing on the  
76    concept of cowshed culture, this paper first shows how farmers' livestock trading practices are  
77    developed and maintained. Drawing on the Trigger Change Model, we further explore how these  
78    behaviours are disrupted and reorganised in relation to the management of diseases, particularly  
79    bovine tuberculosis (bTB). The paper begins by providing further details on the conceptual  
80    framework, before detailing the methodology and discussing the results.

82    2        **Methodology**

83    **2.1 Conceptual framework**

84    **2.1.1 Path-dependency and cowshed culture**

85    The development of cultural approaches to understanding farmer behaviour has been a reaction to  
86    behaviouralist approaches (31). For Burton (24, p. 365), various challenges associated with these  
87    approaches lead to a failure to produce data ‘capable of producing a broad enough picture of farmer  
88    motivation’. Instead, he argues for an approach that incorporates the importance of the ‘self-concept’  
89    and ‘self-identity’ (32). Burton argues that farming is ‘heavily imbued with status symbols’ which  
90    contribute to the notion of ‘good farming’ and the ‘good farmer’ which play an important role in  
91    guiding and shaping farmer behaviour (33–36). Status in agriculture is linked to the practical skills  
92    and abilities that constitute a ‘good farmer’. Frequently, these abilities are linked to the ability to  
93    maintain ‘tidy landscapes’, produce quality livestock or operate a successful business objectified  
94    through new machinery (36–38). The open nature of farming allows farmers to constantly examine  
95    other farms for the symbols of good farming – a process known as ‘hedgerow farming’ – such as  
96    maintaining tidy farm yards, planting crops in straight lines and/or maintaining effective stock fences  
97    (35). The absence of this symbolic capital leads to low status and damages the reputation of the  
98    farmer. The failure of agri-environment schemes to develop broader cultural change may therefore  
99    reflect a lack of recognition of the importance of these cultural symbols (37,39). Similarly, a recent  
100   study showed that the concept of self-identity is also important in explaining farmers’ biosecurity  
101   practices such as reporting and prevention of exotic diseases (40).

102   Models of farming change and transition also emphasise the significance of self-identity. For  
103   example, Sutherland et al’s (30) model of farming change (see Figure 1) begins with the premise that  
104   farmer behaviour is path-dependent and locked into social, material, natural and economic  
105   relationships that guide and legitimize existing farm practices. These ‘socio-technical lock-ins’ are  
106   difficult to escape: farmers are locked into markets and required to meet contractual arrangements for  
107   which they have invested in technological systems. This kind of technological lock-in may also be  
108   accompanied by knowledge path-dependency. Here farmers develop forms of practical ‘know-how’  
109   (41) taking routine advice from trusted knowledge sources but which may limit their ability to  
110   respond to new challenges (30). Therefore, path-dependency can be expressed in various forms. It  
111   may exhibit as a behavioural form, where farmers are locked into specific farm management  
112   practices. Or, it can take a social form—farmers may be locked-in specific beliefs or morals.

113   Path-dependency and the significance of cultures of good farming should not however be seen as  
114   simply a social construction. Drawing on recent post-human analyses of farming conduct (42),  
115   Burton et al (2012) incorporate the non-human into farming cultures (29). In this view, farm animals  
116   and farming materialities (farm sheds, milking equipment, ear tags, and fields) contribute to the  
117   relational construction of farming culture. Segerdahl (43) and Hemsworth and Coleman (44), Burton  
118   et al (27, p. 176) argue that these relations construct ‘a human/animal culture with each farm  
119   developing its own particular culture as a result of interactions between humans, livestock and the  
120   farm buildings’. These relationships are constantly in the making and are influenced by neighbouring  
121   farm cultures, but collectively form what Burton et al. refer to as ‘cowshed’ cultures which provide  
122   each farm with its own distinct path or trajectory (29).

123 Drawing on these perspectives, we frame farmers' behaviours as shaped and locked-in by various  
124 factors including their self-identity, belief, farm environments, and farmer-animal relationships,  
125 which are referred to as cowshed culture.

## 126 **2.1.2 The Trigger Change Model**

127 One challenge facing cultural theories of farmer behaviour is working out under what circumstances  
128 farmer behaviour changes. According to the 'Trigger Change Model' (30), path-dependencies may be  
129 challenged by 'trigger events' which create windows of opportunity for farmers to change practices.  
130 Triggers may be positive or negative, singular or multiple and may accumulate over time or represent  
131 a shock event. Sutherland et al. identified three broad categories of triggers. First, triggers relating to  
132 the farm business such as commodity prices, land availability or regulations. Second, those relating to  
133 the life course of the farm household such as retirement, unexpected injury or death, and fluctuations  
134 in labour availability. Finally, triggers may relate to challenges to farmers' moral beliefs about the  
135 purpose and practice of farming which may arise following disease outbreaks (45). Triggers prompt an  
136 assessment of options but Sutherland et al. stress that this is not linear, and may occur over several  
137 years during which a passive approach to problems alternates with active appraisal of options (30). For  
138 some farmers, assessment of options may involve active experimentation, whilst others seek  
139 professional advice, or speak to other farmers. Change may therefore be an incremental process rather  
140 than a radical switching between different options and farmers may return to actively assessing  
141 practices to assist the consolidation process.

## 142 **2.2 Study context**

### 143 **2.2.1 Institutional structure of New Zealand dairy farming**

144 Two distinct features of New Zealand dairy farming system make it suitable to study stockpersons'  
145 livestock trading decision-making. First, almost all New Zealand dairy farms run an extensive seasonal  
146 pastured-based system, where farmers heavily rely on the growth of pasture for animal nutrition.  
147 Second, the majority of milk produced in New Zealand is exported to an international market, meaning  
148 that the financial status of dairy farms is substantially influenced by international milk prices. These  
149 two uncontrollable external factors (weather and international market price) are dynamic and to some  
150 extent unpredictable. New Zealand dairy farms therefore need to manage their systems flexibly  
151 according to the changing situation. In particular, farmers are required to continuously adjust their herd  
152 sizes: the size often needs to go down if there is insufficient pasture to minimise a running cost and go  
153 up when a milk price is higher to increase a profit. This leads to dynamic and frequent livestock  
154 movements throughout the country. The need of a dynamic change in a herd size also provides  
155 difficulties for dairy producers because their trading events are irregular in terms of size and timing.  
156 For instance in UK, stockpersons may be able to trade with the same partners over years (17). In such  
157 a situation, studying farmers' decision making may not be straightforward because trading livestock  
158 with an established partner can be merely a routine such that farmers do not have to consider, if any,  
159 factors in relation to trading. On the other hand, New Zealand dairy producers may have to identify a  
160 new partner at every trading event (this need is repeatedly mentioned in our interviews shown below).  
161 Taken together, the New Zealand dairy farming system therefore offers a distinct opportunity to  
162 understand the development process of livestock trading decision-making. This does not, however,  
163 preclude applicability of our findings to other countries (see Discussion).

