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The effect of animal health compensation on ‘positive’ behaviours towards exotic disease reporting and implementing biosecurity: a review, a synthesis and a research agenda

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Highlights

- Full compensation leads to lax preventative behaviour
- Less than full compensation may encourage positive behaviours but needs to be conditional
- A range of regulatory, fiscal and nudging policies required to achieve optimal positive behaviour

Abstract

With an increasing burden on public sector budgets, increased responsibility and cost sharing mechanisms for animal diseases are being considered. To achieve this, fiscal and non-fiscal intervention policies need to be designed such that they consistently promote positive disease risk management practices by animal keepers. This paper presents a review of the available evidence towards whether and how the level and type of funding mechanism affects change within biosecurity behaviours and the frequency of disease reporting. A Nuffield Health Ladder of Interventions approach is proposed as a way to frame the debate surrounding both current compensation mechanisms and how it is expected to change behaviour. Results of the review reveal a division between economic modelling approaches, which implicitly assume a causal link between payments and positive behaviours, and socio-geographic approaches which tend to ignore the influence of compensation mechanisms on influencing behaviours. Generally, economic studies suggest less than full compensation rates will encourage positive behaviours, but the non-economic literature indicate significant variation in response to compensation reflecting heterogeneity of livestock keepers in terms of their values, goals, risk attitudes, size of operation, animal species and production chain characteristics. This may be of encouragement to Western Governments seeking to shift cost burdens as it may induce greater targeting of non-fiscal mechanisms, or suggest more novel ways to augment current compensation mechanisms to both increase responsibility sharing and reduce this cost burden. This review suggests that a range of regulatory, fiscal and nudging policies are required to achieve socially optimal results with respect to positive behaviour change. However, the lack of directly available evidence which proves these causal links may hinder progress towards this optimal mixture of choice and non-choice based interventions.

Keywords: compensation; behaviours; exotic diseases; biosecurity; Nuffield ladder.

1. Introduction

A series of high profile epidemics of exotic animal diseases including bluetongue, classical swine fever (CSF) and foot and mouth disease (FMD) have called into question current systems of animal disease prevention and control in Western Europe. The benefits of avoiding or better controlling such outbreaks are obvious and could offer substantial returns. Several enquiries (e.g. Anderson, 2002, Royal Society, 2002; Bourn, 2002) and related academic reviews (e.g. Donaldson et al., 2002; Taylor, 2003; Murphy-Lawless, 2004; Campbell and Lee 2003) have examined the experiences in detail in an effort to identify better ways to manage animal health. One of the key findings of these works has been that policies of compensation for both animal and production losses due to infectious diseases need to be re-designed in a way that consistently promotes positive disease risk management practices, such as early reporting and notification of suspicious cases of contagious disease by animal keepers. This will provide the best return on investment for stakeholders. In addition, early detection, diagnosis and notification of disease are considered by the World Organisation for Animal Health (OIE) as critical to minimise the consequences of outbreaks (World Organization for Animal Health, 2010, 2015). To tackle the significant problem of financing of costs and losses of epidemic livestock diseases, formation of a global emergency response fund for animal epizootics (GERFAE) has been suggested that will, among its other functions, “encourage an effective and rapid emergency response for control of epidemic livestock diseases in developing and transition countries, including through compensation of livestock holders” (Alleweldt et al., 2007, p.9).

Design considerations of compensation policies for such an outcome should include aspects of information asymmetry, that is when one party has more or superior information compared to another during a transaction, and incentive compatibility, namely when the incentives that motivate the actions of individual participants are consistent with following

the ‘rules’ established by the group. In addition, the design of mechanisms needs to consider whether responsiveness varies with both the nature and source of compensation, as well as other influences on animal keeper behaviour (Gramig and Wolf, 2005; Jin and McCarl, 2006; Koontz et al., 2006; Pannell and Vanclay, 2011; Oparinde and Birol, 2012; Hennessy, 2013; Hennessy and Wolf, 2015).

Positive behavioural change is a common term within Government policy agendas and relates to modifying a target group’s actions to achieve an outcome or set of outcomes which are socially desirable. In this case, positive disease risk management alludes to the effect of compensation payment to livestock keepers in changing their biosecurity behaviours and/or disease reporting in order to, ultimately, reduce the total disease cost and incidence. Within a new institutional economics approach, if the behaviours have been adequately identified then farmers could be ‘nudged’ towards a positive behavioural outcome, or, in some cases, expect elements of stricter regulation to restrict negative behaviours (e.g. Barnes et al., 2013).

A useful schematic of the choices available to Government agencies is the Nuffield Health Ladder of Interventions (NCB, 2007). This shows a series of interventions mapped against the imposition of available choices for the target population. This approach facilitates the identification of possible interventions which encourage positive behaviours through fiscal (e.g. financial compensation or penalties) and non-fiscal processes, (e.g. group sharing of information or increasing pressure through social norms to report a suspicious incident). An example of such a ladder applied to positive behaviours is shown in Fig. 1.

This figure shows a range of interventions which could be used to encourage positive behaviours. These are ranked in terms of increasing levels of choice for the livestock keeper. Regulatory approaches and incentive-based systems tend to impose more control on the livestock system compared to the other interventions and hence, within a neo-liberal agenda

such as in the UK, there is a desire to shift this responsibility and cost burden through more voluntary approaches, to encourage co-operation both across livestock keepers, but also within a supply chain to manage animal health or, more commonly, by providing and targeting information on biosecurity and awareness of exotic disease for reporting. The main focus of this review is on fiscal or incentive-based interventions, namely compensation and penalties. Nevertheless, the possibility of using a mixture of fiscal and less fiscal incentives that promotes greater positive disease risk management practices by animal keepers is also discussed.

