Prevention and control of Foot-and-Mouth Disease, Classical Swine Fever and Avian Influenza in the European Union: An integrated analysis of epidemiological, economic, and social-ethical aspects

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Executive summary

Ruud Huirne, Mart de Jong, Koos de Vlieger and Marcel van Asseldonk

Introduction

The recent outbreaks of Foot-and-Mouth Disease (FMD), Classical Swine Fever (CSF), and highly pathogenetic Avian Influenza (AI) in the European Union (EU) have shown that such contagious animal diseases can have a devastating impact in terms of animal welfare, economics and societal outcry and disturbance. Insights into the three interrelated, aspects of epidemiology, economics, and social-ethics are crucial in order to better prevent and control contagious diseases in the future. Because of the sometimes conflicting aspects a broad spectrum of stakeholders received a prominent position in the national public debate during and after the recent outbreaks. In order to quantify the impact of alternative views by alternative stakeholders science-based models are a prerequisite. The main goal of the project is therefore to conduct an integrated analysis of epidemiological, economic and social-ethical aspects of (potential) control strategies.

First the results of a survey are presented which focused on prioritising epidemiological, economic and social-ethical aspects. Subsequently, an integrated analysis is described in order to obtain insight into the impact of the above mentioned differences between stakeholders. A detailed analysis is presented for six EU member states and three contagious diseases (FMD, CSF and AI).

A stakeholder's survey

Different stakeholders are likely to have different ideas about the strategy to be chosen based on their views and their mission, which is to represent the interests of for example the farming community, the commercially involved secondary industry, the animals, or the consumer of food or recreation. This may create a situation of conflicting interests between stakeholders. Economic motives may prevail in the views of some, animal or human welfare motives may be prominent in the views of others. By means of a survey the relative importance of conflicting criteria and indicators per criterion were elicited. In total 81 stakeholders responded, of which 20 Chief Veterinary Officers (CVOs) and 61 other stakeholders.

For the stakeholders sample as a whole the epidemiological criterion was the most important one. CVOs weighed the epidemiological criterion with a relative importance of 53%. Corresponding average weights for the economic and social-ethical criteria were 30% and 17% respectively. The social-ethical criterion was more important for the non-agricultural stakeholders (35%) then for the agricultural stakeholders (18%). The economic criterion was considered as less important by the non-agricultural stakeholders (15%) compared to agricultural stakeholders (33%). The two clusters comprising the value judgements of CVOs and veterinarians were almost alike.

Only CVOs weighed epidemiological and economic indicators. Duration of the epidemic (28%) and the size of the affected region (25%) were regarded as the two most important epidemiological indicators. Direct farm losses (15%) and consequential farm losses in the affected region (14%) were regarded as the two most important economic indicators.

The relative weights for the social-ethical indicators differed between the clusters of stakeholders. In general, non-agricultural stakeholders weighed the indicators animal health and animal welfare as more important than agricultural stakeholders and CVOs.

Member state studies: epidemiological analysis

For each specific country and disease under consideration, we selected the largest area with relatively high farm and animal density and subsequently estimated the outcome of epidemics (in terms of probability distributions for its size and duration) occurring in this area under a number of alternative intervention strategies. Density of herds has been found to be the most important characteristic explaining differences in spread during the disease-combat period (i.e. under conditions of movement regulation and increased biosecurity). For the purpose of the further (economic and MCA) analyses we focus on those intervention strategies that are (ultimately) effective in controlling the epidemic. The results of epidemiological scenario analyses were categorized as follows. The outcome fell into one of only three categories:

1. Relatively swift control of the outbreak: occurrence of relatively short and small epidemics only.
2. Elaborate control of the outbreak: epidemics may last for several months during which a large number of herds are culled or vaccinated.
3. Failure to control the outbreak: a high probability that the outbreak spreads throughout most of the region included in the calculation.

Areas that fell into in the last two categories were defined as Densely Populated Livestock Areas (DPLA). In DPLA the basic intervention measures required by EU regulations are not sufficient.

Our results indicate that, for most EU member states, control of FMD outbreaks with basic EU measures is not possible. Most or even all EU member states have (large) high-risk areas (DPLA) for spread of FMD. In contrast, our results indicate that in some (but not all) of the six member states analysed, CSF and AI epidemics can be controlled by employing the minimum EU requirements for intervention. However, some small DPLA for CSF or AI might have been missed due to the spatial level of the available data. Where we do find DPLA for the spread of CSF or AI, these areas tend to be less extensive than the DPLA of FMD susceptible animals.

Member state studies: economic analysis

Net exporting member states of the relevant products (like milk, beef, pork and mutton) are more affected by export bans then net importing member states. Therefore net exporters as well as net importers were represented in the member state studies. In each member state a certain area of interest is chosen. The reason for this is to reduce the need for data of farm structure and to have regions in which the relevant animals are in an adequate numbers present. However, the size of the regions, expressed in percentage of the total number of animals present in the member state varied. The percentage ranged from 0,033% to 30%, but was in most cases between 2% and 5%. This implies that the results of the economic analysis are not comparable between regions, only the results of different control strategies within a region are comparable.

Animal productivity, costs of production and gross margin were calculated on basis of data comprising zootechnical aspects (e.g. production per animal), financial aspects (e.g. prices and costs) and the farm structure in the selected regions. Subsequently, direct farm losses, operational costs of control measures and indirect costs of farmers were estimated by combining the economic components with the output of the epidemiological model. Net income effects of an outbreak on the rest of the economy were calculated with the Global Trade Analyse Project (GTAP) model. The input for this model is the change in production, and if relevant export impacts, due to the outbreak.

The economic analysis showed that the optimal control strategy chosen was affected by the region and disease under study. Furthermore, the relative importance of the direct farm costs, indirect farms costs, organizational costs and income effects in agribusiness and recreation differed per control strategy. In a number of cases the impact of price effects, induced by a change in supply, exceeded the impact of a change in quantity. Income gains were realised in the agricultural sector in the non-affected regions and in other sectors of the economy.

Member state studies: multi criteria analysis

Decision making in controlling contagious animal diseases is a complex, conflicting process, characterized by a mixture of epidemiological, economic and social-ethical value judgements. An integral evaluation framework is developed to illustrate the potential support of evaluation techniques such as the Multi Criteria Analysis (MCA) in choosing the control strategy that best meets all conflicting judgements.

MCA establishes preferences between alternatives to an explicit set of objectives and measurable criteria to assess the extent to which the objectives have been achieved. A key feature of the analysis is its emphasis on the judgement of the stakeholders involved. The performed MCA deals with the control decision problem by breaking the problem into more manageable pieces (i.e. epidemiological, economic and social-ethical objectives) to allow data and judgements to be brought to bear on the pieces. Then the technique reassembles the pieces to present a coherent overall picture.

The presented MCA is based on the average judgement values of the CVOs, as elicited by the survey. Results show a general tendency towards the ranking of control alternatives, which in most of the cases appears to be independent of the evaluated disease. In the Moderate Populated Livestock Areas (MPLA), the basic EU control strategy and the protective vaccination (EUdef+Vac_live) strategy are generally appreciated over the other control strategies. In the DPLA situations, preference is mostly given to the pre-emptive slaughter (EUdef+Pre) strategy, followed by the protective vaccination (EUdef+Vac_live) strategy as second best option.

Individual CVOs - or in general – individual interest groups often differ in their views of the relative importance of the criteria. Using the MCA framework to examine how ranking of alternatives might change under different preferences or weighting systems can show that, for instance, two alternatives always come out best. Their order, however, may shift. If the differences between these best alternatives under different weighting systems are rather small, accepting a second best option can be shown to be associated with little loss of overall benefit.

CONTENTS

1 General introduction
Ruud Huirne and Marcel van Asseldonk

1.1 Background

The recent outbreaks of Foot-and-Mouth Disease (FMD), Classical Swine Fever (CSF), and highly pathogenetic Avian Influenza (AI) in the European Union (EU) have shown that such diseases can have a devastating impact in terms of animal welfare, economics and societal outcry and disturbance. Society is increasingly concerned about such types of economic and emotional losses and many people think that this cannot be accepted anymore in the 21st century. Therefore, in some EU member states, in particular those who experienced outbreaks of CSF, FMD or AI, there is an increasing interest to review and reconsider the current (EU) legislation and practices concerning these list-A diseases, including the option to apply emergency vaccination. Recent EU-decisions with respect to vaccination against FMD and CSF are a good step in this respect. Insights into the three interrelated, aspects of: (1) epidemiology, (2) economics, and (3) social-ethics are crucial in order to better prevent and control contagious diseases in the future. Because of the sometimes conflicting aspects a broad spectrum of stakeholders received a prominent position in the national public debate during and after the recent outbreaks. In order to quantify the impact of alternative views by alternative stakeholders science-based models are a prerequisite.

For more than a decade, many researchers of Wageningen University and Research Centre and the Faculty of Veterinary Medicine at Utrecht University have worked jointly on scientific computer models to support decision making to prevent and control contagious disease outbreaks (FMD, CSF and AI). After each epidemic, they have obtained all the data and facts to evaluate decisions made, and to update and revise their epidemiological and economic models. After the FMD-outbreak, these models have been extended with social-ethical aspects. Based on these models, the research group has developed an integral evaluation and planning framework in which epidemiological, economic, social-ethical aspects of (any) contagious disease are combined and weighed. The objective of this framework is to support policy makers in choosing the strategy that is supported by the majority of the stakeholders. The integral framework provides a good basis for investigating the impact of certain EU and other (hypothetical) disease-control strategies. It can be used as a mirror for own ideas, for instance to explore new EU-strategies. The framework is also very suitable to perform so-called what-if analysis, which means that the impact of (real or hypothetical) scenarios can be determined.

1.2 Goals of the project

The main goal of the project is to conduct an integrated analysis of epidemiological, economic and social-ethical aspects of (potential) control strategies. The following individual goals can be distinguished:

1. To obtain a general understanding and overview of preferences and their weight with respect to decision criteria for highly contagious diseases, in particular concerning differences between stakeholders and EU member states;
2. To obtain insight in the impact of the above mentioned differences on preferences for particular control strategies against FMD, CSF and AI;
3. To broaden the understanding of policy makers, particularly Chief Veterinary Officers (CVOs) in scientifically-based decision support in the field of highly contagious disease control;
4. To quantitatively explore the impact of current and possible future control strategies against FMD, CSF and AI under various conditions, taking into account a broad set of decision criteria;
5. To provide a comprehensive state-of-the-art integrated approach on the control of highly contagious diseases in the EU.

The results were disseminated in a large conference held in Brussels in 2004. Various stakeholders with different interests were invited, e.g. politicians from the EU and member states, disease policy makers, scientists from various disciplines (veterinary science, economics, etc.), NGOs, and other stakeholders. Aim was to provide and discuss a broad and comprehensive overview of prospects and (im-) possibilities of various ways to prevent and control highly contagious animal diseases.

1.3 Research outline

The outline and activities distinguished are depicted in Figure 1.1.