### 164 **2.2.2 Bovine tuberculosis in New Zealand**

165 Bovine tuberculosis (bTB) in livestock is designated a notifiable disease in New Zealand. Herds  
166 identified with bTB are required to immediately cull bTB positive animals and are placed under cattle

167 movement restrictions until the disease is cleared, which can cause significant economic burdens for  
168 affected farms. New Zealand has succeeded in substantially reducing the number of bTB infected  
169 livestock herds based on various control strategies (46). Regionalisation and risk-based trading  
170 schemes are assumed to have played a pivotal role in preventing a bTB spread between herds  
171 (10,28,47). In this context, regionalisation categorises livestock herds into several groups primarily  
172 based on the risk of bTB infection in their geographical area. Previous research has found evidence  
173 that this may result in risk-averse purchasing practice where farmers in low risk regions avoid  
174 purchasing cattle from high risk regions (10). In contrast, the risk-based bTB trading scheme in New  
175 Zealand reveals whether or not a farm is currently infected with bTB, and confers a number (maximum  
176 10) to each bTB free farm to indicate how many years the farm has been bTB-free. This system,  
177 referred to as C status, may provide stockpersons with further information regarding a bTB risk;  
178 however, in areas of historic high bTB prevalence, stockpersons' experiences of disease incidents  
179 mediates the meaning and understanding of C status, affecting their herd management decisions (28).  
180 Regionalisation and C status therefore provide an opportunity to analyse how disease risk information  
181 affects farmers' livestock purchasing practices.

## 182 **2.3 Qualitative interviews with farmers**

183 Data were collected from 15 qualitative interviews with New Zealand dairy producers. New Zealand  
184 dairy producers can be categorised into three groups: farm operator, share-milker, and worker. A farm  
185 operator owns both the cattle and the land and may hire workers. A share-milker owns the cattle, but  
186 not the land, and therefore leases infrastructure (e.g. land and cowsheds). A common type of share-  
187 milker is a so-called fifty-fifty share-milker, who receives 50% of the total profit from the milk  
188 production. A worker includes those who work for either farm operators or share-milkers and do not  
189 own either the cattle or the land. In this study, we included both farm operators and share-milkers since  
190 they are responsible for making decisions around livestock trade —hereafter, we refer them to as  
191 farmer.

192 The interviewed farmers included individuals from both low and high bTB risk areas to investigate  
193 differences in how they develop a livestock purchasing strategy. For a low bTB risk area, we  
194 purposively chose Waikato, Taranaki (North Island), and Canterbury (South Island) because these are  
195 the major dairy producing areas in New Zealand (48). For a high bTB risk area, we chose West Coast  
196 (South Island), which has maintained one of the highest prevalence of bTB in New Zealand over several  
197 decades (46,49). Figure 2 depicts each region in relation to bTB risk. Our sample size of 15 was  
198 determined to maximise the sample size within the budget and time. We aimed to obtain the size larger  
199 than 12 based on findings from Guest et al., (50) that data saturation in qualitative interviews can occur  
200 at the sample size of 12; this was also shown in other recent studies of farmers' decision making and  
201 disease control (51). The sampling frame was generated by asking researchers, veterinarians, and  
202 industry stakeholders to provide a list of candidate stockpersons in each region that may be willing to  
203 participate in the study. We also contacted individuals in OSPRI— the organisation responsible for  
204 bTB control in New Zealand— to provide a list of farmers who had previously experienced a bTB  
205 breakdown and would be willing to participate in this study.

206 All potential participants were contacted by phone and the objective of the study (i.e. livestock trading  
207 decision making) was explained. After their willingness to participate was confirmed, in-depth face-  
208 to-face interviews were carried out between November and December 2016 at the interviewee's  
209 preferred location which in all but one case was the farm property. Interviews lasted between 30 and  
210 83 min. Two interviews were conducted with female farmers, 12 interviews were conducted with male  
211 farmers, and one conducted with a husband and wife couple. The profile of interviewed farmers was

212 summarized in Table 1. The interviews were semi-structured whereby farmers were initially asked  
213 several questions about background information of themselves and their farms. Interviewees were then  
214 asked if they had purchased or sold any cattle recently and if so they were asked to tell stories about  
215 the experience. Subsequently, depending on how interviewees responded, different lines of enquiry  
216 were used to ask the following questions; how and when they made a purchasing and/or selling  
217 decision; any experience that changed their trading practices. All interviews were conducted by the  
218 first author. To compensate interviewees for their time, a NZ\$100 gift card was given to each  
219 participant after the interview.

220 **2.4 Analysis**

221 Interviews were all audio-recorded and transcribed by the first author. Personal identifiers were  
222 removed from the transcribed files to ensure the anonymity of interviewees. Transcripts were imported  
223 into NVivo Pro 11 for Windows (QRS International, Australia). Data was analysed using thematic  
224 analysis drawing on the concept of cowshed culture and the Trigger Change Model as described above.  
225 The transcripts were coded and then clustered into themes, whose inter-relationship was subsequently  
226 analysed.

227 **3 Results**

228 Analysis of interviews focused on how farmers' livestock trading behaviours are shaped by the four  
229 key stages of a farm culture development—emergence of cowshed culture, path-dependency period,  
230 trigger events that disrupt existing cowshed culture, and recovery from the disruption. The following  
231 details how each of these stages influence farmers' livestock purchasing practices.

232 **3.1 Shaping cowshed culture: contributions of physical and natural farm environment**

233 Although 'hard work' is a characteristic of farming cultures (33), the theme of 'making things easy'  
234 was frequently mentioned by farmers in interviews. Specifically, 'making things easy' referred to two  
235 key components in farm management: firstly, developing and maintaining a smooth milking flow. This  
236 referred to the ability to milk cows as quickly and efficiently as possible. Secondly, developing and  
237 maintaining smooth pasture grazing management. This referred to the ability to flexibly manage the  
238 grazing intensity and area on pasture to maximise its quality while meeting the energy requirement of  
239 cows to secure sufficient milk production. Farmers therefore try to develop farming practices that  
240 enable these two components, creating a cowshed culture specific to each farm. Our analysis  
241 highlighted that both physical and natural farm environments play a role in shaping farmers'  
242 management practices.

243 **3.1.1 Developing a smooth milking flow**

244 The following extract of farmer 1 (Canterbury) exemplifies the importance of a physical environment  
245 in shaping farmers' behaviours.

