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Measuring the benefits of farm animal health

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Abstract

A methodology is described to establish the relative financial benefit of farm animal disease prevention (biosecurity). This methodology is demonstrated using the example of bovine viral diarrhoea virus (BVDV) incursion on beef suckler farms in Scotland. A random sample of 276 herds was taken and a proportion of young stock on each farm tested for previous exposure to BVDV. There was evidence that 0.4 of herds had been exposed over one year prior to sampling. All herds completed a questionnaire about their biosecurity practices. The influence of these practices on relative risk of BVDV was subjected to a Chi squared test and practices ranked accordingly. Most important risk factors were animal buying in strategy, farm size and a single farm boundary. The economic benefit/disbenefit of these strategies was assessed using a bio-economic model of a 10-year BVDV epidemic. Expected output losses due to BVDV infection and risk were affected by biosecurity strategy and by level of biosecurity threat. The implications of these findings for animal health strategy at farm and regional level are discussed.

Keywords and [JEL codes](#) Biosecurity, BVD, Economic Impact

Introduction

The Animal Health and Welfare Strategy in Great Britain (Defra et al., 2004) is based on the premise that disease prevention is better than cure and that any interventions must be based on a clear understanding of the costs and benefits concerned. These principles should apply from individual farm level right up to national and international policy making. These are good principles, but in practice it is very difficult to establish the benefits of actions intended to prevent a future outbreak of animal disease (biosecurity). Absence of the necessary understanding has led to a haphazard approach that often lacks scientific and economic rigour. Emphasis is placed on average total costs of disease, which may then be used to justify any measures thought to contribute to reducing such costs without regard to their marginal net benefit (McInerney, 1996). This may have contributed to relative disregard of biosecurity amongst cattle and sheep farmers despite high profile disease outbreaks such as the foot and mouth disease epidemics of 2001 (Patterson et al., 2003). More recent studies of stakeholder attitudes to biosecurity (Gunn et al., 2008) found that overall farmers believe that other stakeholders, such as the government, should make a greater contribution towards biosecurity within Great Britain. Conversely, veterinary practitioners saw their clients' ability or willingness to invest in biosecurity measures as a major constraint. Veterinary practitioners also felt that there was need for additional proof of efficacy and/or the potential economic benefits of proposed farm biosecurity practices better demonstrated. The authors concluded that improved decision support tools, that make the benefits of improved biosecurity more apparent, are needed for real progress to be made. This paper is a response to that conclusion.

Lack of stakeholder interest in biosecurity is likely to have very high social costs as biosecurity measures applied at farm level for private gain bring many public benefits due to the positive effects of a few biosecurity actions on a wide range of diseases (Chi et al., 2002) with possible impacts on the environment, food safety and animal welfare as well as productivity. The role of biosecurity in a wider actor network is emphasised by Donaldson et al. (2002) in the case of the 2001 foot and mouth disease epidemic in Great Britain. In view of these issues, we aimed to measure the benefits of farm animal health using the example of biosecurity measures applied by commercial beef suckler farmers in Scotland.

Methods

SAC veterinary investigation officers collected blood samples from young stock on 276 randomly selected Scottish suckler (cow-calf) herds. These samples were tested (Svanovir BVDV antibody ELISA, Svanova Biotech AB, Uppsala, Sweden) for evidence of previous exposure to the causative agent of bovine viral diarrhoea (BVD). BVD is a common endemic disease known to have high economic impact on Scottish livestock farms (Stott et al., 2003) and abroad. We therefore used absence of BVD virus (BVDV) antibodies as a marker of relative benefit of alternative biosecurity measures. Managers of the farms where blood sampling took place were asked to complete a questionnaire relating to actions and circumstances that affect biosecurity. The questionnaire yielded 30 biosecurity related variables such as grazing land enclosed within a single boundary. In addition compound biosecurity variables were made up of combinations of questions from the survey instrument. These were

devised by epidemiologists using their judgement about the most appropriate sets of biosecurity actions.

