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**Incentive Systems under ex post Moral Hazard to Control Outbreaks of
Classical Swine Fever in the Netherlands**

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Incentive Systems under ex post Moral Hazard to Control Outbreaks of Classical Swine Fever in the Netherlands

Previous experience in coping with outbreaks of epidemic animal diseases has shown that such diseases pose a true threat for regional and national economies as well as for an individual farmer and for related industries in the chain. In recent years, besides causing potentially high losses, combating outbreaks of highly contagious diseases raises social-ethical issues related to the mass slaughter of animals when controlling an outbreak. Yet animal welfare merits a more prominent position in the discussion regarding animal health. Added to this, there is growing concern about the potential impact of certain animal diseases (such as avian influenza) on human health and the possibility of a new pandemic. A proposal for a new European Community Animal Health Policy Strategy to improve the prevention and control of animal diseases was therefore announced in 2004, culminating in a Commission Communication in 2007 setting out actions for 2007-2013 (European Commission 2004). Among other new initiatives, one of the important suggestions to this strategy is to recognize an essential role of behaviour on the part of livestock farmers and other participants in the chain (such as failure to comply with preventive and control measures or unwillingness to notify authorities) while combating animal diseases (Dutch Ministry of Agriculture, Nature and Food Quality 2006).

Numerous epidemiological and economic studies have been carried out to support decision making with respect to prevention and control of animal disease epidemics. Hennessy, Roosen, and Jensen indicated that while useful in forecasting the spread of disease, analyzing direct impacts of diseases and the effectiveness of different preventive and control strategies, with few exceptions (Bicknell, Wilen, and Howitt 1999; Kuchler and Hamm 2000), the previous studies have not directly recognized the role of adequate incentives in promoting private decisions to reduce divergence between private and public consequences of a farm's actions in combating animal diseases.

Recent economic studies more often emphasize the public good aspects and externalities associated with prevention and control of contagious animal diseases (Grannis and Bruch 2006; Ott 2006).

The potentially large influence on the course of epidemic is pointed out to externalities referring to the farmers' decisions on implementation and maintenance of preventive measures, early disclosure of a disease outbreak or a suspected problem, compliance with movement still control strategy and no deliberate infection during an epidemic (Meuwissen et al. 2006). Obvious incentives would exist for farmers to manage epidemics in a proper way because potential losses caused by an outbreak are high. In reality, farmers might pursue own interest and not always contribute to an adequate prevention and control policy. While making decisions both prior to an outbreak (*ex ante*) and following an outbreak (*ex post*) farmers will almost always know more about their risk exposure than the government. The presence of such information asymmetry leads to different contexts of moral hazard problem. Verifying that farmer behaviour is consistent with policy objective is very costly given the number of farms. Thus, structuring incentives so that a farmer's actions are consistent both with their individual objectives and those of policy-makers should be paramount while dealing with the externalities to design animal health policy (Gramig et al. 2006).

The current paper focuses on incentives systems under *ex post* case of moral hazard problem of early disclosure. This is when the farmer already possesses private information on the disease status or a suspected problem and makes the unobserved choices whether to report it (Graming et al. 2005). Depending on the design of the indemnity payments and the magnitude of regulatory costs of disclosure, the farmer may have an incentive to withhold the information on possibly infected animals if he expects to be worse off after disclosure. The situation when the profits from disclosing are less than profits from not disclosing forms the essence of principal-agent problem between the regulator and the farmer and highlights the conflicting incentives in their relationship. Specifically, farmers may either wait, hoping that their suspicion is false, or to ship the animals to market. In the case of true disease, either way the whole sector can be influenced negatively. If the animals are diseased and are shipped to market, the disease could be easily spread to other animals. Even if the diseased animals are not shipped to market, the disease can still be spread through feed suppliers and other inter-farm traffic (Ott 2006). Meanwhile,

timely government response in terms of implementing control strategies to limit the spread of epidemic and eradicate it is delayed.