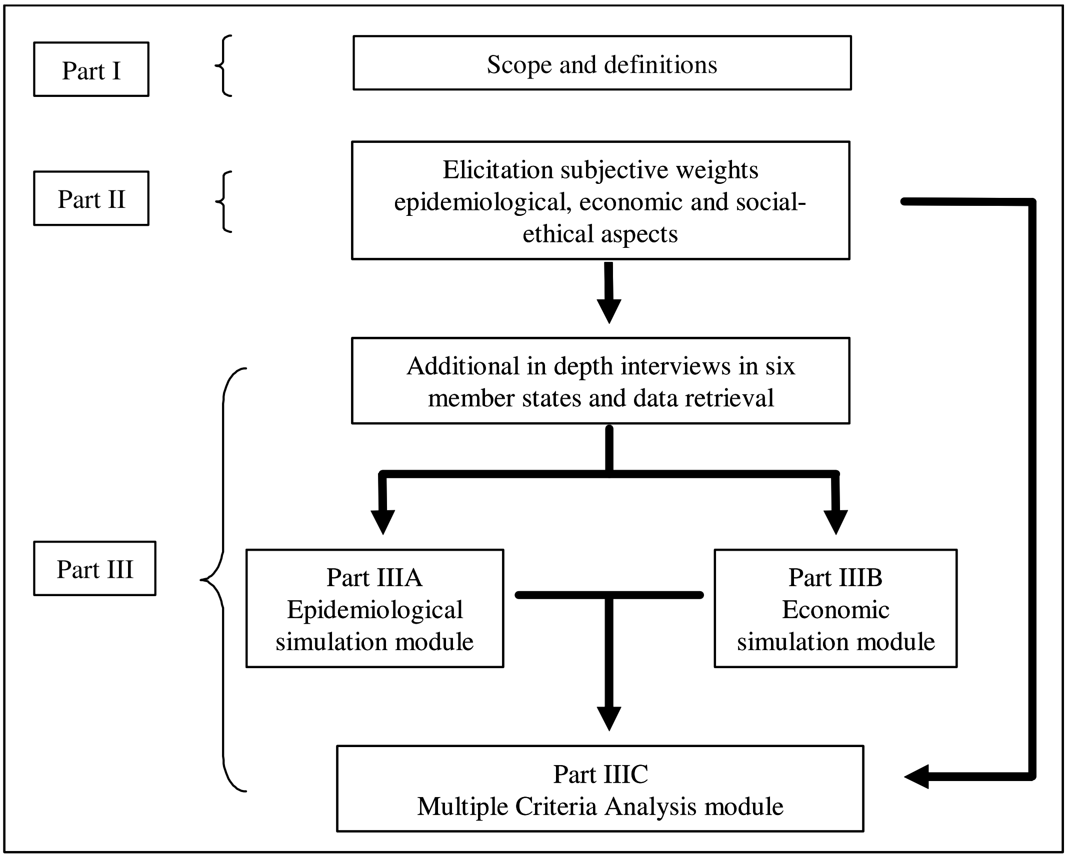

Figure 1.1: Outline of an integrated analysis of epidemiological, economic and social-ethical aspects.

In part I scope and definitions are provided of epidemiological, economic and social-ethical aspects because stakeholders might not be familiar with one or more of these aspects.

In part II the results of a survey are described which focused on prioritising epidemiological, economic and social-ethical aspects. This questionnaire was sent to all CVOs of the EU member states and numerous stakeholders. This activity can be considered as a follow-up of the CVO-questionnaire of September 2002 in Finland at the OIE Regional Commission for Europe.

In part III a detailed analysis in six EU member states is presented. Data was collected in the various countries comprising demographic and general data, epidemiological and economic data. The collected data were used as inputs in the various analysis modules included in the integral evaluation framework. In this analysis the integral evaluation and planning framework focused on FMD, CSF and AI. The aims were to obtain a detailed epidemiological (part IIIA) and economic (part IIIB) insight in the impact of outbreaks of these diseases, and to quantify the impact of preferences of various stakeholders with regard to different kinds of decision criteria on the decision making in this respect (part IIIC).

Part I

2 Scope and definitions

Marcel van Asseldonk, Thomas Hagenaars and Nina Cohen

The EU aims at assuring a high level of animal health and animal welfare without compromising the functioning of the internal market (Mission Statement DG Health and Consumer Protection; Anonymous, 2004). This requires a comprehensive EU strategy to combating epizootic livestock diseases, such as FMD, CSF and (highly pathogenic) AI.

This chapter gives an overview of the epidemiological, economic, and social-ethical aspects of epidemic livestock diseases. During the last decade governmental (EU and national) regulation with respect to the control of contagious animal diseases has been mainly focused on epidemiological and economic aspects. Also in research and literature, epidemiological and economic aspects have received much more attention, in contrast to the social-ethical aspects. However, the EU-society is increasingly concerned about the social-ethical consequences of an outbreak. Therefore, the latter will be described in more detail, particularly referring to experiences obtained from the recent large outbreaks in the UK and The Netherlands.

This chapter starts with a description of the epidemiological (2.1) and economic aspects (2.2). Thereafter, the social-ethical aspects are described (2.3) in terms of animal welfare and related ethical aspects and social aspects. Finally, the trade-offs between the three aspects per control strategy are described (2.4).

2.1 Epidemiological aspects

2.2.1 The epidemic diseases under study

FMD is a contagious viral disease that affects cloven-hooved animals (cattle, pigs, sheep, goats and all wild ruminants and suidae). The incubation period of FMD-virus is 2-14 days. There are seven serotypes of the virus, i.e. O, A, C, SAT 1, SAT 2, SAT 3 and Asia 1, all of which cause similar symptoms, although some strains cause symptoms in only a subset of the species mentioned above. Infection with one serotype does not confer immunity against another. The disease may be fatal to young animals, but is rarely fatal to adult animals. Those that survive, however, are often debilitated and suffer chronic lameness, aborted pregnancies, chronic inflammation of the mammary glands or udder in female cows and possible sterility.

FMD-virus can be transmitted (in order of decreasing importance) through: 1) direct or indirect contact (droplets); 2) animate vectors (humans, etc.); 3) inanimate vectors (vehicles, implements); and 4) wind (airborne spread; mainly within 5 km but up to 60 km over land and 300 km by sea under special meteorological conditions). Transmission by rodents and birds is negligible. Sources of virus include: 1) incubating and clinically affected animals; 2) breath, saliva, faeces, and urine; milk and semen (up to 4 days before clinical signs); meat and by-products in which pH has remained above 6.0; 3) carriers (particularly cattle). Risk factors for the introduction of FMD-virus in countries that are officially free from FMD (in order of decreasing importance) include: 1) import of livestock; 2) import of animal products (food industry, tourists); 3) feeding of import swill (organic waste material, from airports and harbors); 4) empty livestock trucks returning from abroad; 5) wildlife; and 6) air currents.

CSF, also known as hog cholera or swine fever, is also a highly contagious viral disease affecting domestic and wild pig populations. Under natural conditions the most frequent route by which CSF virus enters its host is oronasal with an incubation period of 4-10 days. Acute and chronic courses of CSF are known. All courses of the infection have in common that the animals are viraemic at least as long as they show clinical signs. The disease symptoms range from mild to severe and can be fatal. CSF may cause a large number of deaths in affected herds. Symptoms of CSF include fever and cyanosis/haemorrhages of the skin, as well as incoordination, diarrhea, and pneumonia. Severe cases of the disease appear very similar to African Swine Fever.

The risk factors for the transmission of CSF-virus are comparable to those for FMD, with the exception that spread by air over larger distances is considered to be negligible. Furthermore, special attention should be paid to spread by wild boar.

AI is an infectious disease of birds caused by type A strains of the influenza virus. All birds are thought to be susceptible to infection, though some species are more resistant to infection than others. The incubation period is 2-5 days. Infection causes a wide spectrum of symptoms in birds, ranging from mild illness to a highly contagious and rapidly fatal disease resulting in severe epidemics. The latter is known as “highly pathogenic AI or fowl plague”. This form is characterized by sudden onset, severe illness, and rapid death, with a mortality that can approach 100%. Sixteen subtypes of influenza virus are known to infect birds, thus providing an extensive reservoir of influenza viruses potentially circulating in bird populations. To date, all outbreaks of the highly pathogenic form have been caused by influenza A viruses of subtypes H5 and H7. Because some strains have the potential to infect humans (potentially zoonotic), robust contingency plans are required.

AI-virus can be transmitted through: 1) direct contact with secretions from infected birds, especially faeces; 2) contaminated feed, water, equipment and clothing; 3) clinically normal waterfowl and sea birds may introduce the virus into flocks; and broken contaminated eggs may infect chicks in the incubator. Sources of virus include: 1) faeces, respiratory secretions; and 2) highly pathogenic viruses may remain viable for long periods of time in infected faeces, but also in animal/bird tissues and water.

2.1.2 Recent outbreaks

Epidemics in livestock, such FMD, CSF and AI, may inevitably affect many farms at the same time. These outbreaks have a devastating epidemiological impact: FMD, CSF and AI caused the slaughter of millions of cattle, sheep, pigs and poultry (OIE, 2004).

Around the world, many countries are officially free of FMD (without vaccination), other countries vaccinate against the disease (preventive vaccination), and in some countries FMD is still endemic. In member states of the EU, preventive vaccination is prohibited since 1991. Since then, FMD epidemics occurred in Greece and Italy (1993, 1994, 1996) and the UK, Ireland, France and The Netherlands (2001-2002). In Turkey, bordering Greece, FMD outbreaks occur every year and preventive vaccination is applied.

At the beginning of the 21st century, CSF is still endemic in many parts of the globe. Successful eradication has been achieved in many countries including North America, Australia, and parts of Northern Europe, and in the absence of vaccination resulting in a totally susceptible swine population (Edwards et al., 2000). Preventive vaccination was stopped in all EU member states in the early 1990's (Westergaard, 1991). In the 1990's large CSF outbreaks (more than 40 farms infected) occurred in The Netherlands (1997), Germany (1993-2000), Belgium (1990, 1993, 1994) and Italy (1995, 1996, 1997) (Laevens, 1998 and Handistatus II of the OIE, 2001).

Recent outbreaks of AI occurred in Italy (1999-2000), Belgium (2003), Germany (2003) and The Netherlands (2003). High pathogenic AI outbreaks are also reported in other parts of the world, for example a large epidemic in South East Asia in 2003/2004.

2.1.3 Control strategy

EU member states are obliged to apply the control measures laid down in EU directives if an outbreak arises of so-called 'List-A diseases' (Office International des Epizooties, 1998). The basis for these measures originates from EU Council Directives. Measures include 1) stamping-out of infected herds; 2) pre-emptive slaughter of contact herds; and 3) the immediate establishment of surveillance zones around such herds (3-10 km). In these zones, animal movements are restricted and to a large extent prohibited. Depopulated farms may repopulate 21 days (FMD and AI) or 30 days (CSF) respectively after the cleaning and disinfecting of the farm (7-10 days after diagnosis), or, after the lifting of restriction zones (lifted only after negative clinical and serological tests). The latter generally takes much longer than 21-30 days. As an example, during the 1997/98-epidemic of CSF in The Netherlands many pig farms were in restriction zones for more than 6 months.

In accordance with Community legislation, all member states have contingency plans in place to ensure that the most appropriate measures are immediately implemented in case of an outbreak. Depending on the severity of the epidemic, national governments can, after obtaining EU approval, take additional control measures. If restriction zones with a movement standstill lead to severe animal welfare problems on the farms (possible with 25-kg piglets on farrowing farms, and on farms with 110-kg hogs and veal calves), so-called welfare slaughter is generally applied. Also, a more comprehensive pre-emptively slaughter scheme can be applied to control the disease more effectively. Furthermore, all susceptible animals within a large area around the infected herds might be vaccinated (emergency vaccination, 'ring vaccination'). For example, in the 2001 FMD-epidemic in The Netherlands, the Dutch government decided on a number of additional measures. There was a temporarily complete movement standstill in the whole of the country, including also horses and poultry, and the transport of feed and animal products, such as manure and milk. Also, herds within a 1-km radius of contact herds were pre-emptively culled. Furthermore, all susceptible animals within a large area around the infected herds were vaccinated and destroyed afterwards (delayed destruction).