246 F: "When we take the heifers into the herd for milking in their first lactation, we will split them  
247 between 2 sheds on breed. Because this shed down here is rotary with grain feeding, short  
248 tracks... so the tracks aren't very long and very good tracks. So we put the all Friesian, the big  
249 cows, down here. And the other shed, it's a herringbone shed, old cowshed. Not made for big  
250 cows with no grain feeding. Very long walks and the tracks aren't quite as good. So we put the  
251 cross-bred and Jersey, anything with harder feet, we put them in this shed [...]."

252 I: "So they rarely mix?"

253 F: "No. [...] It just makes the management easier when you have all your cows are the same.  
254 All these cows are roughly the same size, uhmm and all cross-breds, all black and brown, and  
255 when they line up in the herringbone it's easier to have whole lot of cows the same than just to  
256 have big cows and small cows and.. or whole big cows and try to fit little one in the middle...  
257 they don't like it. If you keep them all the same, it's nicer for them, they fit better."

258 Interactions between the material farming infrastructure (cowsheds and walking tracks) and the  
259 behaviour of cattle, in turn shapes farmers' herd management decisions. In doing so, cattle are less  
260 likely to have lameness and feel less stress during milking, contributing a smoother milking flow which  
261 saves farmers time and stress.

### 262 **3.1.2 Developing a smooth pasture grazing flow**

263 Many New Zealand dairy producers run an extensive pasture-based grazing system. The seasonal  
264 weather patterns distinct to each region affect the growth of grass and paddock conditions. Grazing is  
265 not only about feeding cattle in New Zealand; but it is an important part of farming to control the  
266 quality and growth of grass (52). Grazing with too much intensity may damage the soil and grass, and  
267 poor paddock conditions may lead to lameness in cattle, which disrupts milking flow. A successful  
268 understanding of this complex relationship enables stockpersons to manage a farm better. For instance,  
269 farmer 4 in West Coast, which has high rainfall, explained how their cattle stocking rate is determined  
270 by the weather:

271 "That would be a typical rate around here, about 2 to 2.3 [cows per ha] maybe. Because you  
272 know when it gets, I mean if you get a year what you would consider to be drier, then everything  
273 is going good... you would think oh you know we could run probably 3 cows to ha and probably  
274 you could. But then it'll go bad and you wish you had known. One of the neighbours up road  
275 said to me "Oh we run about 2.1". And I thought "It's not many". But after being here for 7  
276 years I can see why. You don't have too many cows over here. Because when it gets wet there  
277 is nowhere to put them."

278 Importantly, these cowshed cultures emerge over time and may take many years to develop and become  
279 established. A cowshed culture specific to each farm contributes to various farming practices such as  
280 which cattle breed and how many of them to keep and how to manage them, which in turn guides  
281 farmers' livestock trading practices. For instance, farmer 11 (Waikato) explained how his observations  
282 of cattle behaviours in his natural farming environment shaped his decision to purchase from farms  
283 that have similarly hilly paddocks in Palmerston North—300km apart from his farm—rather than  
284 Morrinsville, which is one of major dairying areas nearest to his farm.

### 285 **3.2 Path-dependency**

286 Our analysis highlighted that a specific path-dependency is created through interactions between  
287 various factors including physical and natural farm environments and farmers' beliefs. Firstly,  
288 decisions to purchase cattle are guided by the cowshed culture of each farm. For instance, share-milker  
289 12 demonstrated how his choice of livestock to purchase is dependent upon the interactions between  
290 cows and the material design of his milking shed:

291 "[...] you've got things like [which] cowshed they are coming from as well... like herringbone  
292 or rotary... there are always things you got to think about. Some sheds go clockwise and

293 somewhere anti-clockwise. [...] You are still gonna disrupt the cow flow when you are training  
294 them, yeah it makes a difference. Just a little thing that people are not always interested in.  
295 Practical things, you can't explain all these things."

296 This extract further emphasises that this farmer's behaviour is guided by his practical capital: skills  
297 that are 'difficult to explain' but understood by farmers. Such practical capital, or 'know-how', may  
298 arise through experiencing 'what works and does not work' under their material and natural farming  
299 conditions (30). The ecology of each farm also contributes to creating a path-dependency. For instance,  
300 farmer 10 explained how the availability of fodder in the pasture he owns determined his farming  
301 practices, creating path-dependent livestock trading behaviours:

302 "We have to really [buy replacement animals] because as I say we are selling out cows every  
303 year, we haven't got enough cows to supply all our extra replacement that's why... if we  
304 weren't selling the cows, we are good to be our own. But we are selling cows we have to buy...  
305 especially the grazing block, to keep that fully functioning, we need so many stock. If we had  
306 our own herd and we don't sell anything out every year we kept them all and certainly we could  
307 have our own... numbers and replacement so we could be selling extra heifers each year but...".

308 This farmer demonstrated in the interview that he has been selling almost half of his milking cows  
309 every in the past years because there has been a continuous demand of a large number of cows from  
310 South Island farmers. This selling practice, however, results in a shortage of replacement because not  
311 all of remaining cows are artificially inseminated hence their calves may not be suitable as replacement  
312 (calves from cows that are not artificially inseminated usually have inferior genetic merits and lower  
313 milk production). However, the extra paddock he owns allows him to purchase a large number of calves  
314 and heifers, which will serve as replacement. This system was proven to be profitable, therefore, he is  
315 'locked-in' in the situation where he continues to purchase and sell livestock, although he theoretically  
316 has an option to have a closed herd. Path-dependency is therefore not necessarily inefficient: some  
317 farmers believe that being on a path-dependent farming trajectory is important. For example, farmer 9  
318 explained he is trying to achieve the maximum potential of his herd by breeding only animals which  
319 perform well in his specific farm environment and management practices, instead of introducing  
320 animals with better genetic merits.

### 321 **3.3 Triggers and disruptions to farming cultures**

322 Interviews revealed several triggers that disrupt cowshed cultures and alter livestock purchasing  
323 practices. Firstly, relocation to another farm was a significant factor in triggering reassessment of  
324 existing practices. The role of share milking in the New Zealand dairy industry means that relocating  
325 a herd can be a common practice, with herd relocation occurring annually on June 1st – referred to as  
326 'gypsy day' – when existing share milking contracts end and new ones begin. Given the significance  
327 that farm environments play an important role in shaping cowshed culture and farm practice, ending a  
328 share-milking contract may provide an opportunity to develop new farming practices. However,  
329 moving may also trigger further complications where the fit between new and old cowshed cultures is  
330 poor. For example, as a share-milker, farmer 3 needed to relocate to a new farm and he noted that they  
331 were trying to down-scale the size of animals in his herd after the relocation:

332 "Main reason we wanna bring the size of the animals down is... cos the cows are getting too  
333 big and this farm gets quite wet in winter and big cows are gonna sink, so they get a lot of lame  
334 feet, and.... Little cows just seem to be more profitable... it is lighter on feet and easy to  
335 maintain."

336 In this example, new farm environments provide opportunities to see how the relationship with existing  
337 cows results in new challenges, and the need to change the kind of animals reared.