What follows is a review of literature which has examined the consequences of these various interventions on encouraging or, indeed, discouraging these desirable positive behaviours. This is established against the landscape of highly contagious exotic diseases, which has been explored by a number of authors (Ekboir, 1999; Sumner et al., 2005; Otte et al., 2004).

In re-designing compensation schemes, governments and other stakeholders need to reframe incentives to change behaviour in a way that reduces overall risk and scale of exotic diseases. Evidence and lessons from the literature on the impact of exotic disease compensation policies on animal keeper behaviours' and the likely effectiveness of different compensation measures for promoting positive disease risk management practices, are therefore essential. A series of seven questions (Table 1) that were deemed to be the most important to underpin the redesign of compensation policies were posed by the research sponsor (Defra), who required a quick (two-month) turn-around on the project and hence commissioned a Rapid Evidence Assessment (Petticrew and Roberts 2006) rather than a more extended study.

The purpose of this paper is to investigate whether these questions have been answered in the literature and, in so doing, identify possible knowledge and research gaps.

Accordingly, the main objective of this review is to investigate the relationship between exotic disease compensation policies and observed positive behaviours in terms of reporting and implementing biosecurity when outbreaks occur and in “peacetime”. In parallel, the effects of possible other factors that induce positive behaviours were also investigated.

The fragmented nature of the literature, across several domains such as agricultural economics, sociology, human behaviour as well as veterinary epidemiology, may constrain a search of relevant literature. However, prevailing literatures in behavioural theory as well as that existing in the animal health economics sphere (covering farmers’ individual and social behaviours, socioeconomic and epidemiological studies) were the main domains of these studies. Overall this approach enabled us to assess the level of evidence around exotic disease compensation and positive behavioural response. The primary questions were defined as: *a) to identify the relationship between exotic disease compensation and positive behaviours with respect to biosecurity measures; and b) other factors that most influence how quickly animal keepers report exotic disease and carry out essential biosecurity measures.*

The next section outlines the methodology used and the application to the framework. This is then followed by results which firstly examine the economic investigations, as the role of compensation in shaping incentive structures is clearly driven primarily by economic insights. This is then followed by ‘non-economic’ investigations to provide a broader perspective to fully implement these mechanisms in a heterogeneous population such as farmers and hobby livestock keeping. Gaps are identified and then a list of recommended topics to address the identified gaps are presented and discussed.

2. Methodology

An adapted Population, Intervention, Comparator, Outcome (PICO) approach was used to design search strings for use in web search engines and databases of academic literature. In

addition, to further understand the policy dialogue and regional impact of compensation on positive biosecurity behaviour 10 international experts and academics who have conducted research and reviewers of animal health related compensation mechanisms were contacted based on their contribution to the literature and also through suggestions from policy colleagues. This enabled us to seek further (grey) literature on compensation in these countries including Germany, the Netherlands, France, Belgium, Spain and Australia.

The PICO process which is a widely used method in conducting systematic literature reviews was adopted to develop a literature search strategy (Miller et al., 2013; Houghton-Carr, et. al., 2013; Petticrew and Roberts, 2006). Particularly the PICO process was used to break down the mentioned research questions into components (Table 2) that best represent the initial scope of the work and to aid further analysis of the available evidence. A selection of databases namely: Web of Knowledge, Web of Science, Scopus and Google Scholar were used to optimise the coverage of the research. The search was restricted to papers published in English. The titles, keywords and abstracts of the published articles were gathered using search strings developed within the team and by a set of policy experts within Defra. The search strings presented in Table 3 were used and were combined using the Boolean OR operator and the Boolean AND operator.

The search of Web of Science generated 224 hits of which 49 were judged worth looking at in more detail once titles and abstracts had been reviewed. Papers were included if they were judged to address ‘compensation/incentives/behavioural’ issues for disease control and were excluded if they did not relate to disease control or to livestock disease. A small number of papers on (e.g.) crops or aquatics were retained as they could be of related interest to the questions. The same search on Google Scholar generated a further 50 hits (only the first 10 pages were reviewed), of which 12 were not present in the Web of Science results. Of these, 10 were deemed worthy of further consideration. A simpler search on AgEconSearch

(AgEconSearch, 2015) because the full search string was too complex for that database (so a simpler “livestock disease compensation” string was used) yielded two additional papers. Closer inspection of the combined 61 papers eliminated five, leaving 56 as relevant. However, using Google Scholar to see where these 56 had been cited and looking at each paper's list of references generated a further 42 relevant papers. Also, two additional papers were suggested by academics that the research team contacted.

The search on Science Direct generated 853 papers of which 190 were judged worth looking at in more detail once titles and abstracts had been reviewed. From these, 38 papers not already identified above were judged applicable to the questions outlined in Table 1. In addition, published papers in the past four years (2011-2014) in the journal of Preventive Veterinary Medicine were reviewed and a further five relevant papers not captured by the search term were identified. Also, a review of the reference lists of the three most relevant papers (i.e. Elbers et al., 2010a; Delgado et al., 2014; Toma et al., 2013) found that all the relevant papers in those reference lists were already included in our previous searches, offering some reassurance on search coverage despite its necessary haste.

The above mentioned search process generated a total number of 141 papers. This initial list was then refined by applying exclusion criteria based on the research scope and domains depicted in the PICO process. In total 95 articles which met all the exclusion and inclusion criteria were reviewed at full text. One area which was particularly underrepresented is in relation to “bonuses and penalties” in disease compensation (question 4 in Table 1). To accommodate this aspect a limited additional search was used to identify potentially relevant example articles from other areas such as human health interventions, employment contracts and regulatory design. Two sources namely Web of Science, last five years (i.e. 2010-2015) only, and Google Scholar, first two pages only were used for this purpose. This added a further 12 articles.