In our analyses we investigate three types of intervention strategies:

1. *EUdef*. Standard (EU) strategy: stamping-out of infected herds and contact herds, and implementing surveillance and protection zones (3 km and 10 km).
2. *EUdef+Pre*. EU + pre-emptive slaughter (ring culling within a 1-km or larger radius around infected/contact herds)
3. *EUdef+Vac*. EU + vaccination. (ring vaccination within a 1-km or larger radius around infected/contact herds).

Whereas for FMD and CSF, vaccination as an intervention tool has been found to be effective in preventing within-herd transmission, for AI such an effectiveness has not yet been fully established. Complicating factors here are the broad range of AI virus types and the lack of a diva vaccine. Therefore our calculations for AI vaccination strategies, as they assume the vaccine to be effective in immunizing flocks, are of a more tentative character than those for the other scenarios.

2.1.4 Epidemiological issues: general aspects of the transmission dynamics and control

In order to understand the crucial factors that determine the level of success in controlling an epidemic, it is instructive to review the broad structure shared by epidemics in livestock of all three list-A diseases considered here. This will also allow us to introduce some epidemiological terminology that will be used further on in this report.

2.1.4.1 Threshold behaviour and risk of epidemic spread

The impact of interventions in disease transmission is hardly ever proportional to the invested amount of intervention effort. This property arises from the threshold behaviour of the transmission process: if each case of infection (infected farm in our context) on average generates at least one new case of infection, the epidemic will progress; if not, the epidemic will die out of its own. 'The threshold value of the reproduction number is equal to one' (Anderson and May, 1998, p67; J.D. Murray, 1993, p613; Edelstein-Keshet, 1988, p247), is another way of phrasing this. Here the reproduction number is defined as the number of secondary infections caused by one primary infection throughout its infectious period. Indeed, at least one secondary infection on average per primary infection is needed for the transmission chain to be maintained.

As a result of the threshold behaviour, the effectiveness of interventions depends on the amount of invested effort in a non-linear manner. For example, if the reproduction number can be brought below one by a small extra intervention effort, this small extra effort has a very large impact.

A very important epidemiological determinant that can be estimated directly from agricultural census data is the local farm density. To a large extent, this quantity determines the potential for local farm-to-farm spread that remains in the presence of emergency movement restrictions and bio-security measures. This local transmission potential, measured by the reproduction number (corrected for movement restrictions and bio-security measures), increases with increasing local farm density. As a result, the threshold behaviour of the transmission process leads to the distinction of two types of areas depending on farm density: one of low risk, where the local transmission potential, is below one and thus insufficient to cause sustained transmission; and a second one of high risk, where the (local) reproduction number exceeds unity and thus further interventions are required to achieve epidemic control.

2.1.4.2 Risk of introduction of the infection into the country

In the European Community, of the three diseases considered in this study, CSF arguably is the most often introduced into livestock. In European countries where CSF is endemic in the wild boar population, outbreaks in domestic pigs occur quite frequently. For this disease the active surveillance, discussed in the next section, in various member states is relatively intensive. Measures aiming at reducing the introduction risk include regulations against swill feeding, and combating endemic CSF in the wild boar reservoir through vaccination. Such measures are described in the "Manual for combating CSF in wild boar" (Anonymously, 1999), which also provides guidance for estimations of the size of the wild-boar population. We note that the problem of determining the adequate spatial scale of CSF vaccination territories for wild boar can only be solved based on an analysis of the transmission dynamics. The same is true for the determination of the required spatial scale of epidemic control strategies such as those studied in this report.

For FMD, introduction risks are much lower than for CSF. The same holds for (highly-pathogenic) AI, yet the trend in the number of primary outbreaks in the past 50 years is suggestive of an increase in introduction risks (Alexander, 2000). Introduction of HPAI might often occur through a virulence shift from an AI strain of low pathogenicity upon transmission from one poultry farm to another (Suarez et al., 2004; Ferguson et al., 2004).

Apart from its historic importance due to the recent FMD epidemic in Britain and its spill-over counterparts in Ireland, France and The Netherlands, FMD is an epidemiologically important representative of List-A diseases in livestock due to its high transmissibility between farms. In particular, estimates from the recent FMD epidemic in Great Britain of transmission parameters pertaining to a situation where a movement standstill and bio-security measures have been implemented, indicate that self-sustaining local transmission in that situation is already possible for moderate farm densities of the order of 1 farm per km^2. The low introduction risk but high risk of a large epidemic for FMD is in sharp contrast with the situation for CSF, where the relatively high introduction risk is accompanied by a much higher estimated minimum farm density required for self-sustaining local spread in the presence of movement standstill and bio-security measures. This contrast illustrates an important issue in assessing epidemiological risks as well as in developing policies aimed at risk reduction: risk of introduction and risk of spread are independent types of risks that need to be considered together in order to assess the efficacy of risk-reduction strategies.

2.1.4.3 High-risk period: transmission throughout the country

We define the high-risk period (HRP) as the period between the first introduction and the first detection of the infection in the member state. As there are no control measures in place during this period (except possibly a local movement standstill upon suspicion, immediately preceding the first confirmed detection), the infection can ‘freely’ use the available transmission routes to spread from the location of the primary outbreak to produce secondary outbreaks on other farms.

In practice this does not necessarily mean that secondary outbreaks actually occur. If the local farm density and contact frequencies are such that the local reproduction number is below one, the transmission chain will terminate within at most a few generations of infection, possibly already after the first outbreak. Even if the local reproduction number is above one, the transmission chain may terminate early by pure chance, again possibly already after the first outbreak. Indeed, we believe that some of the very small epidemics or isolated outbreaks reported in EU member states in the past have remained small or isolated by pure chance.

If the local reproduction number is above one (in an area comprising a sufficient number of farms) and the transmission chain does not terminate early, self-sustaining transmission will occur. In that case, the length of the HRP and the transmission intensity during the HRP are both critical determinants of how widespread the infection already has become within the member state at the moment that intervention measures are initiated. Consequently, these also determine the spatial scale at which intervention measures have to be implemented, and thus the scope for intervention success given the limits on resources and on logistics (i.e. speed of implementation). For example, for highly transmissible pathogens as FMD virus and highly-pathogenic AI virus, a few days difference in the length of the HRP could make a big difference in terms of the prospects for successful intervention.

2.1.4.4 Strategies to minimize the impact of the high-risk period

Measures designed to reduce the impact of the HRP may relate to either reducing the transmission potential during this period or to reducing the expected duration of the HRP. The first can be achieved by constraining the structure and the frequency of contacts between farms. An effective means to do this is imposing routine animal movement restrictions. An important example are animal standstills imposed on farms after buying in animals, for example in England and Wales for pigs (20 days) and for cattle and small ruminants (6 days). In The Netherlands cattle farms that have purchased ruminants are kept closed for 21 days (Dutch legislation, 2004). These national regulations are endorsed in the Commission’s Decision (2001/327/EC): concerning restrictions to the movement of animals of susceptible species with regard to foot-and-mouth disease.

The standstill regulation for cattle and small ruminants in England and Wales was introduced after the 2001 FMD epidemic, in which intensive sheep movements were particularly damaging contributors to transmission within the high-risk period (Ferguson et al., 2001; Mansley et al., 2003).

There are several ways to reduce the expected duration of the HRP. Intensive routine surveillance is an important instrument for reducing this duration through early detection of outbreaks. This instrument is used by several members states in the context of CSF. The EU Directive 90/638/EEC and Directive 2002/943/EEC lay down Community criteria for surveillance programmes for a number of animal diseases and zoonoses. Mathematical modelling can be used to evaluate the effectiveness of possible surveillance strategies (Klinkenberg et al., 2004).

Other duration-reducing measures relate to enhancing alertness and preparedness. For CSF there is a need for improvement on both fronts in several member states according to the most recent FVO reports. Country-specific information from FVO mission reports about the prevention and control of epidemic diseases such as CSF, are available at: http://europa.eu.int/comm/food/fs/inspections/. "Alertness" includes training of veterinarians in early recognition and "preparedness" includes minimizing the expected delay due to confirmatory testing of the first detected outbreak, a clear organization of a chain of command, contingency planning, and role-playing exercises (for a recent example see http://www.defra.gov.uk/news/latest/2004/280604hornbeam.htm). Better preparedness enables the authorities to be faster in putting movement restrictions and bio-security measures into place. Clearly, contingency planning is also important for being able to quickly initiate further interventions such as emergency vaccination and the culling of contact herds. To enable the tracing of contacts between farms, preparedness in the form of a good registration system of animal movements is important. Requirements of central animal identification databases and registration of holdings are discussed in the EU Directive 64/432/EEC on animal health problems affecting intra-Community trade in bovine animals and swine.

Contingency plans for the initiation of intervention measures and eradication plans for certain diseases are regulated by a multitude of EU directives: 90/638/EEC laying down Community criteria for the eradication and monitoring of certain animal diseases, 90/424/EEC on expenditure in the veterinary field, 2002/943/EEC on approving programmes for the eradication and monitoring of certain animal diseases and for the prevention of zoonoses presented by the Member States for the year 2003, 2001/89/EC on Community measures for the control of CSF, 2003/85/EC on community measures for the control of foot-and-mouth disease, and 92/40/EEC introducing community measures to control avian influenza.

Many national contingency plans are currently under revision as a consequence of FVO mission reports and recent outbreaks. Member states are obliged use contingency plans that are updated and approved by the Commission, and to implement this planning uniformly throughout the member state, e.g. rejecting the use at sub-national levels of planning documents that are not approved by the Commission.

2.1.4.5 Disease-combat period: local transmission

When the high-risk period comes to an end through the initiation, as a minimum, of the intervention measures required by EU legislation, the different phase is entered, that we will name the "Disease-combat period" (DCP) here. In this phase, that lasts until the end of the epidemic, the movement restrictions should make long-range transmission events unlikely, such that the vast majority of remaining transmission events occurs between farms that are located near or fairly near to each other.

Apart from the level of compliance with movement restrictions and bio-security measures, a further critical determinant of the rate of spread during the DCP is the length of time between infection of a farm and the stamping-out of this farm. This length of time is determined by the timeliness with which clinical signs are reported and by the timescale on which the required on-farm slaughtering and subsequent carcass removal can be accomplished. Thus we can distinguish a number of different factors that are important here: level of monitoring, awareness of clinical signs, intervention capacities and intervention logistics, the so-called mitigation factors.

Unless the decision is taken to cull farms on suspicion, a further important determinant is the speed with which confirmatory laboratory tests are completed. Minimizing the period of time between infection and stamping-out is of paramount importance. This is because the longer this period, the more transmission events will occur from the infected farm to previously unaffected farms, in particular to near-by farms. Given a sufficiently high farm density and a given maximum slaughtering and destruction capacity, it is possible to estimate a critical value for the expected period of time between infection and stamping-out. If this period cannot be brought or kept below the critical value, local transmission will be self-sustaining, i.e. no control is achieved, even if pre-emptive culling is carried out at maximum capacity in addition to the minimum EU requirements for control.
Although most transmission events during the DCP should occur over fairly short distances, the enforcement of a EU-type or wider standstill zone cannot at all times prevent the transmission of the infection to outside this zone. As happened in the 2003 AI epidemic in The Netherlands (Koopmans, 2004), transmission may occur to a previously unaffected, geographically distinct, densely populated livestock area, seeding a second locally propagating epidemic. If such a transmission occurs, the increased awareness of the infection is likely to result in a much quicker diagnosis than for the original first outbreak, possibly leading to better prospects for quickly achieving control.