The impact of the most promising biosecurity actions on the risk of BVDV incursion (IR) was estimated by comparing the presence and absence of such factors on the exposed and unexposed farms. The effect of risk factors was quantified in a manner where values greater than one indicate a positive association between control measure and seroconversion and values less than one indicate a negative association between the two (see Thrusfield 2007 for details of alternative methods to assess the association between risk factors and presence or absence of a condition). For example, the IR for a 'HighRisk' cattle buying strategy (see definition below) was 1.45. The two estimates of IR for a biosecurity action (with or without that action) were used as input parameters in the BVD model in beef suckler herds by Gunn et al. (2004). The BVD model was therefore run at standard parameters as set out by Stott and Gunn (2008) or with the same parameters except for risk of biosecurity breakdown which was increased by a factor of 1.45 to represent a farm using a high risk buying in strategy. Using the methods explained by Stott and Gunn (2008) it was therefore possible to compare the financial losses attributable to BVD by simulation of two farms that are epidemiologically and economically identical except for the use/non-use of high risk buying in strategies. The financial performance difference between these farms therefore gives an estimate of the output losses that may be saved under particular farming circumstances by moving from a high risk to a more biosecure buying in strategy. The model thus provided a means to systematically explore the relative financial benefit of various effective biosecurity strategies under a range of circumstances. As the model of Gunn et al. (2004) is stochastic, the variance as well as the mean output losses due to BVD can be estimated by using multiple runs of the model (in our examples we chose 100 runs per mean value). By varying the baseline parameter associated with a biosecurity action and hence the benchmark mean and variance of BVD output losses it was possible to explore the relationship between average cost of BVD and its variance (risk).

Results

Table 1 shows part of the hierarchy of biosecurity actions including all actions where there was a statistically significant difference in BVDV prevalence between herds with and without a biosecurity action. Farm class (size) showed that the smallest quartile (24 to 98 animals) had much lower prevalence (0.14) than other size classes (0.44 to 0.52), (Q2:99-163, Q3:164-249, Q4: 250-1905 animals). It is interesting to note that one third of farmers who thought that their cattle were not affected by BVDV infection subsequently returned a positive antibody test. Figure 1 shows the IR values involved and depicts a significant positive interaction observed between smallest farm size quartile and existence of a single farm boundary.

The overall prevalence of herds with antibodies to BVDV was 0.4. It was estimated that approximately 0.5 of these would contain at least one persistently infected individual (PI, Houe, 1999) i.e. 0.2 of herds would be experiencing an active BVDV infection. (Although presence of the virus (antigen) was not confirmed, herds with PIs can be identified due to the high within herd prevalence and hence the prevalence of herds with at least one PI can be estimated). This level of prevalence was considerably lower than the estimates of 0.95 antibody-positive and 0.5 antigen-

positive herds on which the recent costs of BVD in Scottish suckler herds by Stott and Gunn (2008) was based.

Figure 2 shows the benefit of avoiding a 'high risk' buying in strategy under different levels of risk of BVDV incursion. All benefits were significantly different from zero ($p < 0.05$) except for herds of unknown BVD status at the start of the simulation when the probability of incursion was 0.5. For a herd of unknown BVD status under the assumption of 0.95 prevalence, no benefits were significantly different from zero except at an incursion probability of 0.2 where the benefit was £3.4/cow/year (+/- 1.42) ($p < 0.05$).

The benefits of small herd size coupled with a single farm boundary are shown in Figure 3. All benefits were significantly different from zero ($p < 0.001$) except for herds starting with unknown BVDV status where regional herd prevalence is 0.95. Benefits then were more variable and not significantly different from zero ($p > 0.05$) at probabilities of incursion of 0.3 and 0.7.

