As agricultural trade continues to increase both volume and diversity, livestock sectors have become increasingly dependent on exports. The increasing importance of trade poses challenges to controlling contagious animal diseases. When a country is confronted with a transboundary disease like foot-and-mouth disease, the infection must be eradicated as soon as possible. A number of countries do this through large scale preventive culling, though vaccination-to-live strategies pose a compelling alternative. Compared to preventive culling, a vaccination-to-live strategy poses several differences, including the size and duration of the outbreak, total economic losses, loss distribution among different stakeholders, and consequences for financing mechanisms. But because vaccination-to-live strategies are relatively new in the European Union, markets may be slow to accept products originating from FMD-vaccinated animals. The objective of this paper is to evaluate different economic aspects of a vaccination-to-live strategy deployed to eradicate FMD in a country previously free of vaccination.
The world has become a global marketplace in which agricultural trade continues to increase both in volume and diversity (Figure 1). This trend is also observed for livestock sectors, which have become increasingly dependent on exports. As Table 1 demonstrates, exports are important not only for countries with traditional export-oriented livestock industries, such as the Netherlands and Denmark, but also for a country like Germany, which sees substantial imports as well as exports. The increasing importance of trade poses challenges to controlling contagious animal diseases. The introduction of diseases like foot-and-mouth disease (FMD) presents a constant threat for countries, and can affect their trade opportunities. Despite OIE and EU regulations to protect countries from the threat of contagious animal diseases, there is always a risk of introduction. The consequences of an FMD outbreak can be devastating for the livestock sector in an affected country and for its economy in general (Box 1 shows the cost of the last outbreak in the Netherlands).

**Figure 1. Export of agricultural products**

Source: WTO, international trade statistics (2012), USD current prices.

<table>
<thead>
<tr>
<th></th>
<th>Netherlands</th>
<th>Denmark</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>1767</td>
<td>3333</td>
<td>2458</td>
</tr>
<tr>
<td>Intra-European Union</td>
<td>1543</td>
<td>2115</td>
<td>2200</td>
</tr>
<tr>
<td>Extra European Union</td>
<td>224</td>
<td>1218</td>
<td>257</td>
</tr>
<tr>
<td>Fraction extra European Union</td>
<td>13%</td>
<td>37%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Source: De Winter et al., LEI 2010.

When a country is confronted with a transboundary disease like FMD, the infection must be eradicated as soon as possible. Both OIE and the European Union offer guidelines on eradication, but additional measures are often needed to contain the outbreak — especially in densely populated livestock areas. In a number of countries, these additional measures include large scale preventive culling of animals around infected premises. Large scale culling is believed to have had a devastating impact on society, animal welfare and the environment, and is associated with high economic losses.
Previous epidemics caused societal outcry and disturbance (Cohen et al., 2007). In several countries, this response bolstered arguments for adopting alternative strategies to control future epidemics. This, in turn, fuelled calls to reconsider non-vaccination policies, and to discuss alternative prevention and control strategies that would be supported by society at large. There were also calls for strategies that would minimise financial and environmental impacts.

One alternative under consideration involved the implementation of a vaccination-to-live strategy. The implementation of a vaccination-to-live differs from culling, as well other strategies in which vaccination is used as a way to postpone culling until a later moment. Decision making in the control contagious animal diseases is a complex process, characterised by a mixture of epidemiological, economic and social-ethical value judgements. Different stakeholders will have different ideas about which strategy should prevail. Their views may represent the interests of the farming community, the processing industry, the animals, the consumer, or the general citizen. This may create a situation of conflicting interests, as economic motives may prevail in the views of some, while animal or human welfare motives may be more prominent in the views of others (Mourits et al., 2010).

Compared to preventive culling, a vaccination-to-live strategy poses several differences, including the size and duration of the outbreak, total economic losses, loss distribution among different stakeholders, and consequences for financing mechanisms. Since vaccination-to-live strategies are relatively new in the European Union, markets may be slow to accept products originating from FMD-vaccinated animals. The objective of this paper is to evaluate different economic aspects of a vaccination-to-live strategy deployed to eradicate FMD in a country previously free of vaccination.

**Economic aspects of an outbreak of FMD**

During an outbreak of a contagious disease like FMD, farmers, livestock sectors and governments are confronted with direct and indirect losses. When evaluating the costs of an epidemic, different components can be distinguished.