2.2 Economic aspects

Obviously, these epidemics can have large economic consequences for farmers but also for other various stakeholders (agribusiness, tourism, etc.). For example, the economic losses due to FMD in the UK in 2001, to CSF in The Netherlands in 1997 and to AI in Italy in 1999-2000 were estimated at 12,500 mEuro, 2,300 mEuro and 500 mEuro respectively (the first estimate is the overall loss including losses in sector tourism and price effects, while other two comprise direct loss and partly consequential loss, ignoring for example price effects).

Economic losses incurred by epidemics of contagious livestock diseases can be divided into various categories. An intuitive distinction can be made between direct losses and indirect or consequential losses. Direct losses refer to the costs of the execution of the eradication campaign reflected by, for instance, the value of destroyed animals and the organisational costs such as the monitoring of farms in restriction zones. Consequential losses are the ‘long-term’ consequences due to movement restrictions and market disruptions. Examples of consequential losses are losses as a result of business interruption, losses related to established restriction zones, additional repopulation costs and price effects.

Price effects depend to a large extent on the fact whether a country in which an outbreak occurs is an importing or exporting country with respect to products involved. For exporting countries these price effects may result in enormous losses, exceeding the direct losses many times.

Different export rules apply per disease and control strategy, affecting distinct economic losses. The OIE and EU trade regulations are summarised below.

In case of FMD, the export to EU countries from the surveillance area's is banned till 1 month after regaining the status of FMD free country and 6 months if vaccination is not followed by slaughtering of all the vaccinated animals. For the animals and animal products from outside the surveillance area's there are no restrictions on export to other EU countries, while for other countries the export ban is according the general rule of OIE. In case vaccination is applied as a control measure, vaccinated animals cannot be exported to other EU countries. The export of meat will be possible. The conditions for these exports will be decided during the outbreak of the disease.

If emergency vaccination has been practised within the CSF domestic pig control area, recovery of the free status can not occur before all vaccinated pigs have been slaughtered, unless there are validated means of distinguishing between vaccinated and infected pigs.

Export from former contaminated area's is possible as the OIE regulation for an AI-free declaration is fulfilled: that is if 6 months without a contamination are passed. This involves products like consumption eggs, egg products, hatching eggs and meat. The countries outside the EU have to decide to cancel the trade restrictions. This can be in accordance with OIE regulations but also for a longer period. The trade restrictions within the EU for surveillance area's are cancelled if during 60 days no contamination of new farms has occurred. In case of vaccination the first 60 days after the last outbreak of AI on a farm all vaccinated animals cannot be transported outside the vaccination area, export of vaccinated and non-vaccinated animals and animal products from the vaccination area is not allowed and have to be sold on the domestic market. In the period from 60 days to 6 month after the last outbreak vaccinated animals cannot leave the vaccination area unless to go to a slaughterhouse. The products of non-vaccinated animals of a farm with no vaccinated animals that is within the vaccination area can be exported freely. The products of vaccinated animals can be exported to other EU countries after being tested for AI. From 6 months after the last outbreak until the last vaccinated animal is slaughtered, export of meat of vaccinated animals to the world market is possible, after being tested on AI.

2.3 Social-ethical aspects

Recent studies concerning FMD outbreaks in the UK and .The Netherlands have tried to clarify sociological and psychological consequences of animal epidemics on the farming community, the changing views in society concerning the role of the rural community , the ethical problems concerned with the mass slaughter of healthy animals and the consequences for animal welfare. Although the studies focussed on FMD outbreaks in the UK and The Netherlands, the issues concerned with this disease are relevant to other diseases such as CSF and AI and to other countries in the EU as well.

2.3.1 Animal welfare and related ethical aspects

2.3.1.1 Animal welfare

The animal welfare problems encountered during the recent animal disease epidemics resulted in a major public debate. The Farm Animal Welfare Council (2002) (FAWC), the Royal Society for the Prevention of Cruelty to Animals (RSPCA) (Laurence, 2002), and Compassion in World Farming in the United Kingdom, and the Dutch Society for the Protection of Animals (Berg,

2001) have monitored, evaluated and criticised the applied control strategy during the FMD crises in the United Kingdom and The Netherlands with respect to animal welfare. Below, the major findings of these reports are described.

Killing

With regard to killing, the following points of criticism were observed:

- unsuitable conditions for slaughter on the farm, reduced killing options and inappropriate killing methods;
- handling and slaughter was sometimes done by unskilled personnel;
- concern about the inappropriate sedation, stunning and killing methods, sometimes leading to situations that still conscious animals were slaughtered;
- the level of veterinary supervision at the slaughter was sometimes questioned.

Movement restrictions

With regard to reduced welfare due to movement restrictions, the following points of criticism were reported:

- uninfected animals may have suffered severe welfare problems (or were killed unnecessarily due to for example overcrowding);
- shortage of fodder, bedding, adequate shelter, or use of fresh land;
- sick, injured or pregnant animals did not always receive adequate veterinary attention.

Movement licences in the United Kingdom were issued for transport, grazing, treatment and gathering and were subject to veterinary checks and done in such a way as to balance the welfare needs of the animals with the need to control the epidemic. A Livestock Welfare Disposal Scheme was introduced to move the animals off the farm in order to alleviate welfare problems due to overcrowding, causing physical problems due to the rapid growth speed in poultry, and aggression and cannibalism in pigs. The licensing arrangements, though, were criticised for their bureaucratic nature, often leading to unacceptable delays (Crispin *et al.,* 2001; Laurence, 2002).

Transport

In the United Kingdom mainly sheep were not killed on-site but transported to mass burial sites. These animals were often transported at a stage in their life cycle or under conditions that were unusual, such as pregnant ewes or very young or sick animals. Transport sometimes took place over long distances and several reports of ewes lambing in transit were received.

2.3.1.2 Related ethical aspects

In the ethical discussion about the killing of animals, four arguments have been put forward to support the moral notion that animals have a right to our protection and a right to live:

- killing denies the animal potential future welfare and future positive experiences;
- animals have a preference to live, however this cannot be easily proven. Nevertheless, most ethicists feel that only animals with self-consciousness possess this rational notion of living as opposed to not living;
- animals are a ‘subject of life’ and have a right to a natural course of life. In this respect, the following criteria are of interest: 1) animals should possess emotions such as preferences and convictions (to possess the capacity to reach preferred goals), desires, inner life, sensations of pain, pleasure, memories and a sense of the future, and 2) animals should have an inherent value. Some problems arise from the differences between humans and ‘higher’ (complex, such as vertebrates) animals as opposed to ‘lower’ (less complex, such as invertebrates) animals.

- animals have an intrinsic value, hence there should be a respect for 'the natural course of life' which implies that the killing of animals is morally problematic because it interferes with the natural course of life, and therefore requires sufficient justification.

In 2003, Noordhuizen-Stassen performed a sociological and normative-ethical study into the societal and moral acceptability of the killing of kept animals. The aim was to describe and analyse the opinion of the Dutch public (The Netherlands experienced three major outbreaks in seven years) about the circumstances in which the killing of animals is acceptable and justified and in which circumstances the killing of animals is problematic from a moral point of view. The study aimed to formulate a normative viewpoint, supported by society, on the moral acceptability of killing animals The study included a random sample of the Dutch population of 1939 respondents. The main conclusions were:

- 71% of the respondents considered killing and destruction of infected animals during an outbreak of an epidemic animal disease acceptable, considering the disease is highly contagious to other animals, for 10% this is not acceptable;
- 78% considered killing of non-infected pigs for reasons of economic interest not acceptable;
- many respondents criticised a control strategy based on economic motives;
- the inconsistency of a policy of non-vaccination while at the same time products of vaccinated animals are imported was criticised;
- killing of animals to avoid future animal welfare problems due to movement restrictions was not considered a preferable option since vaccination provides an alternative;
- the majority of the respondents were in favour of vaccinating susceptible animals.

Noordhuizen-Stassen (2003) concluded that 1) a re-evaluation of the EU non-vaccination policy, a re-structuring of the sector and an increased focus on the internal market would be supported by a majority of the Dutch public, 2) the development of a marker vaccine is considered a priority and 3) the majority of the respondents are of the opinion that the killing of healthy animals is morally unacceptable when the motivation is unreasonable or when alternatives are available.

2.3.2 Social aspects

2.3.2.1 The role of farming in society

With regard to the role of livestock farming in society, several studies were conducted (Haaften *et al.,* 2002; Stafleu *et al.,* 2004; Zijpp, 2002). The main conclusions of these studies were:

- the rural areas are used for livestock farming, but also for nature conservation, tourism, and housing, hence they are an area of public interest;
- not only farmers keep animals, many private owners keep and breed backyard animals or rare breeds as a hobby or as pets;
- society as a whole feels that present farming should be based on social, ecological and financial values, and farmers who are mainly guided by economic motives are criticised;

2.3.2.2 Sociological and psychological studies

After the last FMD outbreak in 2001 in the United Kingdom, an inquiry was made in North Cumbria into the health and social consequences of the crisis on farmers and their families, workers in related businesses, veterinarians and others directly involved (Cumbria FMD Inquiry Panel, 2002; Institute for Health Research 2002).

The findings of the study have identified several social and psychological aspects which should be considered:

- those directly involved had experienced a loss of control over the basic routines of life, they lived in a world of isolation;
- the role of communication was considered very important, and it was felt that communication and information exchange with the authorities had failed, e.g. delays in diagnosis, slaughter and disposal were reported and information and advice were constantly shifting;
- post traumatic stress symptoms were found in farmers and in frontline workers involved in the killing and disposal of the animals, which were caused by the stress created by circumstances over which they had little control;
- farmers experienced a loss of confidence in central and local decision-makers, and a loss of self-esteem and self-confidence due to a number of recent agricultural shocks in which their way of life and social identity was called into question;
- major traumas were caused by the severe restriction on animal movements, denying farmers access to their animals, the on-farm slaughter of healthy animals and the burning of the carcasses;
- both farmers and the non-farming businesses, such as the tourism sector, experienced a loss of work and income.

These findings were confirmed by a Dutch study, including 661 farmers (Haaften *et al.*, 2002). Other relevant findings were:
- it is important to realize that the working and private lives are intermingled, implying that also the direct private lives of farming families is affected;
- in the aftermath, farmers had to start from scratch again, however .due to all the problems described above, some were .not no longer able to make a new start;
- particularly in cattle farms, breeding lines are within the farm for generations, and loss of these animals sometimes affects the farming families. deeply;
- farmers were also frustrated because of the slow process of compensation payments;
- between 20% to 30% of the respondents suffered from socio-psychological problems with symptoms such as isolation, stress and depression. In was striking that particularly women seemed to suffer from these symptoms;
- Sometimes the emotional shocks farming families had to face during the epidemic were too great to initiate changes in their normal behavioural pattern.

Recommendations of this Dutch study included the emphasis that the severity of the situation and the vulnerability of the group require formal recognition and acknowledgement, and alternative ways to actively offer professional help need to be developed.