The full texts of the selected 107 papers were critically reviewed against the seven questions defined in Table 1 to assess whether these have been answered in the literature and also to identify important gaps in knowledge that require further research. In order to do this, papers were categorised based on the described seven research questions and the main findings of each paper were extracted in summary form. In addition a three-point qualitative score, based on the reviewer's judgement, was allocated to each paper in terms of relevance to the question, as well as country applied, livestock sector and specific disease(s) investigated. Results of the full text review of the selected 107 papers are presented in the next section.

3. Results

This section is organised as follows, i) background into the approaches and theories on public intervention tackling exotic livestock disease using economic and behavioural literature, ii) findings that address each of the seven research questions outlined in Table 1, and iii) the lessons of relevance to the compensation review and identified gaps that need to be examined by future research.

3.1 Public intervention into exotic livestock disease: economic literature

Economic analysis of livestock disease generally focuses on how individual farmers respond to disease risks and outbreaks, emphasising how decisions vary across different circumstances, states of nature and incentive structures. This approach highlights linkages between disease epidemiology and farmers' behaviour, stressing the need to account for dynamic endogeneity (i.e. allowing for feedback loops between choices made and the circumstances then faced) and choice architecture (i.e. the design of different ways in which choices can be presented, and the impact of the design on decision-making) rather than

assuming only static relationships or external influences. Although heterogeneity of farms and the effects of both individuals' behaviour and institutions and their circumstances are addressed by various social science disciplines (e.g. psychological or cultural perspectives), economic research frames disease problems and behaviour in simpler and more stylised terms. Moreover, economic insights typically emerge from theoretical or simulation modelling based on a number of simplifying assumptions rather than empirical data. Consequently there is a general lack of comparative evaluations of actual rather than modelled outcomes under different policies. For example, Jin and McCarl (2006), Beach et al. (2007), Hennessy (2007), Gramig et al. (2009), Boni et al. (2013) and Hennessy and Wang (2013) all present algebraic models of behaviour under different compensation arrangements, but with little recourse to empirics.

Where empirical data are used, the applications tend to be restricted to simulations rather than comparisons of actual observed differences. For example, Bicknell et al. (1999) and Gramig and Horan (2011) both use numerical simulations to explore bovine Tuberculosis (bTB) controls in New Zealand whilst Elbakidze (2008) simulate avian flu in the USA and Reeling and Horan (2015) simulate alternative compensation arrangements for FMD during the UK outbreak in 2001. The lack of comparative empirical data is acknowledged by economists (e.g. Rich and Perry, 2011), but as yet few attempts have been made to purposively collect or utilise such information.

Notable exceptions include Kuchler and Hamm (2000) who were able to use observed variation in compensation payments and reporting of scrapie in the USA to show that higher compensation payments are associated with higher rates of reporting, and Ifft et al. (2011) who use household data for small poultry producers in Vietnam to show that disease management cannot be separated from other production decisions. Oparinde and Birol (2012)

take a different approach and use choice experiments to test Nigerian farmers' preferences for different compensation approaches.

Nevertheless, the absence of comparative empirical evidence has not prevented economics from clearly influencing policy thinking and contributing to promotion of cost and responsibility sharing (Sanco, 2006; McKenzie et al., 2006; OECD, 2012; OECD, 2013). This partly reflects a desire to ease pressure on public budgets, but also reflects economic insights into interactions across farms and between private and public efforts to combat diseases. In particular, there is potential for public funding to dampen private efforts and reduce overall effectiveness, meaning that payment rates and conditionality (i.e. eligibility criteria) for public funding need to be set with regard to their effect on the incentives facing farmers. For example full (100%) compensation for culled animals is shown by economic models to lead to less on-farm effort to prevent disease (in essence '*why bother if outbreak costs are covered?*') and thus higher probability of contracting diseases and consequently production losses than if partial compensation is available (Gramig et al., 2009). Hence, in essence, this means that sharing of risks alters farmers' behaviour. This is despite the fact that empirical support cited for incentive effects often take the form of poorly described case studies or anecdotal observations (e.g. McKenzie et al., 2006) which makes formal comparative evaluations of different arrangements very difficult (Sanco, 2006; OECD, 2012).

However, although the insights offered by economic analysis may be influencing policy thinking, they take the form of general guidance rather than detailed prescriptions for specific cases – indeed variation across different diseases and different farming structures (e.g. farm type and size, production method) is anticipated. Published compensation guidance (e.g. McKenzie et al., 2006; USDA, undated) thus appears to reflect a mix of economic principles and “rules of thumb” drawn from observed policy arrangements across different

countries. For example, pegging compensation at 70% to 90% (McKenzie et al., 2006) and making payment of partial compensation conditional (or indeed offering subsidies) on adherence to certain management practices to also encourage greater biosecurity (although this imposes additional monitoring costs on government).

Similarly, the same economic models and published guidance suggest that the timely notification of diseased animals can be encouraged by making payment of compensation conditional on early reporting, typically gauged by the prevalence of diseased or dead animals on the farm at the time of reporting (i.e. higher payment is offered if only a few animals are diseased or dead). Where policies have seemingly been adjusted for cost and responsibility sharing (e.g. Australia, Netherlands) it is not clear the extent to which variation in compensation arrangements across different diseases and/or different farmers is grounded in detailed empirical evidence rather than simply heuristics (rules-of-thumb) and stakeholder negotiation (Sanco, 2006; OECD, 2012).

3.2 Public intervention into exotic livestock disease: behavioural and sociological literatures

Whilst the economics literature focuses very clearly upon the relative effect of alternative compensation effects, the behavioural and sociological literatures rarely consider financial incentives at all. Two exceptions are Ellis-Iversen et al. (2010), for cattle farmers in England and Wales, and Lupo et al. (2014), for oyster farmers in France. More generally, the behavioural literature identifies a range of non-financial influences on adoption of biosecurity measures and disease reporting. These interventions are considered as nudges or choice-architecture in the Nuffield intervention ladder. For example, farmers' awareness/knowledge of diseases, feelings of guilt or shame, belief in the efficacy of control measures, and trust in neighbours/advisory services/government bodies are repeatedly reported as important (e.g.