**Direct costs related to the control of the epidemic**

These include infrastructure costs to control the epidemic, the costs associated with culling and destroying of infected and contact animals, the costs associated with destruction of feed and eggs on detected farms, and compensation and vaccination costs. In EU member states, these costs are co-financed by the European Union (Council Decision 90/424/EEC).

Consequential losses can occur during an outbreak, as well. These include the following.

**Box 1. Costs of the 2001 FMD outbreak in the Netherlands**

Twenty-six infected herds were detected. All susceptible animals on approximately 1800 farms were vaccinated. All farms were subsequently depopulated. In total, approximately 260,000 animals were culled.

- Total for Dutch society: EUR 900 million or 0.3% GNP
- Direct costs (e.g. enforcement costs, compensation of culled animals, screening): EUR 90 million
- Indirect and export market losses: EUR 320 million
- Other parts of the livestock chain: EUR 215 million
- Tourism and recreation sector: EUR 275 million

*Source (CPB 2001 cited by Huirne et al., 2002)*
Costs related to movement restrictions affecting the primary sector

Farms culled during the epidemic are confronted with income losses; during the time, stocks are not fully repopulated and culled farms are not in production. Farms are also confronted with new start-up costs. Farms in a surveillance or movement restriction zone face indirect losses during the standstill period, mainly due to the fact that they are not able to freely move animals or livestock products. An epidemic affects the entire livestock sector, restricting national and international market access to animals of susceptible species and their products. Even after the outbreak has passed, it takes time to lift restrictions and return to pre-epidemic market conditions.

Ripple effects

The effects from outbreaks are felt upstream and downstream along the livestock value chain, from breeding, feed production, input supply, slaughter and processing, to final sale and consumption.

Spill-over effects

During outbreaks, tourism and other services in a member state may be confronted with reduced incomes. Because typical agricultural production is becoming more important for the rural economy, these spill-over effects are likely to comprise a large part of total epidemic costs.

A major drawback of consequential losses is the fact that they are difficult to determine, and can usually be estimated only after the outbreak has ended, once the situation has returned to “business as usual.”

Recent research from the Netherlands as illustration

A number of recent studies in the Netherlands have examined vaccination-to-live strategies (Backer et al., 2012a, Backer et al., 2012b, Backer 2009). Results from these studies indicate that the epidemiologic and economic outcomes of an FMD outbreak depend on both the control strategy chosen, as well as the farm density in the region where an outbreak occurs.

In these studies four alternative control strategies were evaluated.

- the EU minimum strategy (EU-min); this strategy consists of culling of infected farms, tracking and tracing of risky contacts and establishment of inspection zones (3 km) and surveillance zones (10 km) (COUNCIL DIRECTIVE 2003/85/EC).
- a culling strategy (Cull1), which calls for the culling of all FMD-susceptible and infected animals within a radius of one kilometre around infected farms (in addition to the EU-min strategy).

The remaining two preventive vaccination strategies are identical to the Cull strategy, differing only with respect to the size of the vaccination radius.

- Vac2 (radius of two kilometres); and
- Vac5 (radius of five kilometres)

The Cull strategy would be implemented during the first week of the outbreak, before the deployment of a vaccination strategy. (A maximum one-week delay was anticipated, taking into account the necessary preparation of a vaccination strategy.)
The effect of each identified strategies was determined for a typical Dutch, densely populated livestock region with more than four farms per kilometre. The economic analysis was based on the results of a stochastic epidemiological FMD simulation model. It was developed to investigate the consequences of the aforementioned alternative control strategies, and is described in detail by Backer et al., (2012a and 2012b). A partial budget model was developed to evaluate the economic consequences of different control strategies (Dijkhuizen and Morris, 1997). Economic parameters were estimated based on previous outbreaks and were discounted to reflect current prices. Cost parameters were based on Meuwissen et al. (1999), Mangen et al. (2002), Huirne et al. (2002) and Meuwissen et al. (2003), among others. Products of vaccinated animals had to be processed separately from the products of non-vaccinated animals (logistic slaughtering), resulting in reduced market access — especially for non-EU countries. Logistic slaughtering and reduced market access pose substantial costs to the industry (Meuwissen et al., 2009). Due to volume and reduced market access, products derived from vaccinated animals will lose value.