338 Secondly, the share-milker system may also act as a trigger to land owners themselves who contract  
339 share-milkers. While share-milkers' goals are often to produce sufficient amount of milk in each season  
340 so that they can save money to buy their own land in future, land-owners may have a longer-term  
341 priority such as maintaining pasture quality:

342 "yeah [I own] all the cows, the farm owner owns the land. They live in the next farm. Some  
343 farm decisions we make together...cow number... we make budgets. There's lot of  
344 communications there. We have to do a weekly report. Like emailing every the other day.  
345 Because they don't own the cows... they like to know all these information.... But you've got  
346 to communicate... it's hard cos they're running other business... They come and see farms in  
347 a different angle cos they don't know all the practical things.... Running the cowshed and  
348 managing the staff...they never milked before. (Share-milker 12)"

349 This extract highlights this share-milker's frustrations and difficulties in communicating with land-  
350 owners who "do not know practical things"— the difficulty in creating and maintaining material  
351 (running cowshed) and social (managing staff) aspects of cowshed culture. But this extract also clearly  
352 highlights that the difference in their background and business goals also create frustrations in land-  
353 owners. These frustrations may accumulate over time, and can act as a trigger event either by looking  
354 for a new share-milking partner, or by taking control of the farm management completely. For example:

355 "...until 7 years ago we didn't own cows... any dairy animals at all. We had a 50-50 share  
356 milker on here so they owned all the livestock and then we've done that for 12 years... decided  
357 we want to more control... and we're going to put a management on... but obviously that meant  
358 we had to buy cows, buy more machineries, need to hire staff... so went on and bought a whole  
359 herd of cows in one year for that farm... and then we went to do the same thing following year  
360 for the new conversion. So we bought 1200 and something cows and it took 2 years to get these  
361 2 farms up running... so it kind of went from not being a dairy but having a dairy to put all in  
362 (Farmer 1)."

363 Thirdly, the arrival of new cattle onto a farm – either due to the relocation of a new share-milker or the  
364 routine purchase of replacement cattle – can lead to triggering events. Purchasing livestock can disrupt  
365 an established farm management flow for various reasons, and this can repeatedly pose physical and  
366 psychological stress on farmers, which act as a trigger. For instance, share-milker 2 demonstrated how  
367 a disruption in the milking flow due to introduced cattle stressed him, which made him reluctant to  
368 purchase livestock anymore:

369 "Because our shed's quite unusual, you don't get too many internal rotaries.. [...] there's not  
370 many sheds like this so there's not many cows that know how to come...that's another thing  
371 that stops me from trading is that it's bloody hard to teach cows to come in the shed. So you  
372 can train them how to do that... so it took us 3 months to teach them how to come in. And even  
373 then after years some cows don't wanna come in."

374 Introducing external cattle can also bring diseases onto a farm, which can cause a substantial disruption  
375 to cowshed culture. For example, a bTB breakdown leads to livestock culling, if not a whole herd, and  
376 restrictions on selling and moving animals. The latter can be particularly critical for New Zealand dairy  
377 producers because selling and moving animals to other properties is an important herd management

378 practice when the fodder is limited. Farmer 5 demonstrated how the bTB breakdown imposed not only  
379 an economic but also a psychological distress by limiting his farming options:

380 “When you’ve got no option, you got into a corner... it’s kind of sucks. When you’ve got  
381 option, you’re always on the front foot, thinking about what you can do next, and that’s kind of  
382 where we’ve got to in the last 12 months. And the part of that is changing the whole farm  
383 system. So you know... last 2, 3 years I felt like a death by thousand cuts type things... slow  
384 way of dying... you’re always fighting fires... you’re always wondering where how your next  
385 dollars are coming from... whereas if you’ve got options in your back pocket, then all of sudden  
386 your attitude can change. From fighting fires to actually thinking ‘Ok where the hell am I going  
387 now? What am I gonna do?’ And it’s easy to say just a mindset but it’s actually more than that.  
388 To get that mindset you need the options to start with. You can say ‘Well...get the mindset and  
389 options will come’ but it doesn’t always work out. You know sometimes mindset is because of  
390 lack of options.”

391 This extract demonstrates how the farmer struggled to be economically viable after the bTB breakdown  
392 due to various restrictions. The farmer described that he had been in ‘thinking in a silo mentality’,  
393 where he tried an incremental small change to his farming practices but they did not improve the  
394 situation. This imposed a psychological distress and the accumulation of these experiences acted as a  
395 trigger. The farmer finally succeeded to turn over this situation by changing the whole farming system.

### 396 **3.4 Response to triggers: active assessment of alternatives and implementation**

397 In response to trigger events, farmers may start assessing options more actively. Sutherland et al. argue  
398 that farmers are more motivated in this period to consider a wide range of alternative options and  
399 information compared to when they are at the path-dependency stage. As a result, farmers may change  
400 their practices or beliefs but the approaches farmers take may vary considerably (30). As summarized  
401 in Table 2, we identified several farmers’ responses to specific trigger events. However, in general,  
402 interview data showed two clear long-term strategies for responding to triggers associated with the  
403 movement of animals: firstly, the use and mediation of cattle disease risk scores; and secondly, the use  
404 of stock agents. Both strategies demonstrate how farmers’ decision-making evolves and consolidates  
405 over time in relation to other social, natural and material dimensions of cowshed culture. Moreover,  
406 each strategy seeks to maintain or restore an equilibrium to cowshed culture through purchasing  
407 practices. Details on each below strategy are found below.

#### 408 **3.4.1 Using and translating official disease information**

409 In response to the impact of cattle movements and disease outbreaks, farmers seek to adapt their cattle  
410 purchasing decisions through a process of actively assessing their own experiences of disease with  
411 official information. Interviews with farmers clearly highlighted the impact of trigger events on bTB  
412 risk management, as summarized in Table 3. Farmers in low bTB risk regions and without experience  
413 of a bTB breakdown may not actively assess the importance of C status as long as a source farm is free  
414 from bTB. Nevertheless, farmers seem to change the interpretation of the C status after trigger events  
415 including a bTB breakdown and farm relocation from a low to high bTB risk region; the C status is no  
416 longer just a number but information that need to be interpreted for each farm.

#### 417 **3.4.2 Shady farmers and trusted stock agents**

418 The second strategy farmers employ is developing a trusting relationship with stock agents who can  
419 help farmers source replacement cattle to fit their cowshed cultures. As we describe below, this strategy

420 helps farmers to avoid purchasing from ‘shady’ farms, which was revealed to be a common concern  
421 for farmers. Farmers often demonstrated that unless they are exiting the dairy industry, they normally  
422 send cattle that are unproductive or have serious health conditions (i.e. repeated mastitis and lameness,  
423 and behavioural issues) to slaughter and sell cattle that can still produce milk but only at a suboptimal  
424 level on their farms. Nevertheless, they also often noted their concerns about the presence of other  
425 farmers that sell cattle which should have been sent to slaughter. This is problematic for farmers; it is  
426 difficult to notice these serious mal-conditions when purchasing because it takes a while to recognise  
427 these problems or requires an observation under a specific circumstance such as during milking, as  
428 illustrated by following extracts.