Elbers et al., 2010a; Delgado et al., 2012; Brennan and Christley, 2013; Garforth et al., 2013). Yet such factors are not considered in the economics literature, revealing a significant research and policy gap. Effectively this gap suggests that compensation may be important, but its interactions with other factors are clearly under-researched in relation to both endemic and exotic animal diseases. The more sociological literature offers a slightly different perspective, again highlighting issues of awareness and trust (e.g. Palmer, 2009; Vanclay and Enticott, 2011), but also emphasising how looking at behaviours without considering context can be misleading since behaviours and policy structures evolve jointly and neither are geographically uniform (e.g. Enticott, 2008; Hinchcliffe and Ward, 2014; Maye et al., 2014). Ironically, albeit using different terminology, the theoretical economics literature acknowledges the need to consider behavioural differences (e.g. across farm types and sizes) and dynamic feedback between behaviour and policy decisions (e.g. Rich and Perry, 2011), but largely fails to explore such issues empirically, again this reveals a research gap.

If such a behavioural change, by means of redesigning compensation mechanism, is to succeed, it is crucially important to know what drives key behaviours of animal keepers, whether the policy options available are likely to be more effective, and whether the financial source of the compensation (e.g. Government, industry or levy board, etc.) makes a difference to animal keepers' behaviour. It is known that drivers of behaviours, their effectiveness and importance vary by sector, disease and the circumstances.

3.3 Finding in relation to specific research questions

3.3.1 Factors affecting speed of reporting diseases

These factors can be summarised as (a) financial recompense; (b) getting full market value; and (c) pay-out received for diseased or dead animals. The economics literature assumes profit maximising behaviour by commercial farmers, adjusted in some cases for risk-

averseness but with incentives couched purely in financial terms. Algebraically and/or through simulation modelling, it can be shown that farmers can be incentivised to look for and then report disease (e.g. Jin and McCarl, 2006; Hennessy, 2007; Gramig et al., 2009). Specifically, higher payment rates encourage reporting (Kuchler and Hamm, 2000) whilst the threat of reducing payment rates (or imposing actual penalties) for late reporting can encourage earlier notification. For ease of monitoring, the number of already dead or sick animals on a farm at the time of reporting is usually taken as a proxy indicator of how quickly a disease was identified and reported (McKenzie et al., 2006; OECD, 2012). Stylised economic modelling of non-profit-maximising hobby farmers suggests that they may respond differently than commercial livestock keepers (Ceddia et al., 2008; Kobayashi and Melkonyan, 2011).

One paper (Lupo et al., 2014) specifically pertains to exotic disease, reporting, and behaviour in respect to operations and compensation. These authors designed and conducted a retrospective case-control study of oyster farmers, based on interviews with 27 non-reporting and 89 reporting farmers in France. Information about farmer and farm characteristics, farming practices, farm health history and related financial compensation on the farm, knowledge of the mortality reporting system and reporting behaviour was collected. They used an ordinal logistic regression to model farmers' reporting behaviour. Though centred on oyster farming, it usefully draws upon other studies across animal types internationally. Moreover, it highlights motivational aspects of compensation while separating these from other (broadly behavioural) considerations. In particular, compensation for production losses was observed to be a clear incentive for reporting, but in this context was countered by two main factors: what the authors refer to as a 'habituation effect,' and a lack of awareness of the aims of the reporting scheme. In this case, habituation referred to an interesting combination of lack of continuing alertness and awareness (i.e. complacency) and

also of the level of (continuing) involvement by the authorities that led to an exotic disease, through uncontrolled spread, in fact becoming endemic. The authors also observed that producers pursued self-interest rather than an interest geared to a contribution towards the early detection of disease outbreak.

Habituation can apply to other scenarios whereby producers simply become accustomed to a situation that has previously been stressed as important, and this may lead to a decreased level of (motivated) vigilance. Similarly, through less or decreasing emphasis on partnership and investment in the larger aims and societal benefits of the work, intrinsic motivational processes will be affected. This also implies the need for persuasion and regular baseline communications between agencies and producers to establish and maintain a certain quality of relationship.

Elbers et al. (2010a and 2010b) used a combination of qualitative and quantitative research design to investigate farmers' behaviours with respect to reporting or not reporting clinically suspect situations. For the qualitative part focus group sessions with farmers and other stakeholders as well as personal in-depth interviews with pig farmers and veterinary practitioners were held. The quantitative part was based on an electronic questionnaire survey of the members of a large pig farmer organisation. A grounded theory approach was used to analyse the content of focus group and in-depth interviews and statistical methods were used to analyse the questionnaires. These authors identified six key themes when reporting clinically suspect situations in relation to classic swine fever and avian flu in the Netherlands. These were a lack of knowledge of the early signs; guilt, shame and prejudice; negative opinion of control measures; dissatisfaction with post-reporting procedures; a lack of trust in government bodies; and uncertainty and lack of transparency of reporting procedures. The Dutch system of compensation where healthy animals are fully compensated, sick animals are compensated for 50% and dead animals are not compensated was discussed with a small

group of farmers. The authors identified that the financial ‘reward’ for notifying contagious animal disease as quickly as possible is that the compensation for further consequences, in case there is indeed an outbreak, may be higher.