The mean annualised output losses (costs) due to BVD in a herd using a high risk buying in strategy (worst case scenario) are shown in Figure 4. Those for a small farm with single boundary (best case scenario) are shown in Figure 5. In both scenarios, costs tended to rise at the rate of about £2.50/cow/year per 0.1 increase in the risk of biosecurity breakdown. However, costs in the worst case scenario were about twice those in the best case scenario. Initial disease status had relatively little effect on costs except for high risk buying in strategy when the initial status is unknown but regional prevalence is high (0.95). In that instance the increase in costs was only about £1.10/cow/year per 0.1 increase in the risk of biosecurity breakdown.

Figure 6 shows the relationship between the standard deviation of output losses and the probability of biosecurity breakdown. The variability in output losses tended to decrease with increasing risk of biosecurity breakdown. This was more pronounced when the herd was initially free of BVD at the start of the epidemic.

Discussion

Relatively few biosecurity actions yielded a significant reduction in the probability of observing BVDV antibody positive animals on study farms. This may in part reflect the difficulties of collecting information about biosecurity practices. For example, conformance to a task as described in a questionnaire may be less important for biosecurity than the diligence with which the task is undertaken. The importance of small farm size may be partly explained by the relative ease with which a range of biosecurity actions may be carried out on small farms. Another problem is that once farmers become aware of a disease problem they are more likely to adopt good biosecurity practices in an effort to mitigate the effects of the disease. The similar IR associated with ignorance of BVD status compared to the knowledge of its presence lends some weight to this argument. More importantly, this result demonstrates the occult nature of BVDV that makes it difficult to deal with and to convince farmers of the need for good biosecurity practice.

Our results demonstrate that avoiding purchase of stock from high risk sources was an important biosecurity practice worth up to about 0.3 of the output losses from the

disease (Figures 2 and 4). The dependence of this benefit on a good general standard of biosecurity (low probability of virus incursion) and less on existing BVD status favours urging all cattle farmers to be more diligent. Evidence such as this should help to counter the generally negative attitudes of farmers towards biosecurity and the scepticism of vets reported by Gunn et al. (2008). Of course the benefits reported here are offset by the biosecurity costs. If we assume that a benefit of £5/cow/year is achievable by avoiding high BVDV risk sources of replacements (Figures 2 and 4) and that cows in typical suckler systems are replaced after 7 years (SAC, 2008) then this generates a premium of about £35/cow that can be used to finance purchase of replacements from safe sources. This figure is a small proportion of the purchase price of an in-calf replacement heifer (£750, SAC, 2008). However, it may be an underestimate as it neglects any potential spin off benefits of safer replacement policies such as reduced risks from other diseases. A benefit of £5/cow from purchasing replacements from accredited BVDV free sources is a significant proportion of the gross margin of typical spring calving suckler cows in upland systems of about £30-35 per cow (SAC, 2008).

Small farm size and a single farm boundary produced the greatest biosecurity benefit. Although not as easy to address as buying in strategy, the single farm boundary alone gave some indication of a possible beneficial effect (Table 1) and it may be closely aligned with other boundary features. These might include double fencing, high hedges, woods etc. i.e. a farm perimeter that precludes contact with neighbouring livestock. Our results suggest that further research on the effectiveness of this aspect of biosecurity is justified.

As might be expected, the benefits of avoiding purchase of replacements from high risk sources declines if the subsequent risk of BVDV incursion is high (Figure 2) and/or regional prevalence of BVDV is high and initial herd BVDV is unknown i.e. the chance that the herd is already infected is high. This result highlights the paradox identified by Gunn et al. (2005) that where the risk of BVDV incursion/presence is high, the financial incentive to engage in good biosecurity practices is low. This suggests an economic reason for cattle farmers' failure to improve biosecurity in addition to the sociological reasons reported by Heffernan et al. (2008). These factors combine to make it difficult to instigate BVDV eradication programmes even though such programmes are likely to be effective and cost effective (Heffernan et al., 2009). In this situation, government intervention may be necessary to kick start an eradication programme. However, the benefits of small farm size and a single farm boundary seem less dependent on the over arching biosecurity provision (Figure 3) especially if national herd seroprevalence of BVDV is as reported here (0.4). This and related aspects of biosecurity could therefore be promoted equally to all farmers regardless of their BVDV status or that of the region/country.