429 “Three quarters [...] people don’t want those. Off to the works. Mastitis definitely. We would  
430 not knowingly sell cows that has got mastitis or repeated lameness, we wouldn’t do that. That’s  
431 not honest. That’s a very shady farmer that would buy those and if he is shady he’s got selling  
432 to somebody else. And our industry needs that... we need to be self-monitoring. We need to be  
433 able to trust each other. We don’t need shady people. Cos it’s a very hard industry to be in.”  
434 (Farmer 11)

435 “I don’t actually like sale yards [...] you don’t really know why those animals are on sale yards  
436 sometimes. Fine you might look at these animals and the animals are perfectly healthy. These  
437 animals might have been sent to the sale yard to go to the works because they’ve got problems.”  
438 (Farmer 5)

439 Farmers seem to have various approaches to avoiding shady farmers including personal trading and  
440 using stock agents, as summarized in Table 4. While the use of a stock agent seems to be common  
441 among New Zealand dairy farmers, the extent to which farmers rely on stock agents in deciding which  
442 animals to purchase varies. While some farmers mentioned they do not even see animals which agents  
443 chose for them before purchasing, some farmers make sure they visit and check the selling farm—this  
444 is a further strategy to assess whether the seller is honest and has a good cowshed culture. This  
445 assessment involves either communicating with the seller or visually checking the farm and cattle, or  
446 both. For example, share-milker 3 noted:

447 “He [stock agent] sort of got...3 or 4 herds for me to look at and we went for a drive one day.  
448 I think we went to...the first 3 and I was like ‘Hmm, I hope the last one is good’. [...] The way  
449 the farmer had them... it wasn’t... they were a little bit light and looked ugly. And rough... the  
450 coats were rough. They weren’t shiny, healthy looking. So it just sort of gives you an idea that  
451 maybe he doesn’t do job properly. When we went to the last one the owner came with us we  
452 went around and he told me this cow doesn’t give much production, this is my peak cow here.  
453 You know he just knew his herd. He looked like he had more involvement with it and he  
454 actually cared. As soon as I walked in there I was like this is what I want. It’s a nice looking  
455 herd”.

456 This quote highlights two important points. First, the farmer assessed the sellers’ farm management as  
457 poor based on the ‘ugly’ appearance of their cattle, reflecting the role of ‘hedgerow farming’ and  
458 appearance of livestock as ways of telling apart ‘good’ farmers (35,51). The ‘ugly’ appearance of  
459 livestock therefore indicates farmers’ poor management and hence links to ‘shady’ farm culture—cattle  
460 on these farms may have some hidden problems. The link between the poor animal care, poor  
461 management, and ‘shady’ farm culture is also mentioned by farmer 14: “if he is not looking after his  
462 animals and records probably are not 100% either”. Second, ‘knowing their own herd’ provided the  
463 farmer with a credential that the seller is genuine. Farmers who know their own herds well are likely

464 to be able to identify problems in cattle quickly and minimise stress on cattle, which is an important  
465 component of a good farm culture (29).

466 In summary, purchasing cattle from a genuine cowshed culture is important: animals from such a farm  
467 are less likely to have serious problems. Farmers consider good-looking animals, other farmers'  
468 knowledge on their own herds, and farmers that care for their animals to be indicative of a genuine  
469 cowshed culture. Farmers have various strategies to find such source farms including using a stock-  
470 agent, which helps farmers to keep a consistent farm trajectory and new path dependency.

## 471 5 Discussion

472 In this section, we discuss how our findings inform understanding of farmers' livestock purchasing  
473 behaviours.

### 474 5.1 Trigger Change Model

475 Three important points can be drawn from our findings in relation to using the Trigger Change Model  
476 to assess farmers' behaviour in relation to disease management. First, our research confirms that  
477 farmers' livestock purchasing practices can become locked in and difficult for farmers to change. For  
478 instance, specific farm material infrastructures (cowshed and walking tracks), natural environment  
479 (paddock and weather) and established farmer-livestock relationships may hinder a behavioural  
480 change. Moreover, farmers may develop favourable beliefs about their practices through doing the  
481 practice. Therefore, an apparent lack of biosecurity practices in livestock trading should not be  
482 interpreted simply as a lack of attitude towards disease control among farmers but reflective of the  
483 socio-technical conditions in which farmers work within.

484 Second, voluntary disease control schemes such as revealing source farm disease status may fail to  
485 induce a desired farmer behavioural change without a greater understanding of trigger events. We  
486 demonstrated while some trigger events indeed resulted in a major change in farmers' behaviours,  
487 similar events only induced a minor change in other circumstances. This suggests that the impact of  
488 triggers is context-dependent. That is, for instance, farmers' behavioural response to disease-related  
489 events or information likely depends not only on disease characteristics but also on a wider range of  
490 factors associated with farm circumstance and culture, and livestock trading systems. Together, these  
491 reinforce the need to study farm biosecurity practices from multidisciplinary aspects including animal  
492 welfare, animal production, and social science rather than solely from a biosecurity point of view.

493 Thirdly, the model assumes the consolidation phase follows assessment and implementation phases.  
494 Our data suggests this separation is hard to detect. Rather, change appears to be an incremental and  
495 iterative process rather than a clean break between different options, and farmers may return to actively  
496 assessing practices to assist the consolidation process. These observations may be partially because we  
497 focused on bTB; farmers evaluate the effectiveness of new practice during consolidation phase,  
498 however, the chronic and uncertain nature of bTB, combined with regulations that prevent cattle  
499 movements, renders a complete evaluation of whether a new practice is successfully preventing a bTB  
500 recurrence. In this way, farmers may constantly shift between assessment, implementation and  
501 consolidation but without any clear delineation between these phases. Further research is required to  
502 establish whether the failure to disentangle these stages of the model applies to other livestock diseases,  
503 under which circumstances it is possible to distinguish each phase, and how long each phase may be  
504 expected to last.

### 505 5.2 How do farmers decide what kind of animals to purchase?

506 Dairy farming is considered one of the most physically and psychologically challenging jobs (53). The  
507 importance of establishing a farm system that enables a smooth, or easier, farm management was often  
508 mentioned by the interviewed farmers. Burton et al. argued that an easier farm management leads to  
509 happier farm workers and better treatment of cows, which ultimately results in an improved production  
510 (29). Indeed, our data showed how farmers try to develop such an easier management system through  
511 observing cattle behaviours under their farming environments. This in turn primarily determines the  
512 kind of cows to keep on a farm and which cows to purchase. Therefore, livestock purchasing practices  
513 seem to be shaped in the process of establishing cowshed culture, rather than farmers choosing ‘best’  
514 cows for their farms after considering a whole range of animal characteristics. This means animal  
515 disease status may be dismissed when purchasing animals, although we showed farmers develop  
516 various strategies to avoid introducing a disease onto a farm as we discuss later.

