An insurance model to cover losses due to highly contagious animal disease in the Finnish pig sector

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1. Abstract

This study analyses numerically an animal disease insurance scheme and how it could be operationalized. We focus on animal producer’s incentives to choose an insurance policy and on the feasibility of the insurance system as a whole. We develop a simple simulation model where the producer chooses whether to take an insurance policy at a given price, and the insurance provider simultaneously decides the price of the scheme. We find that producer interest towards such insurance products is limited. Uptake of insurance could be increased through collective actions such as group insurance or through support for the cost of insurance.

Keywords: animal disease, risk management, insurance

2. Introduction

The food sector can suffer large or even catastrophic losses when a highly contagious animal disease occurs (Franks et al., 2001; NAO, 2002; Mangen and Burrell, 2003). A disease outbreak can threaten the continuation of business if the costs must be paid by individual producer in full all at once when the loss occurs—as opposed to the costs being financed over a long time. Hence, schemes have been developed to finance the losses. These schemes are either publicly funded (e.g. state-paid calamity aid) or markets-based (e.g. insurance).

A finance scheme can collect premiums to finance the losses which are compensated to individual producers facing the loss. To be sustainable, premiums should cover the indemnities plus transaction costs, including administrative, operational and maintenance costs required to run the scheme (collect the premiums, resolve indemnity claims and assess damages), costs due to imperfect information, and interest paid for the insurer.

The European Commission (2007) has called for an efficient cost-sharing and responsibility scheme (e.g. through insurance or a fund) which would promote the animal health strategy of the European Union. The new policy implies that the participation of agricultural producers in financing animal disease losses may increase (cf. Civic Consulting, 2006). Despite being a topical issue, only a few studies (Meuwissen et al., 2003; Jansson et al., 2006; Civic Consulting, 2006; van Asseldonk et al., 2005; Niemi and Heikkilä, 2012; van Asseldonk et al, 2013) have examined the alternatives for financing animal disease losses.

The number of currently active cost-sharing schemes is low (OECD, 2013). In Europe the schemes tend to have either a high (>80%) or a low (<10%) rate of participation among the producers (Civic Consulting, 2006; Heikkilä and Niemi, 2008). There are several reasons to the low rate of participation. Firstly, stakeholders tend to prepare inadequately for high impact-low probability of occurrence risks (e.g. Akerlof and Dickens, 1982; Kuhnreuther and Pauly, 2004). The producers may foresee the costs of a finance scheme but not the benefits. Secondly, producers may acknowledge the time value of money and prefer delaying the premium payments. Thirdly, there are other ways such as improved management practices to mitigate the risks than purchasing an insurance policy which entails transaction costs. Fourthly, the price of insurance can be prohibitive. One of the conditions for a risk to be insurable is that the premium is economically feasible (Rejda, 1981). If the transaction costs are too high, producers deem the insurance too expensive. Fifth, if public compensation for the loss is available, or if the government’s commitment to leave the losses to the producers is not credible, producers may not have economic incentives to finance the losses caused by the calamity in advance (cf. Cafiero et al., 2007; van Asseldonk et al., 2013).

The chance that the compensated disease events agglomerate in time and space increases the premiums. Distinct from independent (idiosyncratic) losses (or events) which are well-
suited to insurance applications, the financing of systemic risks is a challenge (e.g. Skees and Barnett, 1999; Shaik et al., 2006). Adverse selection can also increase the premiums and reduce participation rate. It arises when the insurer cannot verify the risk level of an insured client. The high-risk clients falsely state they are low-risk clients and get access to insurance priced according to smaller indemnity (cf. Arrow, 1965; Stiglitz, 1977; Goodwin et al., 1994).

One of the fundamental elements of animal disease insurance is that it smoothens producers’ losses by shifting the uncertainty to another, less risk-averse economic agent, such as an insurance company. A risk-averse producer may be willing to pay a premium to reduce the volatility of disease losses, whereas a risk-neutral producer does not pay attention to the volatility. It is therefore important to know how risk aversion and the type of financed risk affect producers’ incentives to participate in the financing scheme.

This paper contributes to the literature by analysing numerically an animal disease insurance scheme and how it could be operationalized. In contrast to previous studies, we focus on the producer’s incentives to choose an animal disease insurance policy and on the feasibility of the insurance system as a whole. We develop a simple simulation model where the producer chooses whether to take an insurance policy at a given price, and the insurance provider decides the price of the scheme. Hence, these decisions are made simultaneously.

3. The model

We use a simple principal-agent model to illustrate the decision-making regarding the animal disease insurance. Suppose that the producer is maximizing his/her enterprise’s value when there is a risk of animal disease outbreak and associated losses. The producer minimizes the mean-variance costs of the disease risk by choosing to insure or not to insure the production against animal disease related losses in the next year:

\[ V(x_i) = \min_{u_i}(E(\mu_i(x_i)) + \alpha_i \sigma^2(\mu_i(x_i))) \text{ for all } i \]

\[ \mu_i(x_i) = ((1 - u_i)L(x_i)(P(x_i) + \epsilon_i) + u_i(W(x_i) - L(x_i) - C(x_i))(P(x_i) + \epsilon_i)) \]