Results of the simulation studies

Because Backer et al. (2009, 2012a and 2012b) comprehensively described epidemiological consequences in terms of probability distributions, only the descriptive statistics are presented, including the mean value as well as the fifth and 95th percentiles. The duration of an outbreak and the number of farms infected, culled, and vaccinated differ substantially across control strategies (Table 2). The epidemiological simulation outcomes showed that in a Densely Populated Livestock Area (Densely Populated Livestock Area in which the farm density is larger than two farms per km²), the EU-min strategy will too often result in a lengthy outbreak, and is therefore not likely to be a preferred option for involved stakeholders. As a result, it is excluded from further evaluation. In terms of economic consequences, the Vac2 strategy entails the lowest average loss in a Densely Populated Livestock Area (Table 3). However, under favourable circumstances with limited spread, Cull is the preferred strategy (see the fifth percentile); under adverse circumstances, the Vac5 strategy is preferred (see the 95th percentile).

Table 2. Descriptive statistics of simulated epidemiological outcomes for different control strategies of epidemics that started in a Dutch Densely Populated Livestock Area region

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Duration in days</th>
<th>Number of detected farms</th>
<th>Number of pre-emptively culled farms</th>
<th>Number of vaccinated farms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean 5% 95%</td>
<td>Mean 5% 95%</td>
<td>Mean 5% 95%</td>
<td>Mean 5% 95%</td>
</tr>
<tr>
<td>EU-min</td>
<td>254 166 375</td>
<td>1 578 1 099 2 091</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cull1</td>
<td>61 25 111</td>
<td>48 17 94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vac2</td>
<td>70 33 118</td>
<td>78 22 158</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vac5</td>
<td>47 25 78</td>
<td>46 19 88</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EU-min</td>
<td>463 355 572</td>
<td>0 0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cull1</td>
<td>1 015 336 1814</td>
<td>0 0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vac2</td>
<td>199 92 333</td>
<td>2 340 676 4 075</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vac5</td>
<td>188 84 321</td>
<td>3 963 1 831 6 629</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Hobby farms excluded.
Table 3. Descriptive statistics of simulated economic losses for different control strategies of epidemics that started in a Dutch Densely Populated Livestock Area region*

<table>
<thead>
<tr>
<th>Area strategy</th>
<th>Total losses EUR million</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Cul1</td>
<td>193</td>
</tr>
<tr>
<td>Vac 2</td>
<td>163</td>
</tr>
<tr>
<td>Vac 5</td>
<td>170</td>
</tr>
</tbody>
</table>

* Export losses excluded.

Export losses

An epidemic restricts national and international market access for animals of susceptible species and their products. An FMD will result in trade restrictions that are largely related to the epidemic per se and do not depend on the specific characteristics of the chosen control strategy. Once exports resume, it can take considerable time to regain access to profitable markets.

Export market losses were excluded from the calculations. Market access for live animals, meat, meat products, milk and milk products from infected countries is restricted for another three months without vaccination and for another six months with vaccination-to-live (OIE Terrestrial Code Article 8.5.8). The total effects of export losses are determined according to the size and duration of the outbreak, the control strategy applied, and especially the country or area affected.

Distribution of costs and financing the consequences

In addition to differences in total costs, there is a shift in cost components across different strategies, underscoring a variability that has implications for involved stakeholders (Figure 2). EU community measures call for the co-financing of veterinary emergency measures. Council Decision 90/424/EEC allows for co-financing 60% of the costs of compulsory and pre-emptive slaughter for FMD, and any related operational expenditure (Bergevoet et al., 2011). In addition, the remaining costs for specific components are shared between the government and livestock farmers through a compulsory public statutory compensation scheme (Van Asseldonk et al., 2006). Indirect losses — including those arising from lower values for vaccinated animals and their products — are not eligible for compensation. As a consequence, of the covered cost a larger amount of the losses are borne by farmers under a vaccination strategy (Figure 2).

For an outbreak in a Densely Populated Livestock Area, non-eligible costs comprise 13% of total costs related to the Cul1 strategy; this share increases to 46% with a Vac5 strategy. A large part of the non-eligible costs have to be borne by a relatively small number of farmers whose animals were vaccinated. The farmers’ willingness to participate in a vaccination-to-live strategy might be determined by compensation mechanisms put in place to cover losses. Different compensation schemes are currently under discussion in the Netherlands. As described above, there are different ways to organise a cost and responsibility sharing scheme.
Financing mechanisms

When compensating farmers for direct losses during an FMD outbreak, most EU member states finance compensation entirely from their national budgets. Only in a few member states — e.g. Belgium, Germany, Lithuania and the Netherlands — does the animal production sector contribute to the funding for compensation of direct losses. These public-private financing schemes have a compulsory fund structure under which all farmers pay a levy.