Another Dutch study focused on the general public (Huirne *et al.,* 2002). The FMD crisis had left a deep impression, particularly the way animals were killed and disposed of. Most people sympathised with the farmers and the way they were handled by the authorities. Emphasis was put on improved openness, co-operation, integrity, responsibility and trust in case new epidemics would occur. Moreover, the preferred strategy should comprise vaccination of all animals (70% of the respondents) and isolation (50% of the respondents); massive killing was rejected.

2.4 Trade-offs between epidemiological, economic and social-ethical aspects

Potential control strategies need to be evaluated on the basis of epidemiological, economic and social-ethical aspects. Therefore, the pros and cons of specific control strategies are discussed.

<u>Non-vaccination strategy</u>

The non-vaccination strategy comprises the standard EU control strategy, and may in addition comprise, among other possibilities, a pre-emptive slaughter strategy.

EU control strategy

The efficacy in terms of epidemiological parameters of the control strategy as laid down in EU directives if an outbreak arises, comprising 1) stamping-out of infected herds; 2) pre-emptive slaughter of contact herds; and 3) the immediate establishment of surveillance zones, is not straightforward, especially in densely populated livestock areas. There is a risk of large outbreaks which may result in the slaughter of millions of cattle, sheep, pigs and poultry as experienced in the last decade.

As a result, these epidemics can have large economic consequences for farmers but also for other various stakeholders (agribusiness, tourism, etc.). At the same time, there is less risk of export losses with the current regulations.

Several welfare problems and related ethical aspects should be addressed, such as welfare problems due to movement restrictions, and the problems concerned with the handling of animals, on-farm slaughter, killing methods, and transport are a big issue. So-called welfare slaughter can ease the welfare problems only partially. Also social consequences of the crisis on farmers and their families, workers in related businesses, veterinarians and others directly involved need to be addressed with this control strategy.

Pre-emptive slaughter strategy

An additional pre-emptive slaughter scheme in densely populated livestock areas can, on average, reduce the outbreak size and duration. In the short term direct losses will increase as a result of the additional slaughtering. But the expected economic losses could be lower because of the reduced outbreak size and duration which will result in reduced direct and consequential losses. With respect to the welfare problems the same arguments hold as for the default EU control strategy. Whether or not this control strategy dominates the default strategy depends on whether or not the average outbreak size is reduced.

Vaccination strategies

From an epidemiological and socio-ethical point of view vaccination can be an effective strategy to prevent or to eradiate the disease. However, this can have serious economic consequences. The amount of monetary losses ultimately depends on the kind of strategy chosen.

Preventive vaccination

Preventive vaccination is an effective strategy with respect to epidemiological aspects. However, at the moment the serotype specificity of the present generation of vaccines is a limiting factor. Research into improved vaccines for routine and global vaccination with broader specificity is needed, with the emphasis on the validation of marker vaccines, in order to distinguish between infected (antibody-positive following recovery after infection) and vaccinated-but-not-infected (antibody-positive after vaccination) herds.

In addition, this strategy is (currently) not efficient with respect to economic aspects concerned for net exporting counties under the current legislation. On average, a non-vaccination strategy outperforms economically a preventive vaccination strategy because of the vaccination costs and export limitations.

Preventive vaccination might be seen as the best option from an animal welfare perspective. In the studies described in this chapter a majority of the population (UK and The Netherlands) are of the opinion that preventive vaccination is an acceptable alternative to the killing of healthy animals. This view is also held by the FWAC and the Dutch Society for the Protection of Animals (3). However, in other areas this view is not supported.

Emergency vaccination

The epidemiological efficacy of emergency vaccination depends strongly on the area contained by the vaccination programme. The effectiveness of emergency vaccination against the spread of a disease is enhanced the earlier it is applied.

Losses from emergency vaccination, in cases vaccinated animals are destroyed, might arise from direct and consequential losses (business interruption, repopulation costs). Emergency vaccination-to-live is preferable from a welfare point of view. Animal epidemics and the slaughtering of animals are not restricted to farm animals or backyard animals. The lives of animals in nature reserves and zoos are in jeopardy as well. Vaccination-to-live may comprise non-infected animals, backyard and recreational animals, zoo animals and rare breed ruminants. Some people (e.g. Schaftenaar (2002)) suggest that emergency vaccination should be allowed in certain rare or valuable animals provided certain rules and restrictions are observed. Moreover, it is argued by certain stakeholders that zoos should be regarded as special areas where vaccination is applied without compromising the list A-free status of the rest of the country. However, it can also be argued that if the livestock population is vaccinated to control the outbreak, the changes that susceptible non-livestock animals will be infected is low.

With emergency vaccination-to-live as part of a control strategy, it should be accepted that meat and meat products from vaccinated animals enter the food chain normally. The latter is currently regarded as a problem, since meat and milk from vaccinated animals require special treatment. Furthermore, during the 2001 FMD crisis in the United Kingdom, the Nestle Company expressed serious reservations about accepting milk from vaccinated cows because of a perceived consumer reaction. This was referred to as the ‘Nestle factor’. Therefore, it was recognised that more attention should be given to the marketing of products of vaccinated animals. The risk of any danger associated with such products is considered to be low.

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2003/85/EC: on community measures for the control of foot-and-mouth disease

Internet site

FVO inspection reports: http://europa.eu.int/comm/food/fs/inspections/

Part II

3 A stakeholders' survey

Marcel van Asseldonk and Nina Cohen

3.1 Introduction

Preferences with respect to epidemiological, economic and social-ethical criteria will differ between stakeholders and between EU member states. Up to now, little research has been done to quantify these subjective weights. Different stakeholders are likely to have different ideas about the strategy to be chosen based on their views and their mission, which is to represent the interests of for example the farming community, the commercially involved secondary industry, the animals, or the consumer of food or recreation. This may create a situation of conflicting interests between stakeholders. Economic motives may prevail in the views of some, animal or human welfare motives may be prominent in the views of others. Each stakeholder will present arguments, which are considered relevant from their point of view.

The objective of this chapter is to provide a first insight into the preferences for control strategies by weighing criteria and indicators. These preferences are elicited by surveying CVOs and other stakeholders. In addition, perceptions and subjective knowledge related to epidemiological consequences of CSF, FMD and AI epidemics in the EU member states are elicited from the CVOs.

First the survey is described in terms of selection of stakeholders (3.2.1) and design (3.2.2). Subsequently, the analysis focuses the comprehensive CVO questionnaire (3.3.1) and the questionnaire mailed to other stakeholders (3.3.2), followed by discussion (3.4) and main conclusions (3.5).

3.2 Method

3.2.1 Selection of the stakeholders

A comprehensive survey was conducted among the CVOs of the EU member states because the CVO is nationally responsible for: 1) veterinary policy advice for the minister; 2) formal admittance of veterinary medicinal products; 3) veterinary disciplinary law; 4) animal welfare; and 5) crisis management. The CVO is internationally responsible for: 1) veterinary representation in international bodies (EU, OIE, FAO, WTO); 2) veterinary representation in third countries (outside EU); and 3) central coordination for all veterinary matters.

To ensure that the group of other stakeholders' surveyed were a representative selection of stakeholders present in the EU as a whole and per member state, thus reflecting the ideas of a broad range of people and views, the choice of stakeholders was based on a number of selection criteria. The selection criteria to be surveyed as a stakeholder are described below.

1) The stakeholder is a national representative of the European organisations organised in the Groupe Permanent "Questions Veterinaires", which are:
    - Committee of Agricultural Organisations in the EU: COPA;
    - General Committee for Agricultural Co-operation in the EU: COGECA;
    - European Liaison Committee for the Agri-food Trade: CELCAA;
    - Confederation of Family Organisations in the European Community: COFACE;
    - Confederation of the Food & Drink Industries of the EU: CIAA;
    - Eurocommerce;

European Community of Consumers Co-operatives: EUROCOOP;
European Consumers Organisation: BEUC;
European Federation of Trade Unions in the Food, Agriculture and Tourism Sectors and Allied Branches: EFFAT;
Federation of Veterinarians of Europe: FVE.

2) The stakeholder is a national representative of a European organisation which mission statement includes aspects concerning epidemic animal diseases and their economic, social or ethical consequences. Furthermore, the European organisation needs to represent a sufficient number of national organisations, preferably distributed evenly among the EU member states. The following organisations were selected:
   Eurogroup for Animal Welfare;
   Compassion in World Farming;
   Conseil Européen des Jeunes Agriculteurs : CEJA.
3) The stakeholder is a national organisation directly linked to other relevant organisations or departments such as the OIE, FDA or a Ministry.
4) Other relevant stakeholders chosen through personal communication and recommendation of experts in the field.

Approximately 600 stakeholders from the 25 EU member states have been approached. Since the stakeholders questionnaire was send to national representatives the questionnaire was available in five languages, namely English, French, German, Italian, and Russian.

3.2.2 Design of the questionnaire

3.2.2.1 Design preferences

The respondents had to imagine an epidemic of a contagious animal disease in their country in the near future. They were asked which criteria they think will be more important to determine the control strategy to be applied. Subsequently, the criteria are decomposed into a number of independent indicators and prioritised. These types of questions are applied in the CVO questionnaire as well as other stakeholder's questionnaire (Appendix A).

A major distinction in the design of the two questionnaires was that the CVO questionnaire was more comprehensive. CVOs prioritised criteria and indicators per disease while stakeholders prioritised a non-specific epidemic disease. A further simplification was that the stakeholders only focussed on the social-ethical related indicators and not the epidemiological and economic indicators. The simplifications were necessary because stakeholders might not be familiar with these specific technical elements. However stakeholders are more likely to be able to prioritise the three conflicting criteria and the social-ethical indicators.

The arbitrary choices of decomposing the criteria into indicators were made on basis of the design and the results of a previous Dutch study (Huirne et al., 2002) and by consulting experts. Six epidemiological indicators were used: 1) duration; 2) total number of infected farms; 3) size of the affected region; 4) total number of destroyed animals; 5) total number of herds on which animals are destroyed and 6) total number of non-farm animals destroyed. The duration of the epidemic was defined as the period between first infection until the lifting of the last restriction. Non-farm animals were defined as farm animals, such as poultry or cattle or related species, kept for non-farming purposes, in for instance zoos, sanctuaries, nature reservations, or in the domestic environment as pets or backyard animals.

Nine economic indicators were used: 1) direct farm losses; 2) consequential farm losses in affected region; 3) consequential farm losses outside affected region; 4) losses other participants; 5) losses non agricultural sectors; 6) organisation costs; 7) export restrictions EU markets; 8) export restrictions non-EU markets and 9) the amount tax payers had to contribute.

The respondents were presented with ten indicators for or against a control strategy. The arguments addressed in one or both type of questions are: efficacy; socio-economic factors; macro-economic factors, commercially interested parties, animal health; animal welfare; tourism; human health, governmental policy; non-farm animals; natural life-cycle and food source.

3.2.2.2 Design specific elements in CVO questionnaire

The specific elements in the CVO questionnaire consisted three parts, i.e. categories of questions related to: 1) introduction of infectious animal diseases; 2) transmission of infectious animal diseases; and 3) strategies to control infectious animal diseases. A distinction was made between FMD, CSF, and AI if this was recommendable. This part was an updated version of the CVO-questionnaire that was conducted in 2002 (Wilpshaar et al., 2002).