Furthermore, a small sample of pig farmers was surveyed for this study (76 in total). When asked ‘is the difference in compensation between sick and dead animals a good stimulus to report’, 56% of farmers surveyed agreed with this statement. Conversely 45% of the respondents agreed that ‘The threat of possibly paying a penalty for negligence is perceived as an important reason to report a suspicious clinical situation’. This perhaps identifies the heterogeneity of livestock keepers and their perceptions towards the influence of compensation on their reporting behaviour.

3.3.2 Relationship between compensation and biosecurity in peacetime vs outbreak

One of the main messages of the economics modelling literature is that public funding can displace private efforts (e.g. Gramig et al. (2009), who developed a principal-agent model). In particular, full compensation for animals culled as a result of an outbreak (plus funding of clean-up activities) means that farmers may be disinclined to implement (costly) biosecurity since most of the direct costs of an outbreak will fall on others. Hence compensation should be less than 100% to ensure farmers have a stronger financial interest in preventing an outbreak. Behaviour during an outbreak may be different (Delgado et al., 2014), and direct subsidisation of peacetime biosecurity may be merited instead (i.e. compensation payments are being asked to achieve too many things).

Firestone et al. (2014) studied horse owners/managers behaviour and perception in relation to equine influenza using a Bayesian network model on data from interviews conducted during a retrospective case-control study of the 2007 outbreak of equine influenza in Australia. These authors noted that past outbreak experience influenced the perception of

biosecurity, i.e. positive experience of control measures and procedures during outbreak engendered trust and more favourable perception of preventative actions and their effectiveness in peace time. While there are no specific studies on exotic disease compensation and implementation of biosecurity measures there is some evidence of changes in perceptions in relation to biosecurity in peacetime vs outbreak.

Delgado et al. (2014) surveyed Texan livestock keepers using two questionnaires to determine beliefs of farmers about reporting cattle with clinical signs consistent with foot-and-mouth disease (FMD) both prior to and during an outbreak of FMD disease. They analysed the results by using a combination of scenario analysis, Likert-like scale and ordinal logistic regression. Respondents agreed that reporting clinically suspect cases would have positive economic and emotional consequences during peacetime. However, during an outbreak, producers were less likely to agree with these positive outcomes. Accordingly, this seems to indicate that perceptions at least change during an outbreak and this may have an effect on reporting outbreaks if the economic consequences are seen as less positive for the livestock keeper. Writing on the effects of regulatory unrests to disease spread through cattle movements in the UK, based on the results of a stochastic fully individual-based model, Vernon and Keeling (2012) discuss post-policy behaviours on the part of livestock keepers, distinguishing between outbreak and peacetime situations.

Overall, this work highlights that policy alterations have been generally after-the-fact propositions, implying further reasons for prevention and pre-emption of disease outbreaks (and their social welfare and economic costs). But it also adds to the literature that all behaviours of individuals, agencies, and systems are dynamic and reactive, and that this dynamism has recursive effects. The results of their modelling simulations suggest the cattle industry is prone to undergo boom-bust dynamics and the behaviour of producers in epidemic-free times (in peacetime, aimed at maximising profits) may heighten the probability

for large-scale epidemics. No doubt, the experience of past after-the-fact policy (and market turbulence) events and tendencies will contribute to this stakeholder behaviour.

3.3.3 Most influencing factors affecting behaviour

There is limited evidence concerning the above questions which are directly relevant to compensation. The economics literature focuses exclusively on financial incentives, implying that biosecurity and reporting behaviour is driven purely by how financial outcomes are affected by disease characteristics, market forces and policy signals. Conversely, behavioural and social science based literature emphasise other influences on behaviour, predominantly trust in the methods and institutions for policing exotic disease. For example Garforth et al. (2013); explored attitudes and responses of nine sheep and six pig farmers in England to the proposed animal health practices, and factors influencing the likelihood of implementation. Focussing on the management of bTB and drawing on interviews with 65 cattle farmers, Maye et al. (2014) examined neoliberal styles of animal disease governance and farmers' understandings of disease, nature and wildlife.

Some studies using behavioural economic approaches have attempted to measure the influence of financial and non-financial factors on determining uptake of biosecurity practices. For instance by using a structural equation modelling applied to a dataset collected through a stratified telephone survey, Toma et al. (2013) found 'economic factors' to be significantly related to livestock biosecurity for a sample of 900 beef and sheep farmers in Great Britain. However this had less of an effect than having positive 'biosecurity attitudes'. Higher levels of knowledge about biosecurity measures ranked as having the strongest influence. However, given the different contexts, time frames and non-specificity to compensation as a financial variable within these studies we cannot draw any robust conclusions from this literature.

Schembri et al. (2014) applied univariate and multivariable logistic regression models to a dataset collected from 104 detailed interviews with pig farmers in the three eastern states of Australia to examine biosecurity practices of small-scale and peri-urban pig producers. These authors found that biosecurity perceptions to be influenced by the nature and scale of the operation, with small scale producers not reliant on livestock for household income having a lower level of perception towards the importance of biosecurity. The behaviour, or perceived behaviour, of neighbours is referred to in a number of papers as an influencing factor in biosecurity behaviour on farm (Murray, 2014; Rosanowski, et al., 2013; Schemann et al., 2012). Trust in veterinarians (particularly pre-outbreak) is also identified as being important in these studies. Veterinarians are considered a key source of knowledge and advice on biosecurity regardless of livestock, disease and country. Accordingly, they should be deployed as a means of instilling trust within the population and, perhaps, they can increase responsibility of livestock keepers for prevention and control of diseases particularly during an outbreak.

3.3.4 Bonus or Penalty is likely to be more effective

Distinctions between the use of bonuses and penalties, such as rewarding early disease reporting and fining late reporting, are seemingly not considered explicitly in much of the specialist literature on livestock disease. This applies to both the behavioural literature, where financial incentives are rarely considered at all, and to the economics literature, where references to rewards and threats are mentioned (e.g. Gramig et al., 2009) but not in great detail. Prospect theory (Kahneman and Tversky, 1979) distinguishes between gains or losses and people are expected to behave differently under the prospect of either of these outcomes. This leads to the concept of ‘loss aversion’, which suggests that people are more sensitive to

a loss compared to an equivalent gain and their behaviour is moderated through this risk perception framework.