### 517 **5.3 How do farmers know potential source farms to purchase animals from?**

518 Our analysis suggested that the use of stock agent in purchasing livestock is common among New  
519 Zealand dairy farmers and we argue that this may be one form of the path-dependency: stock agents  
520 come to know what kind of animals farmers are looking for; quality and price of animals, and the fit  
521 to each farm’s material and natural environment. In turn, this saves farmers’ time and, perhaps more  
522 importantly, cognitive costs required for a decision making. This system is particularly useful for New  
523 Zealand dairy farmers because they need to purchase and sell animals flexibly in response to the  
524 fluctuations in milk price and weather conditions.

525 Stock agents in general work locally and try to match buyers and sellers in a limited geographical area,  
526 meaning that trades often occur locally. Occasionally, agents try to purchase animals from other regions  
527 when, for example, there are few eligible animals with specific criteria required by buyers. This  
528 facilitates a long-distance livestock movement. This indicates that purchasing farmers are often  
529 provided options only to purchase animals locally, which may be often beneficial for farmers for two  
530 reasons. First, local trading costs purchasing farmers less animal transport fees. Second, farmers in  
531 specific climate and environmental conditions may prefer purchasing animals locally, which better  
532 adapt to their farm environments.

### 533 **5.4 How do farmers avoid introducing a disease?**

534 Our data suggested that farmers may not be concerned about some diseases that they consider would  
535 not disrupt their cowshed cultures. Here, a disruption to a cowshed culture can mean different things  
536 to different farmers, although a breakdown of a smooth milking flow may be a significant issue for  
537 many farmers; for some a production loss can be a disruption, and for some this may damage a farmer’s  
538 reputation. This variation may be attributable to various factors including disease experiences, cowshed  
539 culture, extra time farmers can spare, and whether they are farm owners or share-milkers. Nevertheless,  
540 our study identified several strategies farmers develop to avoid diseases they are concerned.

541 First, farmers use disease risk score information for bTB (C status). As New Zealand farmers are aware  
542 of the serious impact caused by a bTB breakdown and the disease risk score on each farm is relatively  
543 accessible, it is not surprising that farmers use this information. However, our analysis showed that the  
544 way farmers interpret this information varies between farmers depending on their cowshed culture,  
545 disease experiences, and geographical locations, which is supported by a previous finding (28). This  
546 emphasises that farmers do not interpret risk scores linearly, contrary to the way scientists and  
547 government officials tend to interpret this information. It is important to understand this non-linearity

548 because a failure to acknowledge this complexity can hinder the success of voluntary disease control  
549 approach that has been of significant interest for governments (17,54).

550 Second, farmers may take a more blanket approach to avoid unwanted diseases by avoiding purchasing  
551 cattle from so-called ‘shady farmers’ and instead use a stock agent. Farmers demonstrated the difficulty  
552 of finding problems in cows before purchasing because the disease status information provided by  
553 sellers may be unreliable or diseases associated with milking may only appear in the milking time.  
554 Therefore, it makes sense for farmers to avoid shady farmers and deal with genuine farmers, who  
555 provide honest information, keep reliable records, and take good care of animals—animals from such  
556 farmers are deemed to have less problems. Hence, should we aim to deliver recommendations on a  
557 disease control to farmers, we need a better understanding on farmers’ holistic approach to biosecurity.

## 558 **5.5 Why do farmers change their farming practices?**

559 It was evident that farmers made a substantial behavioural change after one or multiple ‘trigger events’  
560 identified by the Trigger Change Model. These triggering events included three types already discussed  
561 by Sutherland et al. (30). While these three types are relatively infrequent events (e.g. devastating  
562 disease, succession and new regulations), we point out that the frequency, and even rareness, of events  
563 is not necessarily an important characteristic of trigger events. Our study suggested that relative  
564 frequent events can be also a trigger: farm relocation due to the share-milking system specific to New  
565 Zealand can also work as a trigger event. We argue that tensions between a land-owner and share-  
566 milker, likely due to the difference in their farming subjectivities, play an important role in inducing a  
567 behavioural change. Although this system is specific to New Zealand, we postulate a similar tension  
568 can occur in any other countries because a farming system often consists of multiple actors including  
569 family members, staff, and neighbours. This suggests that routine farming practices may also be  
570 considered triggers. Moreover, it points to the importance of understanding different subjectivities  
571 within a farm system because a conflict felt by one party (e.g. share-milker) may be different from that  
572 of the other party (e.g. land-owner). The immediate implication is that we need to be careful in  
573 designing quantitative studies of behavioural change because questionnaire studies often only collect  
574 information from one person on the farm. Further studies are warranted to understand how the  
575 coexistence of multiple subjectivities within a farm influence the decision making of a whole farm.

576 Interestingly, it was evident that farmers often demonstrated their frustrations, stress and emotions  
577 associated with triggering events when they were explaining their behavioural changes. Previous  
578 studies on stressors on farmers listed a disease outbreak as one of the most stressful events to farmers  
579 (53,55). A Swedish study also reported that a higher disease (mainly mastitis) incidence rate was  
580 associated with farm workers being more frequently exposed to psychosocial stressors (56).  
581 Introducing a disease or undesirable cows seemed to act as a trigger event because it posed significant  
582 stress on farmers—be it a serious workload to deal with the consequence or the loss of freedom of  
583 doing what farmers used to do. We therefore postulate the degree of stress and emotional impact that  
584 trigger events pose on farmers is an important characteristic which may determine their behavioural  
585 consequences. While we cannot conclude this hypothesis based only on this study, there is a wealth of  
586 knowledge in the psychology discipline that shows ‘coping strategies’ may be employed to diminish  
587 the physical, emotional, and psychological burden that is linked to stressful events (57).

588 Coping may take different forms depending on various factors including the affected person’s  
589 perception of the stressful event, perceived capacity to deal with the event, belief, resources such as  
590 supporting networks, and the person’s situation (57,58). Psychological studies traditionally categorise  
591 these forms into two types: engagement (approach) and disengagement (avoidance) (59). Whereas

engagement coping strategies involve reactions and attentions towards the stressor (stressful events), disengagement strategies involve an attempt to stay away from the stressor. In the context of livestock purchasing behaviours, both forms can, for instance, lead to cessation of livestock purchasing: while some farmers may stop purchasing because they believe they can stay away from introducing a disease (disengagement), others may be more engaged in understanding disease and decide the best solution is to stop purchasing animals (engagement). While these two strategies may lead to the same behaviour, attitudes towards disease control in general may differ between the two. We make it clear that it is not our intention to categorise behavioural changes identified in this study within this coping framework. Rather, we suggest that it is not the outcome of behavioural change that are particularly relevant when understanding a behavioural change—what matters is the process and the context in which a change occurs, as we further discuss below.