Category 1 related questions focussed on the estimations of CVOs about the expected occurrence of a CSF, FMD and AI-epidemics in their country and the main risk factors. The expected occurrence was elicited in the absence of any policy change regarding the prevention of introduction of the infection and in case an optimal policy would be applied. Under an optimal control strategy the manageable part of the risk of introduction is minimised, so that outbreaks are a result of uncontrollable risk factors (e.g., air and wild birds).

Category 2 related questions focussed on the estimations of CVOs about the expected size of a CSF, FMD and AI-epidemic in their country and the main risk factors concerning the transmission. The size of an epidemic was measured by the number of farms infected per sector, the duration of an epidemic and the area that is expected to be confronted with restrictive measures.

Category 3 related questions focused on the preferences of CVOs about strategies to control infectious animal diseases. The minimum EU requirements to control an outbreak of CSF, FMD or AI at this time include the following measures: 1) stamping-out infected herds and contact herds; and 2) surveillance and protection zones (3 km and 10 km). Elicited was the preference of control measures concerning additional and thus more stringent measures.

3.2.2.3 Design specific elements in stakeholders questionnaire

The specific elements in the stakeholders questionnaire consisted two questions, namely related to 1) the decision-making process and 2) priority aspects (Apendix B).

The first question aimed to describe the position of the stakeholder in the decision-making process concerning the choice of control strategy, thus obtaining further insight into the importance attributed to certain views in society, reflected by the composition of stakeholders invited to the discussion.

It can be argued that whether or not a certain stakeholder is involved in the decision-making process for the purpose of an updated contingency plan for future outbreaks, reflects its position in the public debate about animal diseases. Stakeholders with a direct economic involvement in the consequences of animal diseases and the applied control strategy, such as farmers, agricultural organisations and secondary industries are likely to have a prominent position in the decision-making process. Furthermore, involvement of local authorities and veterinarians, who are responsible for communicating and executing the strategy, are also indispensable partners in the discussion. But recent outbreaks have made clear that economic and epidemiological arguments are insufficient grounds to justify the choice of a strategy. Sociological, psychological and ethical aspects have obtained an increasingly prominent position in the public debate. A national government will recognise these views by inviting representatives of organisations such as animal welfare organisations, breeders and keepers of backyard animals, human health organisations, zoos, nature conservation, the tourism sector and consumer organisations to the discussion as well. Therefore, it is argued that the aspects that have received a prominent position in the national public debate and as such are acknowledged by the national authority are reflected in the spectrum of stakeholders involved in the decision-making process.

The second question aimed to obtain further insight into the priority aspects as presented by the stakeholders in the decision-making process. By means of a search of publications and reports about the experiences of recent outbreaks in the EU, five indicators could be identified as relevant aspects in the decision-making process: 1) communication and information procedure; 2) social, psychological and financial consequences for the farmers, their relatives and other workers directly involved; 3) animal welfare and related ethical aspects; 4) preventive measures and 5) reputation and position of the agricultural sector.

Respondents were invited to score the above-mentioned aspects, thus clarifying the stakeholders' priorities in the debate about future strategies. It could be assumed that the priority list of, for instance, a stakeholder in the food-processing industry will be different from the priorities of a nature conservation organisation, but this should not be taken for granted. The total of scores creates a priority list per member state and per category of stakeholder. In the public debate, though, this priority list cannot be presented as a starting point for a discussion about a future alternative strategy as an approach supported by *all parties concerned*, because the distribution of stakeholders governs the outcome but is not evenly distributed. Representatives of, for instance, secondary industries may outnumber the number of health aid organisations, and therefore may dominate the prioritising. The priority list merely clarifies the views per category of stakeholder per member state, and it is for the authorities to implement policy decisions, which reflect a compromise in the ideas of all parties concerned.

3.2.2.4 Measurement aspects and data analysis

Comparative rating scales were used for deriving relative judgements by dividing 100 points between criteria and indicators according to their importance. Comparative rating scales were also used for deriving relative judgements about risk factors concerning the introduction and transmission of an infection. By means of comparative rating scales respondents have to make judgements of each attribute with direct reference to the other judgements being evaluated (Churchill, 1995).

Three-point estimates were elicited to derive information concerning the chance of an outbreak, the number of infected farms, duration and radius of restriction zones. The simplicity by asking for minimum, most likely, and maximum values, in order to completely specify the so-called triangular probability distribution, makes it particularly useful in cases when no sample data are available and the distribution is to be assessed wholly subjectively (Hardaker et al., 1997).

Likert-type scales ranging from 1 to 7 were used to elicit information about strategies to control infectious animal diseases. By means of Likert-scales respondents were asked to indicate their degree of agreement or disagreement with each and every statement in a series by checking the appropriate cell (Schuman and Presser, 1981; Churchill, 1995). Open-ended questions were only used for eliciting absolute values.

3.3 Results

3.3.1 Analysis questionnaire CVO

3.3.1.1 Criteria and indicators

The response rate was about 80% (i.e. 20 questionnaires). Descriptive statistics of the importance of criteria and indicators are depicted in Figures 3.1A up to 3.1E. Since differences between diseases are marginal the weights of the criteria are aggregated by averaging over the diseases.

As can be seen from Figure 3.1A heterogeneity between CVOs exists. The individual weights are presented anonymously (left side of the figure). Since not all CVOs completed this part of the questionnaire the number of observations was less then the number of respondents. For the CVO sample as a whole the epidemiological criterion was the most important one. The preferred weight for the epidemiological criterion ranged from 37% up to 100%.

CVOs preferred the epidemiological criterion with an average relative importance of 53% (right side of the figure), with a standard deviation of 17%. Corresponding average weights for the economic and social-ethical criteria were 30% and 17% respectively (and standard deviations of 10% and 9% respectively).

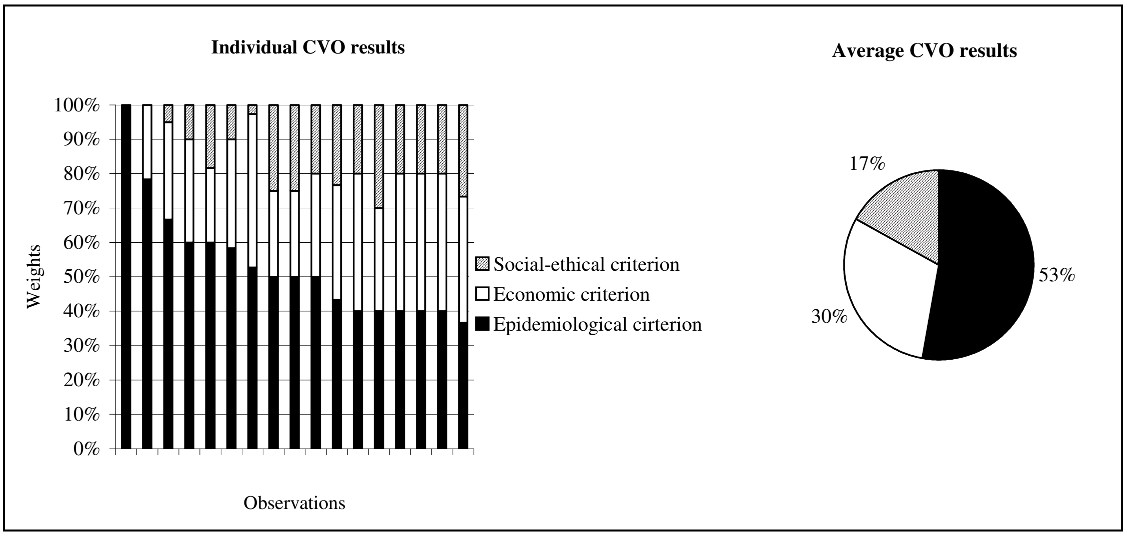


Figure 3.1A: Preferred weights per criterion.

Duration of the epidemic (28%) and the size of the affected region (25%) were regarded as the two most important epidemiological indicators (Figure 3.1B). However, there was a substantial heterogeneity between CVOs. For example, the minimum, maximum and standard deviation of the duration indicator were 0%, 62% and 15% respectively. Corresponding values for the size indicator were 13%, 43% and 7% respectively.

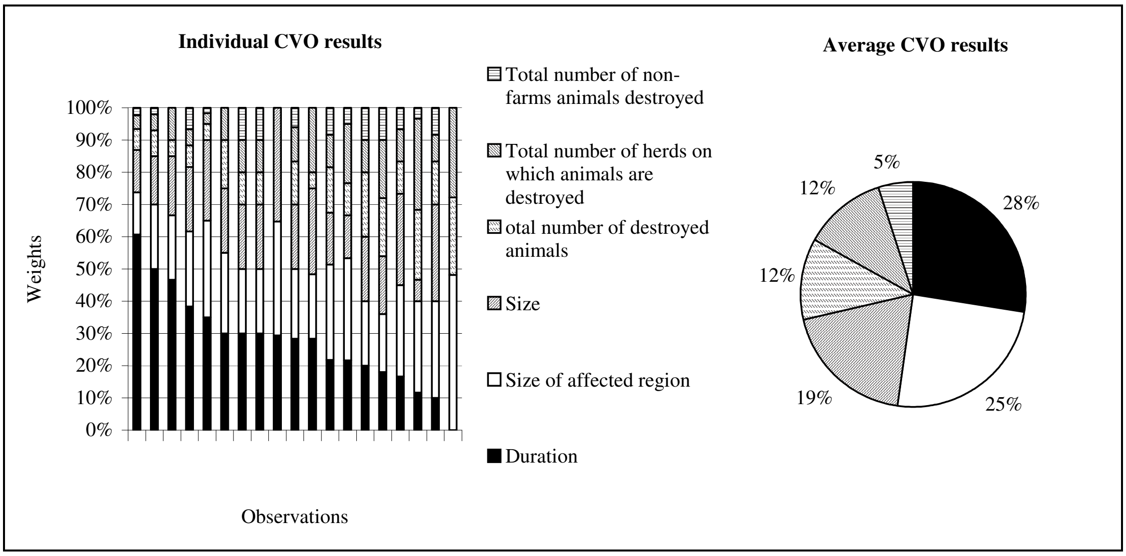


Figure 3.1B: Preferred weights per epidemiological indicator.

Differences between the relative weights of economic indicators were not as profound as the epidemiological indicators. Direct farm losses (15%) and consequential farm losses in affected region (14%) were regarded as the two most important economic indicators (Figure 3.1C). The minimum, maximum and standard deviation of the direct farm loss indicator were 2%, 30% and 8% respectively. Corresponding values for the size indicator were 3%, 22% and 5% respectively.