Early disclosure defines the time between disease introduction and detection of the first case, the so-called high-risk period (HRP) (Horst et al. 1999). During this period disease circulates freely that can result in infection of other herds. So, early disclosure also indirectly affects the number of infected herds present on a day of first detection (IHD). Both HRP and IHD are important determinants of the magnitude and financial consequences of an epidemic, and they cannot be influenced during an epidemic. Thus, the key government objective is to keep the IHD as small as possible by shortening the HRP by means of timely disclosure.¹

Note that epidemic disease will not disappear by itself. Sooner or later it will be detected no matter whether farmers timely report it. However, the HRP shortening in the first place depends largely on the alertness, skills and motivation of farmers who since decades have already been reported to be the most important sources of detection outbreaks (Elbers et al. 1999).²

For these reasons, an incentive structure that results in timely disclosure is of great interest for policy makers. Incentive effectiveness however will depend on how well farmers' behaviour is understood.

Few recent studies presented theoretical principal-agent models that explore incentives compatibility for timely disease disclosure (Graming, Horan and Wolf 2005; Jin and McCarl 2006). These models suggested that incentive design based on the level of disease prevalence and the level of preventive investment would induce truthfully disclose of infected herds. These studies, however, assumed that the farmer knows the true disease prevalence in his herd. But in reality not all animal

¹ The last classical swine fever (CSF) epidemic 1997-1998 in the Netherlands: it was estimated that CSF virus had probably been present for 5-7 weeks in the country before the first herd was detected. Because of the lack of awareness of the presence of the virus during this period, neither was the movement of pigs restricted, nor were specific actions taken for rapid diagnosis of infected herds. This resulted in the large number of infected herds (about 39) before specific control measures came into force that severely changed the effectiveness of the eradication campaign (Stegeman et al. 2000).

² The last CSF epidemic 1997-1998 in the Netherlands: in 322 out of 429 outbreaks (75%), detection was based on clinical signs observed: 32% was detected by the farmer, 25% by the veterinary practitioner, 10% of the outbreaks by tracing teams and 8% by screening teams of the veterinary authorities. In 76% of the outbreaks detected by clinical signs, the farmer reported to have seen clinical symptoms for less than 1 week before diagnosis, in 22% for 1-4 weeks before diagnosis, and in 4 herds (1%) the farmer reported to have seen clinical symptoms for more than 4 weeks before diagnosis (Elbers et al. 1999).

diseases have obvious clinical signs. This means farmers often do not possess exact information on the true disease status. For instance, in cattle and pigs the signs of foot-and-mouth disease (FMD) are usually readily seen, whereas sheep do not always show obvious FMD clinical signs. The clinical picture of classical swine fever (CSF) is not always characterized by a febrile disease with typical clinical signs and high morbidity and mortality (Elbers et al. 1999).³ Also, the previous models ignored animal disease dynamics, which determines the economic consequences of an outbreak; in particular, in the case of highly contagious disease (see HRP and IHD above). Furthermore, for officially FMD or CSF-free countries that do not practice vaccination (World Organization for Animal Health 2006) an epidemic starts when virus is introduced into the animal production sector of the country. This implies that it does not make sense to aim a certain prevalence level of such diseases. The country must simply maintain the disease-free status as any single reported true case would be comparable to a prevalence level of 100%.

In this paper, we argue that the nature of animal disease (e.g. highly contagious or infectious disease, the length of the incubation period, how obvious clinical signs are) matters greatly while designing incentive structure for early disclosure of contagious disease. A more complete analysis of farmer's decision to timely report a disease outbreak or a suspicious case is needed. This study proposes a more realistic approach to tackle the problem of farmers' motivation to disclose of a disease. A simple conceptual stochastic dynamic programming model is used to better understand and optimize the individual farmer decision of a timely disease reporting, given certain incentive parameters defined by a regulator. An empirical study is performed in the context of CSF, a highly contagious disease without obvious clinical signs, in the Netherlands. The model allows us to investigate which disease parameters and economic incentive parameters are essential and how they influence farmers' decision on early disclosure. After providing basic results, the article discusses their implications and the further model improvement and including of principal-agent relationship in the model.