## 5.6 How do farmers change their practices?

Our analysis suggested it is challenging to predict whether a minor or major behavioural change occurs after given trigger events: the change seems to be highly context-dependent. Sutherland et al. discussed that farmers are likely to analyse a message or situation differently between when they are in the path-dependent phase and when they just experienced trigger events (30). They argue that peripheral route processing occurs in the path-dependent phase, where farmers assess a message or situation superficially, leading to only an incremental change. On the other hand, after trigger events, farmers use central route processing, where they actively assess available messages and information, leading to a substantial behavioural change. Nevertheless, the real process of a behavioural change seems more complex. For instance, as exemplified by the quote of a farmer who described the experience of dealing with bTB as ‘fighting fire’, a substantial socio-emotional shock due to trigger events may prohibit farmers from indulging in central route processing. Or, disease outbreak situations such as the current *Mycoplasma bovis* outbreak in New Zealand do not allow farmers to adopt different farm practices due to an imposition of new legislation. Therefore, in general, an incremental change may occur in response to trigger events and a major change may occur without these events. Together, this suggests is that it is not outcomes that are particularly relevant when understanding a behavioural change—what really matters is the process and the context in which a change occurs. Our suggestion is therefore to tie the characteristics of events and the characteristics of situations in which these events occur such as cowshed culture, farm financial status, farmers emotion towards the events (e.g. fatalistic against disease, see 60,61), and how much support farmers received for the event (e.g. whether farmers have an access to specific instructions, 62).

## 5.7 How does individual farmer’s trading influence an overall movement network structure?

As we have already seen, stock agents play an essential role among New Zealand dairy farmers. Here, we discuss how such a system also significantly contributes to generating a larger-scale livestock movement network, using a livestock movement in relation to bTB risk as an example. We have previously reported that the frequency of livestock movement from bTB high risk to bTB low risk regions is much lower than expected (10). Our interpretation was that New Zealand dairy farmers may avoid purchasing animals from bTB high risk regions (e.g. West Coast). Nevertheless, the stock agent system provides an alternative explanation.

This trading system results in the majority of New Zealand farmers not having an option to purchase from high-risk regions for several reasons. First, livestock trading in these regions is not extremely profitable for stock agents. This is because stock agents earn money proportional to the total price that buying farmers pay to the seller, but West Coast farmers usually only have a small number of surplus

636 animals to sell because of its severe and wet climate. Second, stock agents who are looking for a large  
 637 number of animals are unlikely to try to purchase animals from West Coast: it is logically easier for  
 638 agents to secure a required number of animals from a single farm rather than gathering a small number  
 639 of animals each from multiple herds. These factors together limit the number of animals sold from this  
 640 region to other regions, which in turn leads to animals being traded within the bTB high risk region.  
 641 The apparent risk-averse livestock movement pattern therefore does not necessarily mean that farmers  
 642 are intentionally avoiding risky trading. This emphasizes that there are complex factors and actors that  
 643 are involved in shaping an observed livestock movement network.

644 We speculate that movement network structure remains similar if farmers keep using the same agent  
 645 and the supply and demand of livestock does not change dramatically: this is because, again, stock  
 646 agents often match sellers and buyers locally. A significant change in network structures, however, can  
 647 occur if, for instance, farms that sell a large number of animals change their stock agents and/or agent  
 648 companies; this will generate new trade partners, changing a whole network structure. Therefore,  
 649 although our study focused on farm-level change in trading practice, it is also important to understand  
 650 how livestock movement patterns change collectively as a system in response to trigger events such as  
 651 the current *Mycoplasma bovis* outbreak in New Zealand.

## 652 6 Conclusion

653 Farmers' livestock purchasing practices appear to be deeply embedded in cowshed culture, which is  
 654 shaped by physical infrastructure, natural environment, and interactions between animals and farmers.  
 655 As a result, traditional behaviouralist approaches that link farmers' attitudes towards biosecurity and  
 656 their behaviours may dismiss important aspects of farmers decision making on livestock trading.  
 657 Drawing on the Trigger Change Model, we showed how trigger events disrupt farmers' established  
 658 purchasing practices. In response to shock imposed by triggers, farmers reorganise their practices and  
 659 may develop a more holistic purchasing strategy to reduce a disease introduction risk. However, the  
 660 impact of triggers seems to be largely context-dependent. Using voluntary schemes such as providing  
 661 disease status of source farms has attracted a great interesting as a driver of behavioural change. One  
 662 hopes such schemes may be easily integrated into an existing farm practice, however, we speculate  
 663 such an integration is challenging for many farmers due to path-dependency. These schemes may  
 664 therefore fail to deliver their intended behavioural changes without a greater understanding on trigger  
 665 events: do these schemes act as a trigger? How do different triggers work in different situations? How  
 666 do farmers seek support to overcome socio-emotional and economic impacts posed by triggers? How  
 667 does this support influence on behavioural change amongst farmers? Answering these questions  
 668 requires a paradigm shift in how epidemiologists frame farming behaviours—they are much more than  
 669 a biosecurity question.

## 670 Figure legend

671 Figure 1. The 'Triggering change' model redrawn from Sutherland et al. (30).

672 Figure 2. Locations of regions from which interviewed farms were selected in relation to bTB risk.  
 673 Note the current high bTB risk area as of 2019 is smaller than shown in this map.

## 674 Table 1. Profile of interviewed farmers

Farmer	Region	Type	Number of milking cows
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1	Canterbury	Farm owner/operator	1500
2	Waikato	Share-milker	420
3	Waikato	Share-milker	330
4	West Coast	Farm owner/operator	175
5	Taranaki	Farm owner/operator	440
6	Canterbury	Farm owner/operator	2400
7	Waikato	Farm owner/operator	624
8	Canterbury	Farm owner/operator	2700
9	Canterbury	Farm owner/operator	1500
10	Taranaki	Farm owner/operator	350
11	Waikato	Farm owner/operator	3500
12	Canterbury	Share-milker	900
13	West Coast	Farm owner/operator	184
14	West Coast	Farm owner/operator	580
15	West Coast	Farm owner/operator	440

675

676 **Table 2. Examples of trigger events and accompanying responses made by farmers**