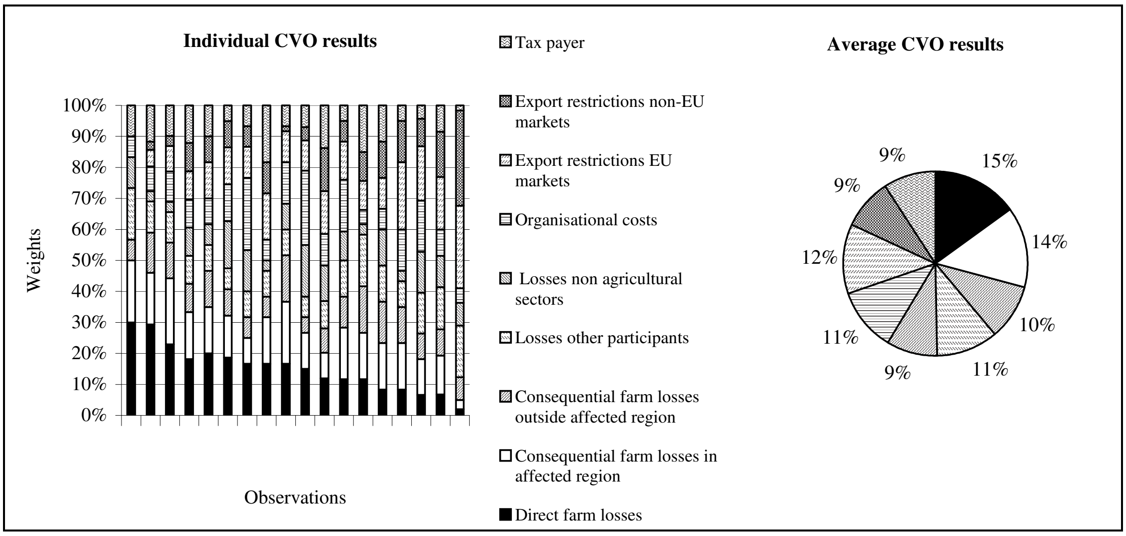


Figure 3.1C: Preferred weights per economic indicator.

The relative weights for the social-ethical indicators are presented in Figure 3.1D and 3.1E. In general, efficacy and social-economic factors were considered as the most important indicators.

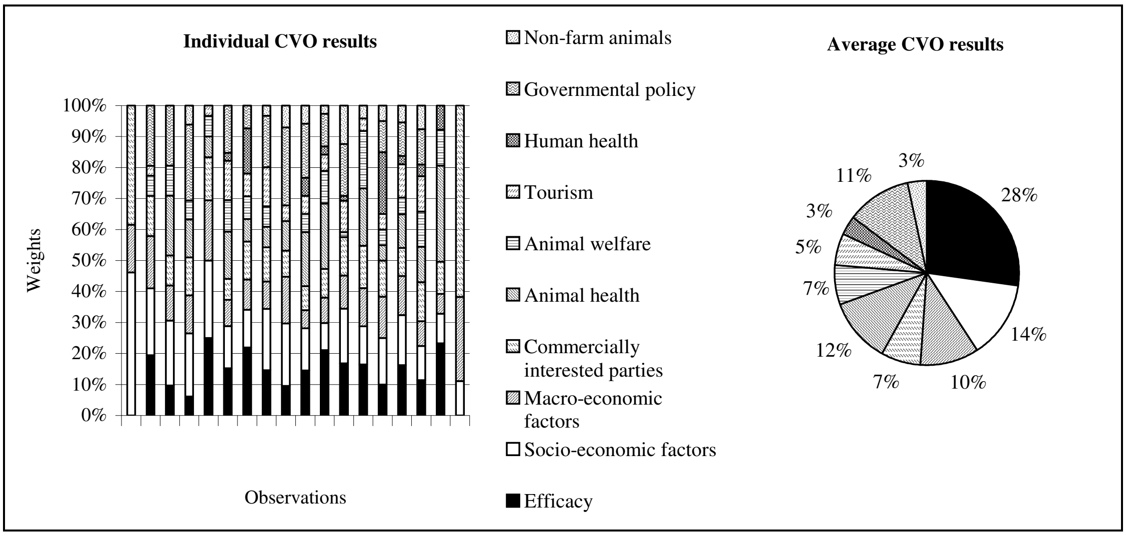


Figure 3.1D: Preferred weights per social-ethical indicator in support.

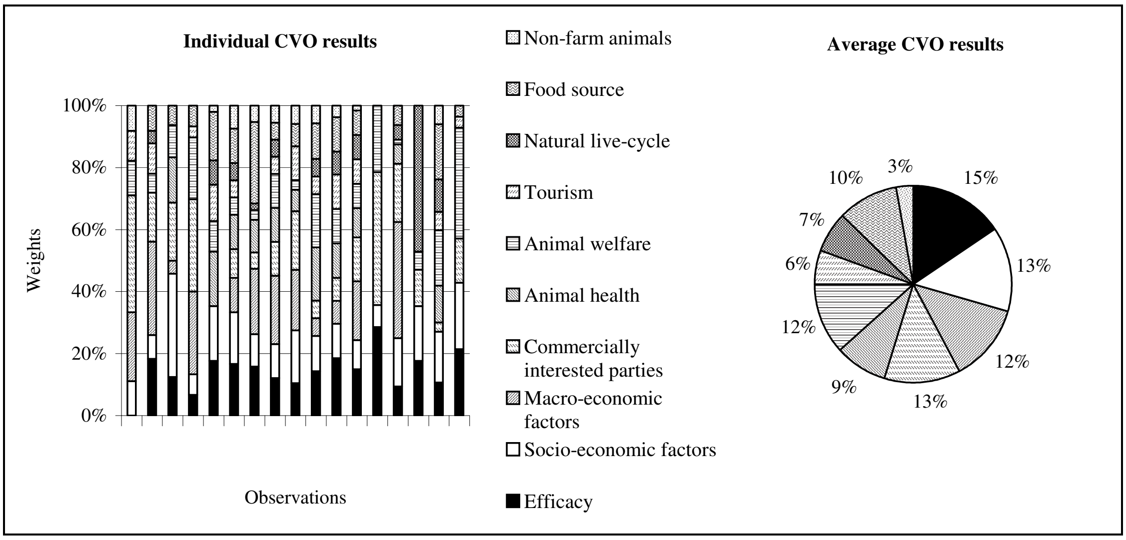


Figure 3.1E: Preferred weights per social-ethical indicator against.

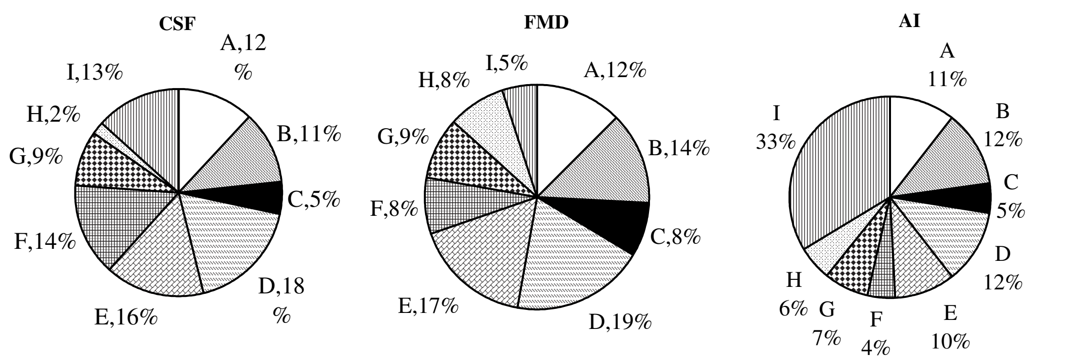
3.3.1.2 Introduction of infectious animal diseases

In Table 3.1 the averages of the most likely, minimum and maximum estimated values of the occurrence of an outbreak are depicted (three-point estimates). Also more extreme probabilities for each disease called ‘optimistic’ and ‘pessimistic’ are shown. CSF is most likely to occur, on average, 1.75 times per member state in the next 5 years. FMD is likely to occur, on average, 0.50 times and AI 1 time per member state in the next 5 years. The elicited values indicated skewed distributions, whit a longer tail to right than to the left.

Table 3.1: Subjective estimations of CSF, FMD and AI outbreaks per country for 2005 to 2010 in the absence (A) of any policy change regarding the prevention of introduction of the infection into your country, and in case an optimal policy (O) would be applied.

	Mean		Optimistic (25% percentile)		Pessimistic (75% percentile)	
	A	O	A	O	A	O
CSF most likely	1.75	0.75	0.00	0.00	2.00	1.00
CSF minimum	0.19	0.00	0.00	0.00	0.00	0.00
CSF maximum	6.38	2.88	1.00	1.00	5.50	2.50
FMD most likely	0.50	0.13	0.00	0.00	1.00	0.00
FMD minimum	0.06	0.06	0.00	0.00	0.00	0.00
FMD maximum	2.94	1.13	1.00	1.00	3.25	1.00
AI most likely	1.00	0.81	0.00	0.00	1.25	1.00
AI minimum	0.13	0.06	0.00	0.00	0.00	0.00
AI maximum	7.94	3.00	1.75	1.00	6.25	3.00

The importance of different risk factors for the introduction of CSF, FMD and AI are elicited by means of comparative rating scales (Figure 3.2). The results show that there is a substantial variation in expectations about the importance of different risk factors between the three diseases.



A: Legal import of livestock, B: Illegal import of livestock, C: Legal import of animal products, D: Illegal import of animal products for personal consumption (tourists), E: Illegal import of animal products for trading purposes, F: Swill feeding, G: Returning empty livestock trucks, H: Air, I: Wildlife (e.g. wild birds, feral, wild boars)

Figure 3.2: Subjective rating scores of the relative importance of risk factors that cause the introduction of the virus.

3.3.1.3 Transmission of infectious animal diseases

In Table 3.2 the most likely, minimum and maximum estimations for the size of epidemic are shown. Included were the number of farms infected, the duration of an epidemic (expressed in days) and the area that is expected to be confronted with restrictive measures.

For CSF, the average most likely value of the number of pig farms that will be affected is 8 with an expected minimum of 3 and an expected maximum of 49 (during the 5-year period). The duration of the epidemic is estimated to last 74 days with an expected minimum of 43 days and an expected maximum of 150 days. The expected size of the affected area is 1,528 km^2 with an expected minimum of 573 km^2 and an expected maximum of 5,654 km^2. Again also more optimistic and most pessimistic individual-member state scenarios are shown by means of the 25% and 75% percentiles respectively. Also the corresponding values for FMD and AI depicted.

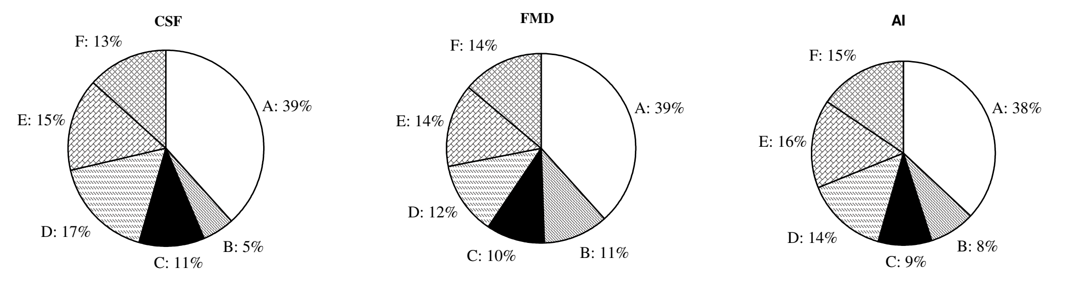
Table 3.2: Subjective estimated size of CSF, FMD and AI-epidemics for the period 2003-2008.

	Most likely			Minimum			Maximum		
	Mean	25%	75%	Mean	25%	75%	Mean	25%	75%
CSF									
Number of pig farms detected	8	4	10	3	1	3	49	5	75
Duration of epidemic (days)*	74	40	80	43	29	45	150	61	180
Area that is affected (km^2)**	1,528	50	2,500	573	25	454	5,654	80	10,000
FMD									
Number of pig farms detected	9	4	13	3	1	4	90	9	43
Number of cattle farms detected	13	5	15	5	1	4	181	18	63
Number of sheep and goat farms detected	7	2	9	9	5	10	7	2	10
Duration of epidemic (days)*	2	0	5	4	0	4	26	10	38
Area that is affected (km2)**	86	60	88	46	29	58	166	90	195
AI									
Number of poultry farms detected	13	3	13	4	1	4	63	11	63
Duration of epidemic (days)*	76	35	68	47	30	49	149	90	173
Area that is affected (km2)**	1,479	50	2,000	787	25	454	5,456	80	8,000

* Period between first detection until the lifting of the last movement restriction.