Bocqueho et al., (2014) tested this theory with a behavioural economic experiment on a diverse mixture of farmers within rural regions of Eastern France. The results of the experiment suggest that farmers respond more to penalties than to bonuses due to this ‘loss aversion’ effect. The idea that farmers fear a loss more than they value a gain can be equated to the mechanism of animal health compensation. That is, if prospect theory holds, farmers should respond to penalties more than offered bonuses for early reporting behaviours. However, the marginal effect of these two outcomes has yet to be tested within the domain of animal disease compensation.

Loss aversion and the effect of framing contracts in terms of rewards or penalties are considered more fully in extensive literatures beyond livestock disease. For example, economists have explored how best to structure employment contracts and public procurement arrangements to improve performance (e.g. Lewis, 1980; Christ et al., 2012; Brink and Rankin, 2013; Bigoni et al., 2014). Equally, the use of financial incentives for human health interventions has also received attention (e.g. Kane et al., 2004; Adams et al., 2014; Wanders et al., 2014). As with the disease literature, there is a mix of mathematical modelling and (small-scale) empirical data, but the policy implications are ambiguous with several papers highlighting how the relative effect of bonuses or penalties is affected by other factors. For example, Christ et al. (2012), suggest that situational complexity can exert a greater influence than loss aversion and Adams et al. (2014) helpfully present systematic review results’ suggesting a range of incentive attributes beyond simply a distinction between a positive bonus and a negative penalty.

3.3.5 Effect of source of fund on biosecurity behaviours

Although the source of funding may differ between private or mutual insurance and public agencies (Assefa et al., 2012), the more abstract economic literature generally treats the basis of the funding as more important than the source per se. That is, insurance funding is typically based on a more detailed risk assessment that differentiates between different diseases and circumstances whereas public funding is typically undifferentiated. The availability of insurance may be a constraint (Koontz et al., 2006). However, the feasibility of insurance funding and farmers' preferences for different types of levies are explored (Meuwissen et al., 2003; Niemi and Heikkila, 2011; Niemi et al., 2014).

There is no specific evidence relating to the source of funding. Many of the studies reviewed discussed the importance of trust in responsible bodies in relation to farmers' perceptions of biosecurity and their behaviour. Trust in agencies may be related to past experiences during outbreaks, or in relation with agencies with respect to other matters (Kristensen and Jakobson, 2011; Palmer et al., 2009; Maye et al., 2014).

3.3.6 Perverse incentives

In addition to the potential 'crowding-out', or reducing the incentive for private effort by public funding (e.g. Hennessy and Wong, 2013), perverse incentives can arise if payments to diseased farms leave them in a better financial position than non-diseased farms that are nonetheless subject to movement restrictions and incur uncompensated costs. In such cases, there is an incentive for these farms to seek infection, and/or to under-invest in pre-outbreak biosecurity. Equally, less than full compensation for diseased animals can incentivise keepers to attempt to sell animals on rather than report the infection (Koontz et al., 2006). However, although economic models suggest these effects, empirical evidence for them is scarce, although anecdotal case studies are alluded to (e.g. McKenzie et al., 2006).

There is no specific evidence reported in the literature relating to policy and perverse incentives surrounding biosecurity, exotic disease reporting or compensation. Nevertheless, there is a wide body of literature on agri-environmental schemes, and therefore outside the domain of this review, which refers to the ‘perverse’ nature of subsidy schemes on affecting farmer behaviour. However, it is debatable whether the generation of ecological goods and the protection of transmittable disease can be considered comparable.

3.3.7 Impact of different compensation arrangements on disease reporting

Much of the economic evidence takes the form of theoretical and/or simulation modelling, which suggests that different compensation arrangements do affect both rates and speeds of reporting (e.g. Jin and McCarl, 2006; Hennessy, 2007; Gramig et al., 2009). This is supported to a limited extent by some empirical applications (e.g. McKenzie et al., 2006), but these are relatively few in number and seldom have a counterfactual baseline against which to judge a particular arrangement (cf. Kuchler and Hamm, 2000). The influence of other factors on reporting is not considered in the economic literature.

In response to our query to experts concerning the impact of different compensation policies, they suggested that the evidence base for compensation arrangements in livestock disease control policies was fragmented and incomplete. In particular, their opinions were that different disciplines were not well integrated and evaluations of policy were hindered by a lack of observed (as opposed to modelled) responses to different compensation rates and eligibility criteria”.

4 Discussion

There are significant evidence gaps in relation to farmers’ perceptions and behaviours with respect to compensation. The majority of work in this area relates to overall perceptions and

behaviour towards biosecurity rather than the effect of compensation per se. Hence, literature from non-economic domains has provided little or no insight into different compensation arrangements.

A number of issues emerge from this study which highlight research gaps and areas which need to be addressed. A range of economics publications were identified that focused on incentive effects for biosecurity and disease reporting. A handful of authors dominate the field, but we identified others offering essentially the same insights based on theoretical and/or simulation models. The basic messages from the economic literature are that *full compensation leads to lax preventative behaviour, so partial compensation may induce better biosecurity but that partial compensation needs to be conditional to encourage disease reporting.*

However, although casual empirics are offered in some cases, such messages are generally derived from stylised modelling exercises rather than empirical data. This means the appropriateness of specific arrangements to particular diseases or farm circumstances is not covered. For example, if (as suggested by the non-economics literature) adherence to biosecurity measures is partly determined by belief in their efficacy which is in turn partly determined by trust in information sources, as well as neighbouring farmers and government, the effect of compensation arrangements is unlikely to be as straightforward as economic modelling suggests.