Although mean output losses due to BVD are lowest at low probability of BVDV incursion/high biosecurity (Figure 4 and 5) the associated variability is highest (Figure 6). This is because at low probability of incursion the variety of epidemiological scenarios are more evenly represented. A greater proportion of herds will remain BVD output loss free dragging down the mean. Others may lose their PI and build up a stock of susceptible individuals causing higher losses if biosecurity is later breached. In other words, there is a trade off between risk and reward associated with investment in improved biosecurity as highlighted by Stott et al. (2003). Like the

issues raised in the previous paragraph, this factor may act as a disincentive to investment in biosecurity and hence in BVDV eradication programmes. However, our results here suggest that the effects at least on absolute SD are similar regardless of initial herd BVDV status and regional BVDV prevalence at risks of BVDV incursion below about 0.3 pa. Therefore as with small farm size and single farm boundary, the risk-benefit trade-off could be dealt with as a universal issue simplifying the knowledge exchange process associated with improving cattle health and hence raising the prospects for success.

Table 1: Sample of Chi (X) squared contingency tables showing the top ranked biosecurity actions (p<0.05 that null hypothesis/no effect is correct) identified in the BVD prevalence study comprising 276 Scottish beef suckler herds

Variable	X-squared	Df	p-value	Frequency table
Herd size	27.9	3	3.9e-06	<div>Level*</div> <div> <div>1234</div> <div>D10313238</div> <div>ND60383631</div> </div>
26**. According to herd manager, cattle are affected by BVD	9.4	2	0.009	<div>Status</div> <div> <div>DkNY</div> <div>D345027</div> <div>ND3210528</div> </div>
18. Farm keeps finisher animals	5.8	1	0.016	<div>Status</div> <div> <div>NY</div> <div>D4467</div> <div>ND9073</div> </div>
HighRisk*** purchase practice	5.6	1	0.019	<div>Status</div> <div> <div>NY</div> <div>D4566</div> <div>ND9273</div> </div>
Purchase from mart or other high risk source	4.4	1	0.037	<div>Status</div> <div> <div>NY</div> <div>D3081</div> <div>ND6699</div> </div>
Biosecurity level for purchase practice	9.8	Na	0.042	<div>Level</div> <div> <div>01234</div> <div>D49381950</div> <div>ND47664174</div> </div>
14. Single farm boundary	3.3	1	0.068	<div>Status</div> <div> <div>NY</div> <div>D5952</div> <div>ND6897</div> </div>

*D=BVDV antibody positive herds, ND= BVDV antibody negative herds, , N=action not applied, Y=action applied, Dk=Don't know. For other classifications see definition of compound biosecurity variables given above.

**Variable names preceded by a number indicates the related question number in the survey instrument. Otherwise the action is a compound variable as explained in the methods section above.

*****HighRisk** is a variable which defines how risky the farms buying in strategy is, certain types of cattle are known to be more risky than others (for example in calf heifers/cows and newborn calves are known to be risky). If farmers bought from the risky categories then HighRisk=Yes.