³ The last CSF epidemic 1997-1998 in the Netherlands: when there were clinical signs, the observed symptoms in infected herds were mainly atypical: fever, apathy, ataxia or a combination of these signs (Elbers et al. 1999).

Incentives for Early Disclosure of CSF in the Netherlands

CSF is a highly contagious viral disease of pigs. Under natural conditions the most frequent route by which the CSF virus enters its host is oronasal (i.e., relating to the mouth and nose) with an incubation period of 7-10 days, which is the time between infection and the start of disease symptoms (Dahle and Liess 1992). CSF is classified by the World Organization for Animal Health as List A disease, which implies compulsory notification.⁴ The Netherlands is free of CSF and introduction of the disease into the country can cause a huge epidemic resulting in dramatic economic losses (Meuwissen et al. 1999; Mangen and Burrell 2003).

There is a legal obligation to report suspicious cases to the authorities. The Dutch Law for Animal Health and Welfare defines that if an animal shows symptoms of contagious disease this must be reported to the government authority, Center for Animal Disease Reporting of the Dutch Food and Consumer Product Safety Authority. However, the actual reporting rate is rather low (3-4 suspicious cases per year), whereas CSF clinical symptoms (e.g., fever or loss of appetite) are more often observed in pigs with other considered animal disease such as flue (Dutch Food and Consumer Product Safety Authority 2003).

Current Dutch surveillance programs that aim at early detection of CSF also mainly rely on the visual recognition of CSF clinical signs. At present, Dutch Animal Health Service has the following 5 surveillance programs in place: (1) routine gross pathology of severely diseased pigs (pathology), (2) routine virological tests of tonsils of all pigs submitted under routine gross pathology (tonsil); (3) daily clinical observation by the farmer (farmer); (4) periodic (4-weekly) clinical inspection by a veterinarian (inspection); and (5) leucocyte counts in blood samples from diseased animals on a herd where antimicrobial “group therapy” is started (leucocyte) (Klinkenberg et al. 2005). Actual participation in surveillance programs (tonsil and leucocyte) is estimated to be alarmingly low, i.e. less than 0.1% of the cases obliged for regular reporting (Dutch Food and Consumer Product Safety Authority 2003).

⁴ List A: includes transmissible diseases which have the potential for very serious and rapid spread, irrespective of national borders, which are of serious socio-economic or public health consequence and which are of major importance in the international trade of animals and animal products. Note that CSF does not pose a risk for public health.

It should be noted that in an attempt to create incentives for early disclosure, the Netherlands has instituted compensation programs that in case of epidemic no longer pay producers for dead animals and only partial compensation is given for diseased animals (Horst et al. 1999). The motivation is that once the animal is dead, too much time has past to compensate farmers.

According to Kuchler and Hamm, an indemnity program that is working will show the number of reports, approaching zero. But the fall has to be the result of increasing difficulty in finding suspicious cases rather than in a lack of incentive to look (Kuchler and Hamm 2000). In this sense, the above information indicates that the incentives for early disclosure do not appear to be compatible as they currently stand in the Netherlands. Extra testing and quarantine costs (farm has to be closed while awaiting test results) borne by the farmer while reporting a suspected case, irrespective of whether this is a true or false case are considered to be the main hindrance to early disclosure (Dutch Food and Consumer Product Safety Authority 2003; Dutch Ministry of Agriculture, Nature and Food Quality 2006).

One way to encourage farmers to act positively on their suspicion of CSF is to offer compensation for extra losses associated with the detection of actual disease status. Also, when the farmer knows that in case of an outbreak, he will be compensated for test-positive animals, then he will more likely contact a veterinarian or animal health official when he suspects disease. On the other hand, an efficient incentive system should consider payments that prevent farmers from over-reporting (or in the worst case, infecting animals themselves during an epidemic in order to get a payment).