The plethora of attitudinal studies confirms a range of other influences on behaviour (although the focus of these is mainly on biosecurity rather than reporting). The results show that the role of compensation for exotic animal disease does not appear to have been considered explicitly in parallel literatures drawing on psychology (e.g. Theory of Planned Behaviour) or broader social-science (e.g. cultural scripts) perspectives of farmer behaviour. In only a few cases is compensation alluded to in these papers.

Equally, although the ambition of this paper was to explore compensation behaviours on a sectoral basis, there are very little data on non-commercial livestock keepers. This is despite acknowledgement within these literatures that they are likely to behave differently to commercial farmers and may be important in combating diseases. Although various papers suggest differences between farmers, this study found only two authors looking explicitly at commercial vs. hobby farmers. These were again essentially modelling rather than empirical exercises (albeit with plausible policy implications).

Hence, although many other influences on biosecurity and disease reporting have been identified, their interaction with financial incentive effects has not been explored. Consequently, echoing research on agri-environmental issues, there is scope for investigating the extent to which the performance of different compensation arrangements might be sensitive to other behavioural influences.

4.1 A future research agenda

Interventions in relation to prevention and control of exotic contagious diseases should aim at inducing long-term positive biosecurity behaviours between animal keepers. The Nuffield Ladder of Interventions concept provides a framework to analyse interventions and design optimal policies. This could include restricting or removing choices by further regulation at both peacetime and during disease outbreaks, encouraging and providing choices (i.e. nudging) by means of voluntary and economic policy instruments (such as compensation, reward or penalty) or a mixture of these options. Given the heterogeneity within animal keepers in terms of their values, goals, risk attitudes, size of operation, animal species and production chain characteristics, it is reasonable to suggest that a mixture of regulatory, fiscal and nudging policies will be required to achieve socially optimal results with respect to positive behaviour change to prevent and control exotic animal diseases. This was

highlighted by the results reviewed literature that specifically revealed a lack of available evidence about the effects of compensation payments for exotic animal disease on positive reporting behaviours or biosecurity measures employed. Hence, there is considerable scope for further investigating the extent to which the performance of different fiscal and non-fiscal arrangements might be sensitive to behavioural influences. What follows is a list of recommended topics and possible novel approaches which can address the significant gaps which emerge from this study and also be explored within applied work around this topic.

Accuracy of economic characterisation

The economics literature offers general guiding principles for setting compensation rates and conditionality requirements to encourage both investment in preventative biosecurity measures and timely reporting of disease incidence, with some allowance for variation to reflect disease and production characteristics (e.g. speed of infection spread, length of production cycle, etc.). At its most basic, livestock keepers should be asked whether they recognise this characterisation of their behaviour as self-interested, rather than contributing to a wider social good (e.g. amongst neighbours or the wider public).

Perverse incentives

As an extension of above, the economic characterisation of behaviour in narrow self-interest terms also suggests scope for perverse incentives. For example, if diseased farms are compensated for culled animals and (since the animals are gone) avoid holding costs imposed during movement restrictions. Non-diseased farms facing holding costs but not receiving compensation have an incentive to seek infection. Again, livestock keepers should be asked whether they agree with this possibility.

Perceived costs and effective compensation rates

The economics literature assumes that compensation relates to the value of culled animals, and possibly disinfection and restocking. If 100% of these costs are covered by taxpayers, farmers are presumed to have no incentive to invest in disease prevention. However, farmers may well perceive additional costs beyond these. For example, business disruption and loss of supply contracts plus emotional distress if losing flocks/herds established by successive generations on a family farm. As such, headline rates would over-estimate effective compensation rates and farmers may well actually have incentives to avoid diseases even if culled animals are fully covered. Hence it is worth asking livestock keepers directly about their perceived costs and incentives for avoiding and, separately, reporting disease. This would possibly also help to tease-out differences between different types of livestock keeper, e.g. commercial vs. hobby.

The economics literature also rather assumes that the value of livestock can be easily determined to allow calculation of full or partial compensation. However, there are different approaches to valuation, for example net present value versus cost of replacement and farmers' preferences may vary by a range of factors, such as sector and size.

Source of compensation

The economics literature focuses on how incentive structures can be adjusted by altering compensation rates and eligibility criteria to place some risk onto livestock keepers. The source (e.g. taxpayer or insurance fund) of compensation payments is not considered to influence incentives per se, although there is some consideration of farmers' preferences to join voluntary insurance schemes and for *post* rather than *pre*-outbreak levies. Nevertheless, it is worth exploring with livestock keepers whether their reaction to different compensation rates would depend on how payments were funded.

Disease management in wider production/business context

The economics literature acknowledges that biosecurity measures are but one of many production decisions taken by farmers. This has two implications. Firstly, disease risk may actually be managed in other ways, including reducing or even ceasing production (e.g. smaller herds, exiting the sector). Hence it is important to ask about perceived substitutability (and complementarities) between different control measures. Secondly, that non-adoption of biosecurity practices may reflect considered prioritisation of other risks and management actions. For example, for some farmers, addressing the risk of losing CAP Pillar I payments from cross-compliance breaches may have a higher priority than biosecurity measures. Hence it may be helpful to ask livestock keepers about how they perceive (or even rank) disease risks relative to other business risks and the extent to which changing compensation rates would affect this.

Multiple disease risks and spillover effects

The economics literature acknowledges that biosecurity measures imposed in relation to one disease can also convey benefits in relation to other diseases (referred to as spillover effects). It is beneficial to explore awareness of on-farm spillover effects, and whether they influence farmers' decisions to adopt particular biosecurity measures. This could be extended to consider inter-farm spillovers, and potential gains from transparent reporting of practices amongst neighbours. This extends the more behavioural approaches outlined above in terms of the social identifications between farmers and the cultural capital of farming, effectively applying the idea of how a 'good' farmer is perceived by other farmers (Burton, 2004). This may help to explore more cost-effective interventions by means of local governance structure (Barnes et al, 2013).