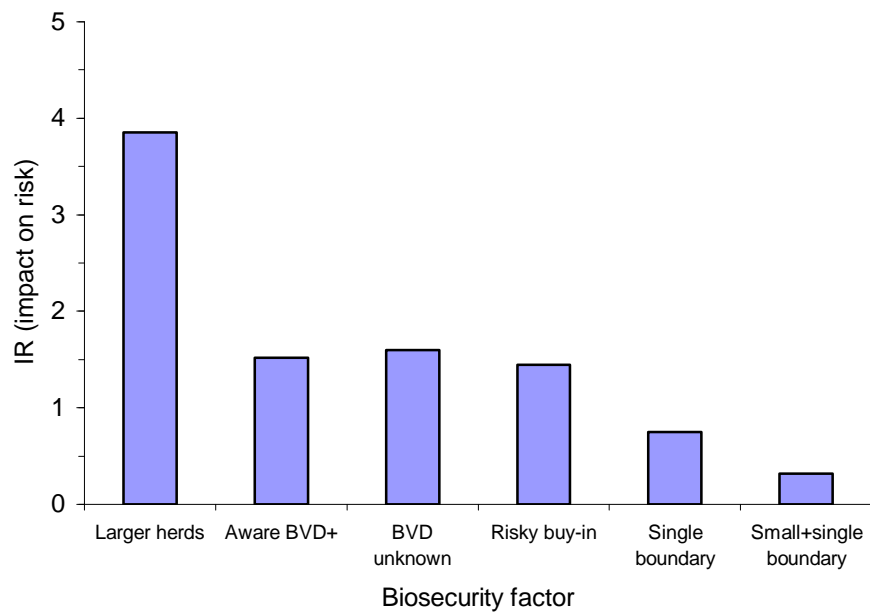


Figure 1: Effect of biosecurity factors on BVDV exposure (IR, value=1.0 suggests no association) (Table 1)

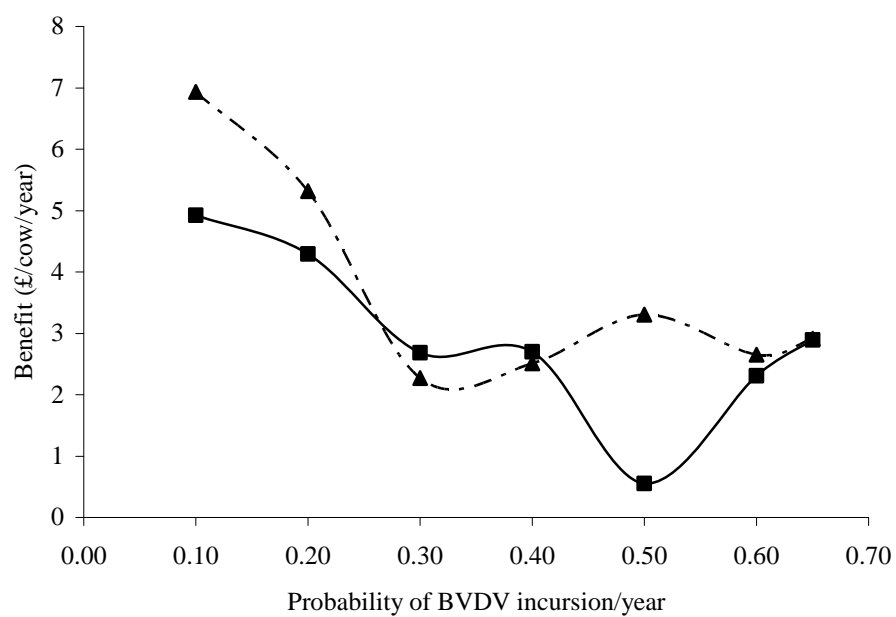


Figure 2: Annual benefit of not using a 'high risk' cattle buying in strategy over a 10-year period of simulated exposure to risk of BVDV incursion for herds free of BVDV at the start of simulation (hatched line) or of unknown BVD status (solid line)