Some EU member states have implemented a compensation scheme for all or part of the consequential losses, either by means of private funding (which is compulsory in Romania), public funding (as in Austria, Cyprus, Czech, Finland, France, Portugal and Sweden), or public-private participation (Denmark, Latvia, and Lithuania).

Statutory compensation schemes finance protection against losses for livestock farmers. These schemes are financed either by state or state-controlled public funds mutual funds with levies, or by ad hoc payments. In situations without state-established systems, only private insurance can be purchased (Koontz et al., 2006). Below, characteristics of public funds and insurance systems are briefly discussed.

Public funds are generally compulsory and guarantee reliable protection for all farmers. They are characterized by the following: catastrophes and disaster protection is state-guaranteed, and there are no financial capacity problems or needs for reinsurance protection. In general, only direct losses are compensated, and compensation is only available for farmers who culled their herds because of formal, state-advised acts. No compensation is paid to farms situated in restriction zones, and indirect losses remain uncovered. There is also limited input and lower incentives for loss prevention measures, and there is no possibility for an individual risk-adjusted contribution or claim settlement.

Risk financing with a levy system is based on pooling within the sector over time. Payments to the fund can be organised through up-front payments (deposit), assessment payments after an epidemic, or both. These latter two systems have no annually fixed levies, and the government will finance the compensation payments in advance. But government input will be repaid over the following years. When an epidemic breaks out, the levy is therefore set according to the amount that the government paid in advance for the sector. It is important to note that the levy can (and in most cases will) vary across livestock species.

In public-private co-financing, the amount financed by the private sector can be proportional or non-proportional. If risks are shared by means of a proportional (pro-rata)
contract between the government and the private sector, the levy is specified as a fraction of the coverage. With non-proportional contracts, the national government indemnifies only claims that are in excess of a particular threshold.

In some countries it is possible to insure consequential losses through private insurance as well as public-private compensation schemes. Private insurance offers compensation for both direct and indirect losses, as well as individual risk-designed contracts for farmers. Private coverage also includes protection against business interruption and loss of income. There are incentives for loss prevention, as well, since insurance protection is available only for farms that meet stringent sanitary standards under surveillance monitoring (e.g. by dairies or pig control units). Insurers have specialised staff for individual risk-adjusted premium and claim settlements. There are also mutual insurance companies that combine the advantages of both mutual funds and insurances. With insurances, however, there is freedom of contracting (not everybody has to participate), and there are no compulsory schemes.

However, private insurance poses some major drawbacks. In most member states, private livestock insurance is not developed, and the insurance industry has shown very little interest. There are problems with disaster coverage, as well, since reinsurance is available on a limited basis, and there are relatively high premiums due to tax and administration costs.

Financing the potential losses arising from devalued vaccinated animals is a challenge for livestock sectors and governments. Since the value loss is seen as a consequential loss, public-private arrangements for compensation might be seen as unwanted government support. An insurance system, meanwhile, may be perceived as expensive, and its freedom of contracting might result in moral hazards that affect non-insured livestock owners.

Conclusion

Research indicates that vaccination-to-live is a viable alternative to large scale culling. Acceptance of vaccination-to-live increases when regulation related to vaccination-to-live is harmonised with either culling or vaccination-as-delayed-culling. Simulation outcomes reveal that in the event of an FMD outbreak in a Dutch Densely Populated Livestock Area, vaccination within a radius of two kilometres would be as effective as culling within a one kilometre radius, with substantially smaller economic and social effects.

For SPLAs (Sparsely Populated Livestock Areas in which the farm density is less than two farms per km²) absolute differences across analysed control strategies — differences that raise epidemiological, economic and social-ethical issues — are of less concern. Economic evaluations of FMD management options are likely to result in different solutions for different countries (e.g. due to differences in livestock population density, trade patterns, or acceptance of products originating from vaccinated animals). The decision making process should be supported by epidemiological and economic models. Agreements on mechanisms to finance both direct and consequential losses should be made before an outbreak occurs.

References