Trust – risk communication, prevention measures and outbreak

The economics literature assumes that farmers are aware of disease risks, understand prevention measures and will comply with outbreak controls. At the national level, member countries of the World Organisation for Animal Health (OIE) are obliged to report outbreaks of the OIE-listed diseases (World Organisation for Animal Health, 2015b), provide facts and documents about the spread of diseases as well as information on the control measures and notifications to the national governments and veterinary authorities (World Organisation for Animal Health, 2015a). All of these require a degree of trust in sources of information/advice and the actions of others. Yet the non-economics literature highlights how such trust is often absent. For example, biosecurity measures can be viewed as ineffective due to poor design and/or poor implementation by neighbouring farmers and/or distrust in government to implement regional or national controls effectively. Therefore it is important to explore the extent to which responses to compensation are contingent on awareness and trust, or whether indeed shifting costs and responsibilities onto farmers overrides such influences, in effect if it is at some level of risk-bearing then behaviour will change.

Exploring how disease is perceived may provide a useful basis for creating understanding between the different stakeholders involved. Recognition of the barriers and constraints experienced by different stakeholders may lead to elements of a ‘common view’ or at least identify the disparities between stakeholders and their disease control strategies. This should provide a deeper understanding of how to address these barriers, whether they are behavioural, institutional or social, towards prompt disease reporting.

Flexibility vs. standardisation

The existence of heterogeneity across farms is highlighted by both the non-economic and the economic literature, with the implication being that a degree of flexibility and locally-determined solutions would be better than standardisation of practices across all farm types/sizes/locations and diseases. However, varying compensation arrangements according to, for example local circumstances and the nature of a disease will inevitably lead to different treatment for different farmers. The perceived fairness of this must be explored with livestock keepers, to gauge understanding and acceptance of the rationale for variation.

5 Conclusion

Responsibility and cost sharing agendas are emerging within Western Governments. Much like other sectors, the aim is to shift more of the burden from taxpayers to the livestock sector. A range of intervention measures have been applied but which invariably centre on fiscal mechanisms to encourage early reporting of suspicious disease. Hence, there are cultural and historical barriers against shifting to a mechanism which offers less fiscal incentives but yet promotes greater positive disease risk management practices by animal keepers. Ultimately, there is a paucity of evidence finding a causal link or indeed, few directly applicable investigations between compensation and behavioural change in the field of exotic animal health reporting that can be used to fully confirm the effect of these interventions. Nevertheless, given certain assumptions regarding the economic behaviour of livestock keepers, full compensation leads to lax preventative behaviour, so partial compensation may induce better biosecurity. Accordingly compensation needs to be conditional to encourage disease reporting but such relationships are affected by a range of other confounding factors including the availability of and trust in advice. This may be of encouragement to Western Governments seeking to shift cost burdens as the propensity of non-economic studies tend to identify both a heterogeneity in response by animal keepers in

terms of their values, goals, risk attitudes, size of operation, animal species and production chain characteristics. This may indicate that the current compensation approach could be reduced and augmented with non-fiscal interventions, for example targeting along the supply chain or through ‘piggy-back’ approaches on current cooperative initiatives such as catchment level management schemes and carbon foot-printing initiatives. Nevertheless, the Nuffield Ladder of Interventions framework suggests a range of regulatory, fiscal and nudging policies are required to achieve socially optimal results with respect to positive behaviour change to prevent and control exotic animal diseases. However, the lack of directly available evidence which proves these causal links may hinder progress towards this optimal mixture of choice and non-choice based interventions.

Conflict of interest

The authors declare that they are not in a situation of conflict of interests.

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Figure Captions

Fig. 1. The Nuffield Health Ladder of Interventions approach showing examples for encouraging positive disease reporting.

Tables

Table 1. The seven research questions for the literature review presented in this paper.

No.	Research questions (RQ)
1	What are the factors affecting speed of reporting suspicious exotic disease cases?
2	What is the relationship between exotic disease compensation and implementation of biosecurity measures in “peacetime” and in an “outbreak”?
3	Most influencing factors affecting behaviour at RQ1 and RQ2?
4	Bonus or Penalty is likely to be more effective at RQ1 and RQ2?
5	Possible effect of source of fund on behaviours with respect to biosecurity measures?
6	Evidence of role of policy in creating perverse incentives?
7	Evidence of significant impact of different compensation arrangements on disease reporting?

Table 2. PICO components of the review questions.

Population	Intervention	Comparator	Outcome
(Behaviour of) Keepers of livestock susceptible to specified diseases. During “peacetime” and “outbreaks.	Compensation for culled livestock, paid: In full (public)	Before and after policy change within county	(Change in) ex ante biosecurity behaviours
	In part (public-private cost-sharing) Via insurance	Cross-country policy comparison Different farm contexts (e.g. norms, networks, attitudes)	(Change in) ex post disease reporting (Change in) total disease cost and incidence

Table 3. Elements of the search strings.

String 1	String 2	String 3	String 4
Livestock disease	Compensat*	Attitud*	Compliance
Livestock cull*	Cost*shar*	Motiv*	Report*
Disease *	[Co*finance*]	Perce*	Biosecurity
Farm*	Levy	Advice	Cull*
Equine	Insurance	Trust	Risk Management
FMD, AI, Swine Fever, Aujeszky's	Incentive	Network	Behave*
	Governance	Community	
	Penalty	Social	

(* as a wildcard for different word endings). The search strings were combined using the Boolean OR operator and the Boolean AND operator.