Farmers should, however, also have their own incentive to timely report suspicious animals. Despite some extra testing and quarantine costs related to outbreak detection, an individual farmer faces a smaller consequential loss when the outbreak is earlier discovered on his farm. This is a kind of indirect incentive. No disclosure or even hiding sick animals will cause a wider disease spread and, thus, increases the consequential losses for each individual farmer affected by an outbreak. After depopulation the detected farm remains empty until restocking is permitted. The longer the epidemics the longer it takes before farmers can repopulate and operate their farm again.

Model for the Farmer's Problem

Under different scenarios with a range of various incentive system parameters, the discrete dynamic programming model developed in this study identifies optimal time for the farmer to report CSF.

This study considers a single average Dutch, farmer (profit-maximizer) with a herd of 2000 fattening pigs showing certain degrees of CSF clinical signs. Our basic assumption is that the farmer implements all the necessary biosecurity measures to prevent CSF outbreak. Basically, this assumption implies that there is no ex ante moral hazard problem considered in this paper.

The farmer aims at maximizing his expected profits and he should decide whether or not disclosure CSF. As explained above, clinical signs of CSF are not easily observable. Following Klinkenberg et al., the three disease degrees of showing clinical signs were defined:

- non-specific disease: if any clinical symptoms (such as fever, dullness, diarrhea, or loss of appetite) are observed;
- specific disease: if some CSF-specific symptoms (conjunctivitis, skin haemorrhages, cyanotic ears, or lameness) were observed;
- severe disease: if the animal died, or if the highest recorded body temperature was $\geq 41^{\circ}\text{C}$, combined with at least four reported (CSF specific or non-specific) symptoms.

The farmer is assumed to be the final decision-maker in his choice to report the disease status to the government in a timely manner. In real life, veterinarians or other advisors can also be involved in control of animal health status and, therefore, influence the farmer's decision. In the case of disclosure, a farmer will face extra costs (regulatory testing costs and other losses such as costs associated with isolating the farm while awaiting the tests outcomes). These costs are supposed to minimize the risk of extreme cost of CSF epidemics.

The farmer is assumed to be risk averse. Preferences are represented by a constant absolute risk aversion (CARA) utility function (Hardaker et al. 2004). Each time period t (stage), a farmer observes health (expressed by showing degrees of CSF clinical signs: no clinical signs, non-specific disease, specific disease, severe disease) of his pigs S (state), takes an action x_t (decision on CSF disclosure or not),

and gets returns that depends on both the state of the system and the action taken $f(x_t, S_t)$. The farmer seeks a sequence of report - not report decisions that prescribe the action that should be taken in any given state and time period so as to maximize the farmer's net profits over a time horizon T .

It is assumed that a CSF epidemic is started in disease-free zone. In particular, CSF virus is introduced into the farm, though a farmer does not know this for sure ($T = 1$, after incubation period is finished). Time t measured in days of the HRP, 2 days are considered as 1 time period in this study. The farmer faces no decisions after the terminal decision period T , which is defined as the end of HRP and equal to 10 in this study ($T = 10$, which is 20 days).

The next period's state is not known with certainty. The next state of the system depends on the current state, the current stage, the action (decision on CSF disclosure or not). As for the clinical signs disease development data, field data (i.e. from the previous outbreak) could not be used because infection times of individual animals were not known. Therefore, the data were derived from successful experimental infections with the CSF virus strain of the Dutch CSF epidemic (unpublished data) in which the clinical signs were observed closely (Klinkenberg et al. 2005). Based on the experimental data, the following transition probability matrix was obtained (for instance, the transition probability of the herd going from state 0 to state 1 at a certain time period is 88%):

<i>State</i>	<i>no clinical signs</i>	<i>non-specific disease</i>	<i>specific disease</i>	<i>severe disease</i>
	0	1	2	3
0	0.12	0.88	0	0
1	0	0.44	0.42	0.14
2	0	0	0.20	0.80
3	0	0	0	1.00

This study assumes that the farmer does not know the true value of any visual suspect of the observed degree of clinical disease. Probabilities of CSF exposure perceived by the farmer while observing a certain degree of showing CSF clinical signs are used in this study. These probabilities were estimated by experts as 0.2, 0.5 and 0.7 while observing “non-specific disease”, “specific disease” and “severe disease”, respectively.