where \( V(x_i) \) is the minimized loss, \( x_i \) is a variable characterizing the farm size, production type and location of farm \( i \) (\( i=1,...,n \), where \( n \) is the number of farms studied), \( u_i \) is the binary decision variable of farm \( i \) to insure (0=not insured, 1=insured), \( \mu_i \) is the net cost of disease risk to farm \( i \), \( E(\cdot) \) is the expectations operator, \( \alpha_i \) represents the producer’s coefficient of risk aversion, \( \sigma^2(\mu_i(x_i)) \) refers to the variance of \( \mu_i(x_i) \), \( L(x_i) \) is the economic loss caused a disease outbreak should it occur, \( P(x_i) \) is the probability that the disease occurs in this year at farm \( i \) represented as a function of farm characteristics, \( \epsilon_i \) is the random variation in the probability of infection and unobservable to the insurance provider (with mean zero), \( W(x_i) \) is the price of insurance paid for this year, \( C(x_i) \) is the compensation paid for the farm \( i \) should an outbreak occur. Hence, an insured producer will pay a fixed price and if an outbreak occurs, her/his loss will be the difference between the compensation and the actual loss, while an uninsured producer will not be compensated.

The insurance provider determines the scheme according to which the premiums are charged from an insured producer. The goal of insurance provider is to maximize returns:

\[ R(x) = \max_{W(x)} \sum_{i=1}^{n} W(x) - \beta(x) - C(x)(P(x) + \epsilon_i) \text{ s.t. Equation 1.} \]

where \( R \) is the net return to the insurance provider and \( \beta \) is the cost of providing insurance. We examine two options regarding insurance provider, namely a commercial provider and a mutual provider where a fraction of the producers’ loss is taken into account in Equation 2.
The studied insurance policy is planned to cover direct and indirect losses caused by foot and mouth disease (FMD) on average once in 50 years (events in subsequent years are assumed to be independent from each other). As there were no empirical data on losses caused by highly contagious animal diseases, we used synthetic data to characterize the losses. The data were mainly based on Lyytikäinen et al. (2012), who simulated the spread of FMD in Finland and losses arising due to FMD outbreak. We examined only insurance targeted to pig farms and losses associated with pig production. Regression models fitted in these data were used to quantify \( C(x) \) for each individual farm as a function of farm size, production line and the location of the farm. This way we were able to take into account potential differences in risk associated with the type of farm, and hence assess risk-adjusted insurance premiums. Transaction costs represented by the variable \( \beta(x) \) were based on other insurance policies available in Finland. Each farm in the country was assumed to be equally likely the first infected farm in Finland. Farm characteristics determined the probability of losses occurring due to an infection at farm \( i \). Low and high risk farms were determined by using estimation error and variation associated with \( P(x) \). We examined alternative parameter specifications which reflect different levels of producer’s risk-aversion.

4. Results

The insurance premium can be differentiated according to the risk represented by the farm, using the farm characteristics as indicators of the level of risk. Figure 1 shows an example of relative prices for an example policy. According to a previous study (Heikkilä and Niemi, 2012), the producers are rather willing to accept price differentiation based on the farm’s level of risk. Farm characteristics which can be used for differentiation include the number of animals, the location of the farm and the production type of the farm. Our simulations suggest that adjusting the premiums at least by farm size is essential. However, there are challenges in carrying out the differentiation in practice. As the expected indemnity payments are challenging to estimate beforehand, one possibility to reduce problems arising due to imperfect information could be to limit the indemnity to a maximum sum as is currently the practice in many cases. Such an insurance would exclude catastrophic damages and leave these to be covered through other arrangements.

The producers’ interest to expand their insurance cover for animal diseases is rather limited. In many of the simulated scenarios the participation rate of pig producers in the insurance scheme is relatively low. As the price of the insurance increases, the demand for it is further reduced and fewer farms are insured. In addition, adverse selection is a challenge in animal disease insurance. It increases the price and reduces the number of producers purchasing it. The great variation between farms in their expected losses is a challenge in this respect and it can result in low participation rate.

Simulation results show that voluntary policy to be taken by all farms may not be a realistic goal. This is due to the loading of insurance. When transaction costs, and hence the loading, increase fewer producers are willing to purchase insurance. In addition, risk aversion plays an important role. In practice, some degree of risk aversion and sufficiently low prices are needed to reach a high participation rate. The results suggest that when risk aversion increases, the participation rate also increases, but also the premiums are increased as the insurance company can extract higher profits. The participation rate is however higher if the producers losses are at least partly taken into account in the insurance provider’s objective function or if the profit margin of insurance provider is fixed (i.e. the profit depends on the number of insured farms). Hence, to ensure high participation rates, a mutual insurance
arrangement, a competitive market solution or a possibility to reinvest insurance funds at a high interest rate would be needed to keep the price of insurance low.

![Figure 1](image.png)

Figure 1. A normalized example of differentiation of potential annual insurance premiums to be paid by the farms (1=average of all farms) by production type and farm size class. Each class represents 25% of farms in the given production type.

5. Discussion

In conclusion, producers have only a limited interest towards new animal disease insurance policies. It is likely that purely commercial insurance would be too costly even when the premiums are differentiated by farm type specific risk. To improve the participation rates, collective actions are likely needed. These could take the form of, for instance, mutual or group insurance, of which there are good experiences in Europe. Another alternative is to support the insurance premiums.

In further analyses different model specifications, such as different parameter values or objective function specifications will be studied in more detail.

6. References


Agriculture: catastrophic assistance and subsidised insurance in European agriculture. 