Examples of trigger event	Example of the response and quotes
<b>Livestock introduction</b>	<p>Stop purchasing specific animals</p> <p><i>“...we had bulls last year that had a bloody pink eye. Bad... bad strain of pink eye [infectious bovine keratoconjunctivitis]. So we had some teaser bulls [for a heat detection] last year. So decided not to use teaser bull ever again for that reason because...[...]. I mean the benefit</i></p>

	<i>of them is not worth for the risk. So we got about 60 – 70 cows with pink eye in the herd the other side of the road last year and we were very careful not to let any of these cows from this farm mingle with those ones to cross infect. Uhmm I think we've got under control now, but uhmm... it was you know the guys had to be very vigilant looking at eyes and making sure that they treated them. [...] It was more just ... hassle and cost... and stress because you know that they could go through the whole herd and imagine you'd have to put stuff on eyes on every cow... nah." (farmer 9)</i>
Livestock selling	Assess the need of a disease control after having been frequently requested by buyers for the disease status of animals the farmer was selling  <i>"It's something I've never worried too much about, but it's something that are starting to look at more... Because I just had one reactor, get rid of it yesterday. It's probably something we would check... I know it's becoming more.... When we sold cows last year, they wanted BVD status, the history, the records, so yes. [...] I think many years ago I've got herds of heifers out for grazing and quite a few was empty... 8 or 10 empty heifers and we reckon that was BVD that has been spread..." (farmer 10)</i>
Disease outbreak	Purchase new pasture (a run-off) that allows a farmer to stabilise the farm business  <i>"No [I'm not allowed to sell animals] and I'm not allowed to put animals for grazing. But like I say, that's not a problem. I can live with that in a management issue. And that's what I'm saying, thinking farmers that get TB... I highly recommend they become independent. Not really nice but you really do have to operate your farm inside the silo. And that [having their own run-off] means you're not paying grazing anymore. You've got to pay interest on a grass, better to make that decision." (farmer 5)</i>

677  
678**Table 3.** A summary of quotes on the C status from farmers stratified by the risk of bTB in their farming regions and the presence of a bTB breakdown experience

	No bTB breakdown experience	bTB breakdown experiences
Low bTB	"As long as they're passing TB test... yeah as long as they pass TB test I don't think I'm too worried. I've never really thought about it. As long as they're clear and not on	"Probably didn't worry about that back then [before the bTB breakdown], didn't really think too much about it [source farm C status]. I just presumed if they were

<b>risk region</b>	movement control... that's not a factor when I buy animals... definitely I don't wanna get TB" (share-milker 2)  “...as long as they're clear yeah, it's all good. I haven't looked at it too closely. Because most of us are [C]10 here”. (share-milker 3)	clear, they were clear you know. But probably just now look at the history and where they come from and ..., how long they have been on that farm and where they are buying from... share-milkers move around obviously quite a lot so you have to be careful about that.” (farmer 6)
<b>High bTB risk region</b>	“...we bought C1 [a herd that just became clear for bTB a year ago] at the first year we were here [after having moved from Canterbury, which is a low bTB risk area]. And sort of I wished ever since we hadn't but anyway we didn't get TB, touch wood, as far as we know. We haven't had any since we've been here. Yeah I wouldn't do that again. I wouldn't buy C1 again, ever. It's just too risky.” (farmer 4)	“Depends where they are and why they are [with a specific C status]. You know, you look into those sorts of things. And where they are coming from... like here in the coast, it's a TB area so you know that it would be the likelihood but... yeah we just go through... check it out”. (farmer 14)

679 **Table 4. Advantage and disadvantage of identified methods to avoid shady farmers and**  
 680 **associated farmers' quotes**

	<b>Using stock agents</b>	<b>Personal trading</b>
<b>Advantage</b>	<p>1. Stock agents in general have good knowledge about sellers locally and nationally.</p> <p><i>“he [stock agent] knows... ‘this guy is selling cows, selling surplus cows for 5 years or 10 years and we never had problems or he sold some cows and we had a bit of problem 3 years ago so maybe you don't wanna go there’... so he knows all that. Whereas if we're going to trying to deal with other farmer, they don't tell you, you won't know.”</i> (farmer 4)</p> <p><i>“Yeah, at the moment we are looking for 50 more cows. Because we need to keep the numbers for the contract for the farm owners. But there's no.. not much stock in Canterbury...so we're looking in North Island, I think he's [stock agent] in Taranaki now... That's what's going on there. They're busy people, buying around the country looking at animals, but it's good, it's what they do, you know, they're professionals.”</i> (share-milker 12)</p>	<p>The sellers can be trustable if farmers know the seller personally.</p> <p><i>“I mean we've got neighbours around the road but he's got Friesian. If we wanted to buy Friesian, I'm happy to buy them off from him. Because he thinks the same as we do. [...] Honesty, integrity, you know, if there was a problem he would tell you what it was.”</i> (farmer 4)</p>

	<p>2. Stock agents solve issues around trading between farmers, including a price negotiation.</p> <p><i>"We... a few years ago... we sent some young stock away grazing...grazing that was organised through an agent... the grazing didn't go very well... and we went over there and decided we were taking animals home. [...] they were not gaining enough weight fast enough for the money we were paying. [...] So our agent... they sorted it out. It was very interesting... dealing with that. I think if that was a private deal without the agent there, without a contract, you would almost don't have legs to stand on."</i> (farmer 1)</p>	
<b>Disadvantage</b>	<p>Building a trustworthy relationship with agents may be slow and requires a constant assessment.</p> <p><i>"...I contacted one agent that I only met a couple of times and I said "Do you have any profiles for any heifer calves for sale?" and I said I like high index Jersey and he sent me through a profile and they were really average. [...] But now he knows that... if I ask him again he would tell me... only give me a higher one because he knows now that his missed out one because I didn't buy them in the end [...] When you get to know them, they know you and your farming system as well."</i> (farmer 7)</p>	<p>It is often infeasible because</p> <ol style="list-style-type: none"> <li>1. farmers do not know many sellers who are selling at the right timing (farmer 4, farmer 9)</li> <li>2. difficult to agree on a price (farmer 8)</li> <li>3. there is no time to set up a personal deal (share-milker 3, farmer 11)</li> </ol>

681

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689 **8 Conflict of Interest**

690 The authors declare that the research was conducted in the absence of any commercial or financial  
 691 relationships that could be construed as a potential conflict of interest.

692 **9 Author Contributions**

693 AH, CG, GE conceived and designed the study. AH conducted a field interview. AH and CG secured  
694 funding for the study. AH and GE analysed and interpreted data. AH, CG, GE wrote the paper with  
695 significant intellectual input from GE. All provided approval for publication of the content.

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697

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701 **11 Data availability**

702 The datasets for this manuscript are not publicly available because of the privacy nature of the  
703 interview data. Requests to access the datasets should be directed to Dr. Arata Hidano  
704 [A.Hidano@massey.ac.nz](mailto:A.Hidano@massey.ac.nz).

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