The current expected return per farm in the time period t , $f(x_t, S_t)$, under certain incentive system parameters is defined by the following expression:

$$f(x_t, S_t) = -\alpha_3 (TestingCost(x_t) - QuarantineCost(x_t)) - DirectCost(x_t) - IndirectCost(x_t) + \alpha_1 CompensationD1(x_t) + \alpha_2 CompensationD2(x_t)$$

where D1 and D2 is the number of diseased and dead animals, α_1 is the share of the full compensation paid by the government for diseased animals, α_2 is the share of the full compensation paid by the government for dead animals, α_3 is the share of the CSF testing and farm quarantine costs paid by the farmer.

The risk-averse farmer's dynamic programming problem can be formally stated as

$$\max_{\{x_t\}_{t=0}^T} E \left[\sum_{t=0}^T \delta^t (-e^{-\lambda f(x_t, S_t)}) \right]$$

where E is the expectations operator, δ is a daily discount factor and λ is the farmer's constant level of absolute risk aversion. In this paper, λ is assumed to be 0.01, which reflects a moderate risk-averse farmer (Hardaker et al., 2004).

Results and Discussion

Basic results of the developed simple (conceptual) stochastic dynamic programming model show the effect of using different incentive system designs on the farmer's decision to report CSF earlier, given that the farmer observes a certain degree of clinical signs in the herd. Under different incentive system designs, the model defines the earliest period when it is optimal for the farmer to disclosure the disease. To gain more insight into major model characteristics, a sensitivity analysis was carried out.

Optimal Farm Plans of Early Disclosure

Figure 1 shows results of the farmer's optimal policy of reporting CSF scenario for planning horizon of 10 periods ($T = 10$), under the baseline scenario. The baseline scenario was defined as the situation when no extra incentives were applied, compared to the current Dutch compensation policy. That is no compensation for dead animals and only 50% compensation for diseased animals is given, and no

compensation for regulatory costs (testing costs and farm quarantine costs) associated with disease disclosure is provided.

The optimal reporting policy for the basic farm resulted in a decision of the earliest CSF disclosure in the period 7 (i.e., day 14) while observing the ‘specific disease’ degree of CSF clinical signs (table 1). The certainty equivalent gain for the farmer to report in this period is €6.39 per pig. Note that the current simple model does not provide yet steady-state probabilities that the herd will be in each state, i.e., showing certain degrees of CSF clinical signs. In this sense, higher certainty equivalent gains after the period 7 should not be interpreted as optimal policy of waiting and reporting in the latest possible periods. Given the transition probability matrix, the herd most likely will move to the next state, i.e., ‘severe disease’ degree of showing CSF clinical signs, and reporting in this state will be more expensive for the farmer.

Table 1 illustrates how changes in incentive system parameter influence the farmer’s decision on early CSF disclosure. Specifically, changes in parameters α_2 and α_3 , which are share of the full compensation paid by the government for dead animals and share of the CSF testing and farm quarantine costs paid by the farmer, respectively, were analysed. The model was run under scenarios with a range of various parameter settings. The obtained results show that applying penalties for dead animals and providing extra compensation of testing and farm quarantine costs indicate that certain designs of incentive systems may improve the farmer’s deciding behaviour to report CSF earlier while observing certain degrees of the disease clinical signs. However, this would involve rather substantial changes in incentive system design, providing only partly compensation for regulatory costs (testing and farm quarantine costs) associated with the detection whether a suspicious case is the true case would not be enough. For example, to motivate the farmer to report CSF 1 and 2 periods earlier than in the baseline scenario (7th period), introducing of €10 and €40 penalty per dead pig (which are equivalent to -0.1 and -0.4 share of full compensation for dead animals) or providing 20- and 35-time extra compensation of testing and quarantine costs, respectively, will be needed (table 1).