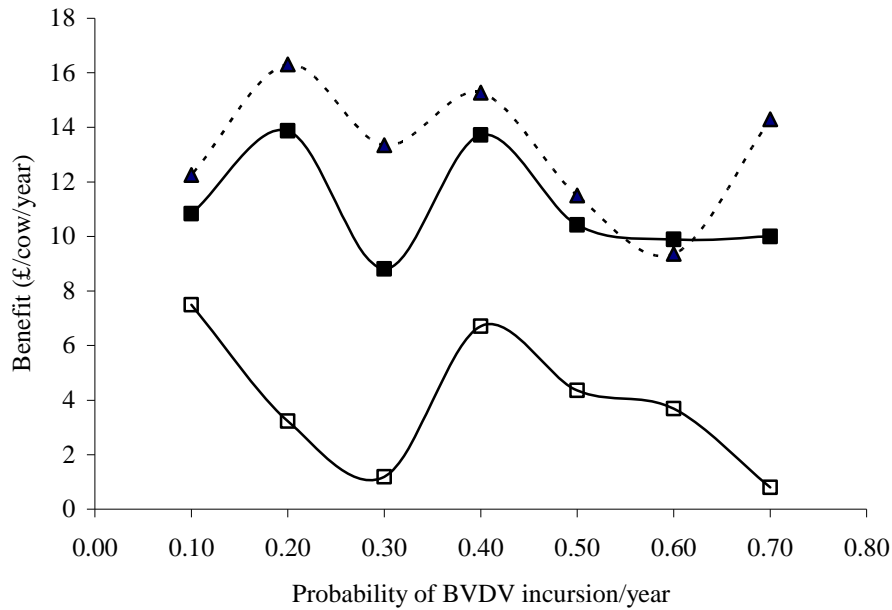


Figure 3: Annual benefit of smallest farm size quartile and a single farm boundary over a 10-year period of simulated exposure to risk of BVDV incursion for herds free of BVDV at the start of simulation (hatched line) or of unknown BVD status (solid line, closed symbols). The solid line with open symbols represents a herd of unknown BVD status where regional herd prevalence of BVDV is 0.95.

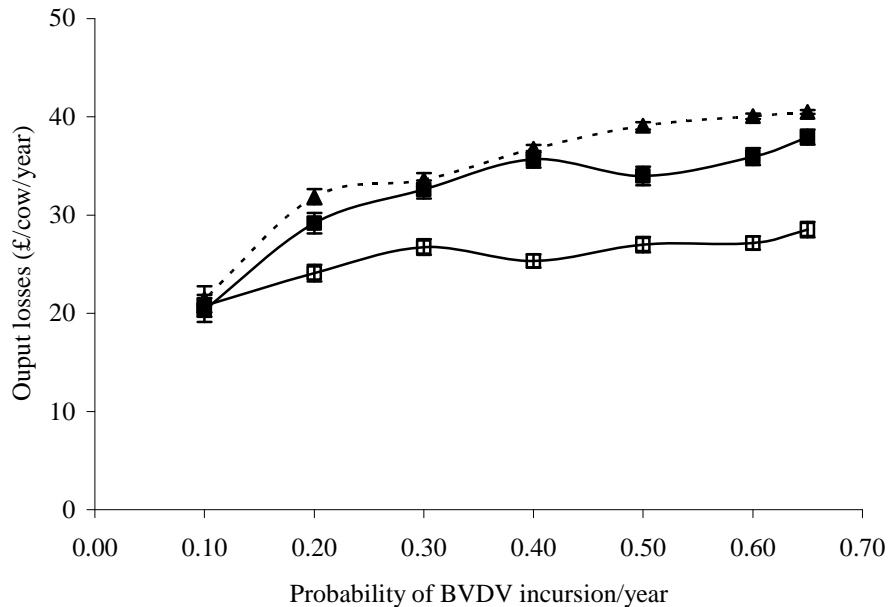


Figure 4: Annualised cost (mean output losses with SEM) due to BVDV for herds using a 'high risk' cattle buying in strategy for herds free of BVDV at the start of simulation (hatched line) or of unknown BVD status (solid line, closed symbols). The solid line with open symbols represents a herd of unknown BVD status where regional herd prevalence of BVDV is 0.95.

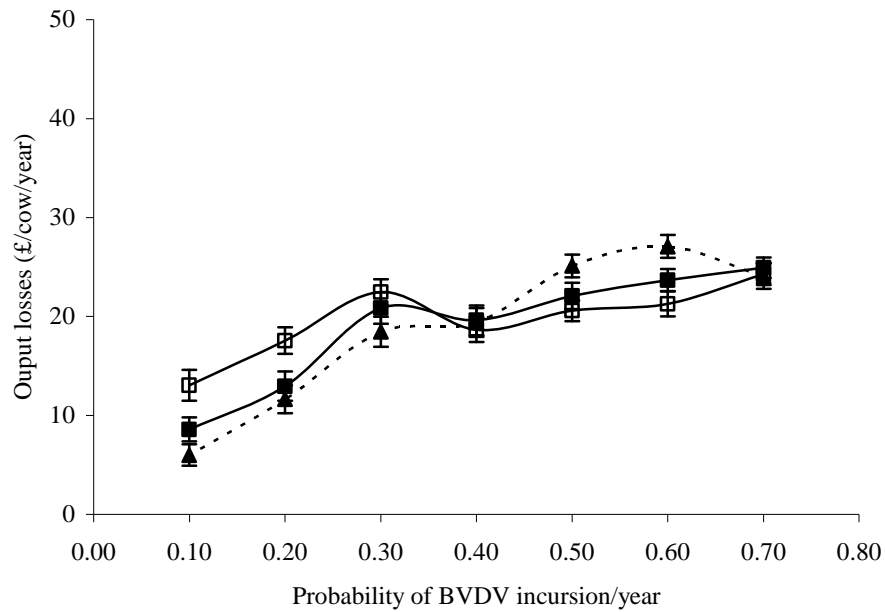


Figure 5: Annualised cost (mean output losses with SEM) due to BVDV for small herds with a single boundary. Herds free of BVDV at the start of simulation are shown with a hatched line, those of unknown BVD status with a solid line and closed symbols. The solid line with open symbols represents a herd of unknown BVD status where regional herd prevalence of BVDV is 0.95.

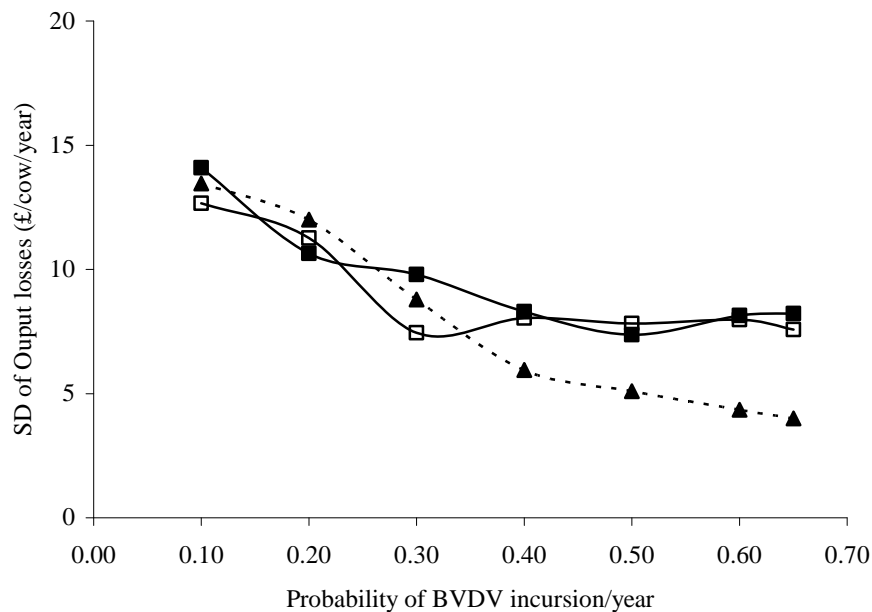


Figure 6: Standard deviation (SD) of annualised cost (output losses) due to BVDV for an average herd size (50 cows) without specific biosecurity factors. Herds free of BVDV at the start of simulation are shown with a hatched line, those of unknown BVD status with a solid line and closed symbols. The solid line with open symbols represents a herd of unknown BVD status where regional herd prevalence of BVDV is 0.95.

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