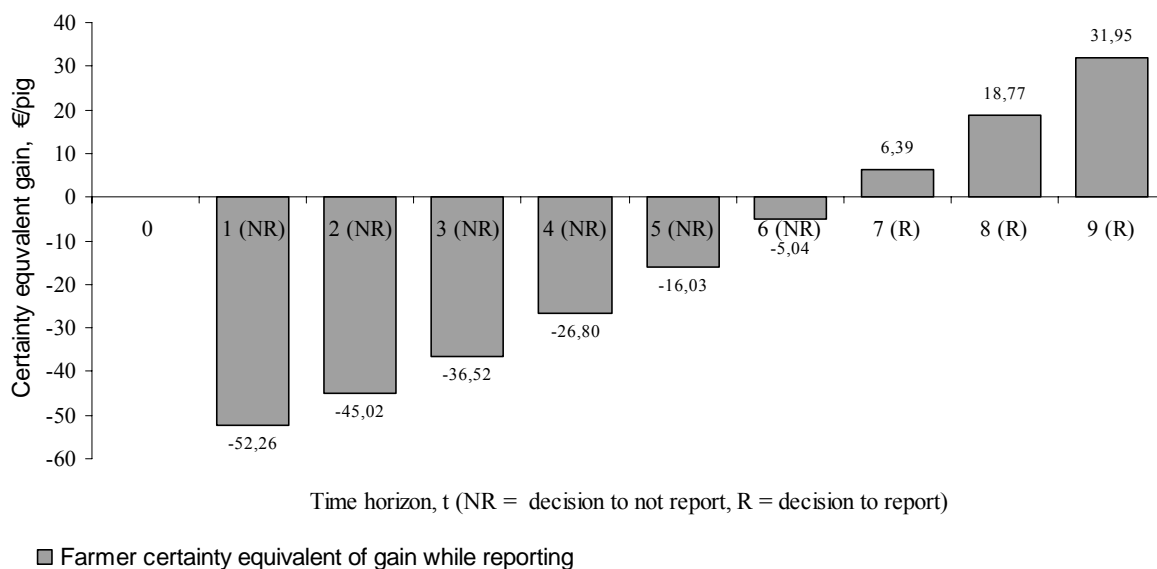


Figure 1. Optimal Farm Plan of Early Disclosure while Observing Specific CSF Clinical Signs ($\lambda=0.01$)

Sensitivity Analysis

Sensitivity analysis was conducted to determine how robust the results of the baseline scenario with respect to the farmer perception of probability of not false alarm decision to report CSF while observing certain degrees of showing CSF clinical signs in the herd. The baseline scenario, presented above, uses expert values of these probabilities, specifically 0.2, 0.5 and 0.7 while observing the degrees of clinical signs ‘non-specific disease’, ‘specific disease’ and ‘severe disease’, respectively.

Table 2 shows the effect of changing probabilities of CSF risk exposure perceived by the farmer while observing the ‘specific disease’ and ‘severe disease’ degrees of CSF clinical signs, i.e., 6 and 4 scenarios of increased and decreased in steps of 0.1 probabilities, respectively. The examined scenarios indicate that the higher the perceived probability of CSF risk exposure the earlier reporting period is and visa versa, compared to the baseline scenario. For example, the probabilities of 0.2, 0.5 and 0.8 while

Table 1. Optimal Farm Plan of Early Disclosure while Observing Specific CSF Clinical Signs Under Different Incentive System Parameters ($\lambda=0.01$)

	Baseline Scenario		Scenarios by Changing α_2					Scenarios by Changing α_3			Scenarios by Changing α_2 and α_3	
Incentive system parameters:												
α_1 – share of the full compensation paid by the government for diseased animals	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
α_2 – share of the full compensation paid by the government for dead animals ¹	0.0	0.5	-0.1	-0.4	-0.6	-0.8	-1.0	0.0	0.0	0.0	-0.2	-0.2
α_3 – share of the CSF testing and farm quarantine costs paid by the farmer ²	1	1	1	1	1	1	1	-20	-35	-40	-35	-35
Optimal time period to report	7	9	6	5	4	3	2	6	5	4	4	4

¹ In this study, market value of a fattening pig is €100.

² In this study, testing and farm quarantine costs are € 3000.

Table 2. Sensitivity Analysis of the Baseline Scenario with Respect to Farmer Perception of CSF Risk Exposure while Observing Certain Degrees of Showing CSF Clinical Signs in the Herd

	Baseline Scenario		Sensitivity Analysis Scenarios										
Probability of CSF risk exposure while observing S_1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Probability of CSF risk exposure while observing S_2	0.5	0.3	0.4	0.6	0.7	0.8	0.9	0.5	0.5	0.5	0.5	0.5	0.5
Probability of CSF risk exposure while observing S_3	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.5	0.6	0.8	0.9	0.9	0.9
Optimal time period to report	7	9	8	6	6	5	4	8	8	5	1	1	1

S_1 = non-specific disease

S_2 = specific disease

S_3 = severe disease

observing the degrees of clinical signs ‘non-specific disease’, ‘specific disease’ and ‘severe disease’, respectively, result a decision of CSF disclosure in the period 5 result, which is 2 periods earlier than optimal period in the baseline scenario.

The sensitivity analysis shows that results of this study are sensitive to changes in probabilities of CSF risk exposure perceived by the farmer while observing a certain degree of showing CSF clinical signs (table 2). This indicates that this parameter is rather critical for the model and accurate elicitation of such parameters is essential. At the same time, these results imply that the surer farmer is about the actual occurrence of CSF in case of observing ‘specific disease’ or ‘severe disease’, the earlier he would report CSF himself, without any extra incentive. In this sense, developing of simple diagnosis tools (e.g. cheap farm-level tests) to support the farmer’s judgment about actual CSF danger would help to assure the early CSF disclosure.

Also, Hennessy, Roosen, and Jensen point to the fact that incentives under any government control program will, in addition to program parameters, depend on the quality of any disease detection tests. In order to better understand the benefits of public veterinary disease management programs, a study of how test quality can affect farm incentives to protect against disease and farm investment decisions should be of interest.

Final Remarks

The current (conceptual) stochastic dynamic programming model shows clearly possibilities of using incentives to influence farmers’ decision on early CSF disclosure. To influence the farmer’s optimal decision-making to report earlier, rather significant changes in incentive systems are needed. The model also shows the importance of the farmer’s perception of CSF risk exposure while observing different degrees of CSF clinical signs.

Currently, the model is further developed into directions, i.e., to better model the farmer efforts, and to include the principal-agent approach. Both directions are explained briefly below.

Effort of the Farmer

The current model assumes that the farmer observes the health status of his animals each time period t , which implies a certain constant amount of the farmer's monitoring effort. In reality, the amount of farmer's monitoring effort affects the farmer's ability to timely report disease. So, it would be logical to include a certain probability distribution regarding the quality of the decision on timely disease disclosure. The underlying assumption is that a greater effort on part of the farmer increases the probability of timely disease disclosure at the same time period t when the system (herd) is in the certain state (certain degree of clinical signs is observable). Basically, chance that the decision will occur at the time period t as the system is in a certain state depends on the farmer's effort to check the health status of the animals. This effort can be expressed as amount of time spent by the farmer each time period to observe the health status of his animals; each amount of time corresponds to a certain detection probability.

Principal-Agent Approach

The presented model helps better understand farmer behaviour while deciding whether to report a disease and how different incentive system parameters influence this behaviour. However, in its current form the model is limited to reveal whether the certain parameter configurations satisfy the regulator. Adding principal-agent relationship to the model would allow identifying Nash equilibrium incentive system parameters and associated indemnity agreements between the farmer and the regulator. Basically, a regulator whose objective is to shorten the HRP in case of the CSF outbreak should be included in the model. The regulator (principal) wants individual farmers (agents) to act on his behalf to ensure timely reporting of cases suspicious for CSF, in practice and not on paper only. To do this, the regulator would consider different than current indemnity agreements with farmers, namely agreements that offer adequate incentives for truthful disclosure of disease status.

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