** Total area that is infected and under restrictions.

The importance of different risk factors for the transmission of CSF, FMD and AI are elicited by means of comparative rating scales (Figure 3.3). Differences between the diseased of risk factors that cause the transmission of the virus were not that profound than the risk factors that cause the introduction of the virus.



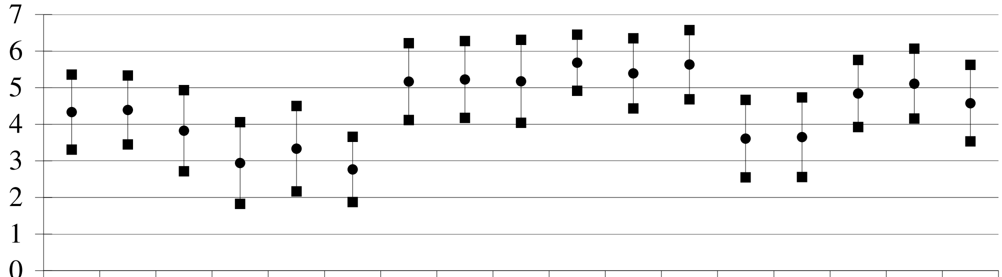
A: Movement of infected animals, B: Airborne spread, C: Movement products of infected animals, D: Vehicles (especially those used for transporting animals), E: Contacts by professionals (e.g. artificial inseminators, veterinarians), F: Unknown / Neighbourhood

Figure 3.3: Subjective rating scores of the relative importance of risk factors that cause the transmission of the virus.

3.3.1.4 Strategies to control infectious animal diseases

In Figure 3.4 the additional control measures (7-point Likert scale answers) and in Table 3.3 the estimated radius and duration movement standstill (open ended answers) are subsequently depicted. With respect to the Likert scales scores of 1 and 7 were defined as not likely and likely respectively.

Pre-emptive slaughter as a means to prevent further transmission (strategy C) and welfare slaughter of animals that are ready to be delivered (strategy D) were regarded as the most likely strategy for controlling CSF, FMD and AI. The corresponding average radius with pre-emptive slaughter was for CSF, FMD and AI, 0.97 km, 1.74 km and 1.71 km respectively.



	A, CSF	A, FMD	A, AI	B, CSF	B, FMD	B, AI	C, CSF	C, FMD	C, AI	D, CSF	D, FMD	D, AI	E, CSF	E, FMD	F, CSF	F, FMD	F, AI
+1/2 Std.	5.36	5.33	4.93	4.06	4.50	3.66	6.21	6.27	6.31	6.45	6.35	6.58	4.67	4.74	5.76	6.06	5.62
-1/2 Std.	3.30	3.45	2.72	1.83	2.17	1.87	4.12	4.17	4.04	4.92	4.43	4.69	2.55	2.56	3.93	4.16	3.53
Mean	4.33	4.39	3.82	2.94	3.33	2.76	5.17	5.22	5.18	5.68	5.39	5.63	3.61	3.65	4.84	5.11	4.58

A: Emergency vaccination + destruction of vaccinated animals, B: Emergency vaccination without destruction, C: Pre-emptive slaughter, D:Welfare slaughter of animals that are ready to be delivered (25-kg pigs, 110-kg hogs, birds), E: Welfare slaughter of very young piglets (< 7 days), F: Breeding prohibition of sows and hatching prohibition

Figure 3.4: Subjective estimations additional measures applied if an outbreak would occur in the near future in the most densely populated livestock area (1 = not likely and 7 = very likely).

Table 3.3: Subjective estimations most likely radius of pre-emptive slaughter and duration of a movement standstill if an outbreak would occur in the near future in the most densely populated livestock area.

	CSF		FMD		AI	
	Average	Std.	Average	Std.	Average	Std.
Duration complete movement standstill* (hours)	38.77	30.26	46.46	30.26	23.08	30.26
Duration partial movement standstill** (hours)	77.45	57.14	86.18	57.14	62.18	57.14
Radius with pre-emptive slaughter*** (km)	0.97	0.70	1.74	0.70	1.71	0.70
Radius in which emergency vaccination is applied**** (km)	3.92	3.57	4.62	3.57	4.13	3.57
Radius with vaccination but without destruction (km)	7.79	7.78	12.13	7.78	11.00	7.78

3.3.3.5 Multi-variate analysis criteria

In order to illustrate the heterogeneity of the relative importance of criteria and indicators between CVOs, the data was split into two subsamples. The classification was based on average weight for the epidemiological criteria. Corresponding descriptive statistics of a number of relevant factors are presented as well. Included were the chance of introduction and transmission, and whether it is a net exporting or net importing EU member state (Table 3.4).

Comparison of the subsamples indicated that a higher weight for the epidemiological criteria was associated with a relative higher perceived chance of introduction and transmission, and were net importing member states. However, the difference between the subsamples with respect to these factors were non-significant (also indicated by the relative larges standard deviations).

Table 3.4: Average and standard deviation per subsamples.

Epidemiological criteria	above average		less than average	
	Average	Std.	Average	Std.
Economic criteria	22.22	11.67	34.97	6.70
Social-ethical criteria	7.22	7.04	21.15	7.02
Introduction[1]	1.23	1.08	1.16	1.21
Spread[2]	1.38	0.91	1.33	1.30
Export pigs[3]	0.00	0.00	0.27	0.47
Export cows[3]	0.00	0.00	0.36	0.50

[1] Normalised chance of introduction with 1 as average chance for the pool as a whole

[2] Normalised chance of outbreak size with 1 as average chance for the pool as a whole

[3] 1 is net exporting and 0 is net importing

3.3.2 Analysis questionnaire stakeholders

3.3.2.1 Criteria and indicators

The response rate was about 10%, excluding the response rate of the CVOs questionnaire. Descriptive statistics of the importance of criteria and indicators are depicted in Figure 3.5, 3.6 and 3.7. The stakeholders were clustered according to the number of responses, resulting in four main clusters.

1) CVOs
2) agricultural category: a) Agricultural industries and organisations; b Secondary industry such as retailers, food processors, tourism sector, and other allied branches; c) Unions;
3) non-agricultural category: a) Consumer organisations; b) Organisations for social aspects, human health or religion; c) Organisations for animal welfare and protection, breeders and keepers of rare breeds or backyard animals; d) nature and environmental organisations.
4) veterinarian category: a) (academic) veterinary research; b) veterinarians involved in the decision making process; c) representatives of the Federation of Veterinarians of Europe .

The average number of observations per question of the 61 returned questionnaires (in addition to the 20 CVO questionnaires) for the agricultural category, non agricultural category and veterinarian category were, 20, 10, and 20 respectively. The remaining were categorised as miscellaneous.

For the stakeholders sample as a whole the epidemiological criteria was the most important. This is in concordance with the results elicited from the CVOs. However, comparing the clusters, it can be seen that the social-ethical criterion was more important for the non-agricultural stakeholders (35%) than for the agricultural stakeholders (18%). As a result, the economic criterion is weighted as less important (15%) compared to agricultural stakeholders (33%). The two cluster comprising CVOs and veterinarians were almost alike. The individual scores are presented in Figure 3.6 in order to illustrate the differences between stakeholders. The range of the epidemiologic criterion is from 0 to 100. For the economic and social-ethical criteria this was [0, 80] and [0, 90] respectively.

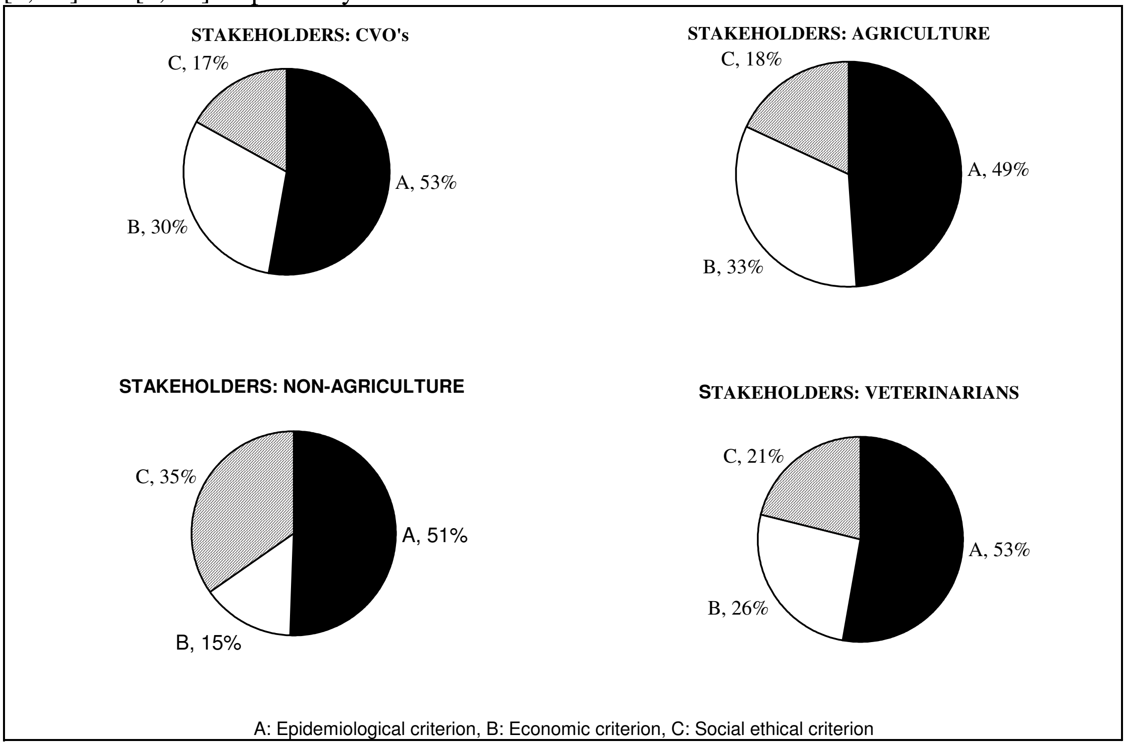


Figure 3.5: Preferred weights stakeholders per criterion.

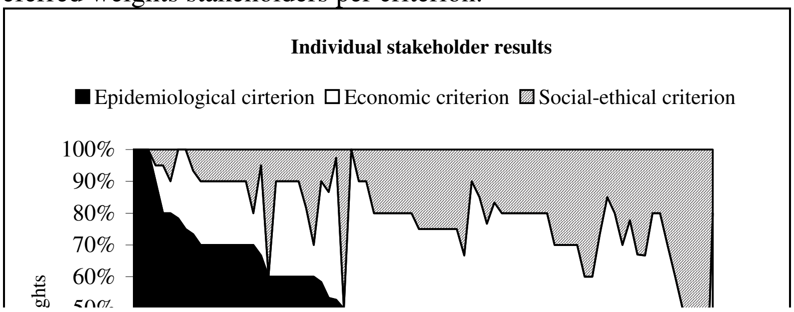
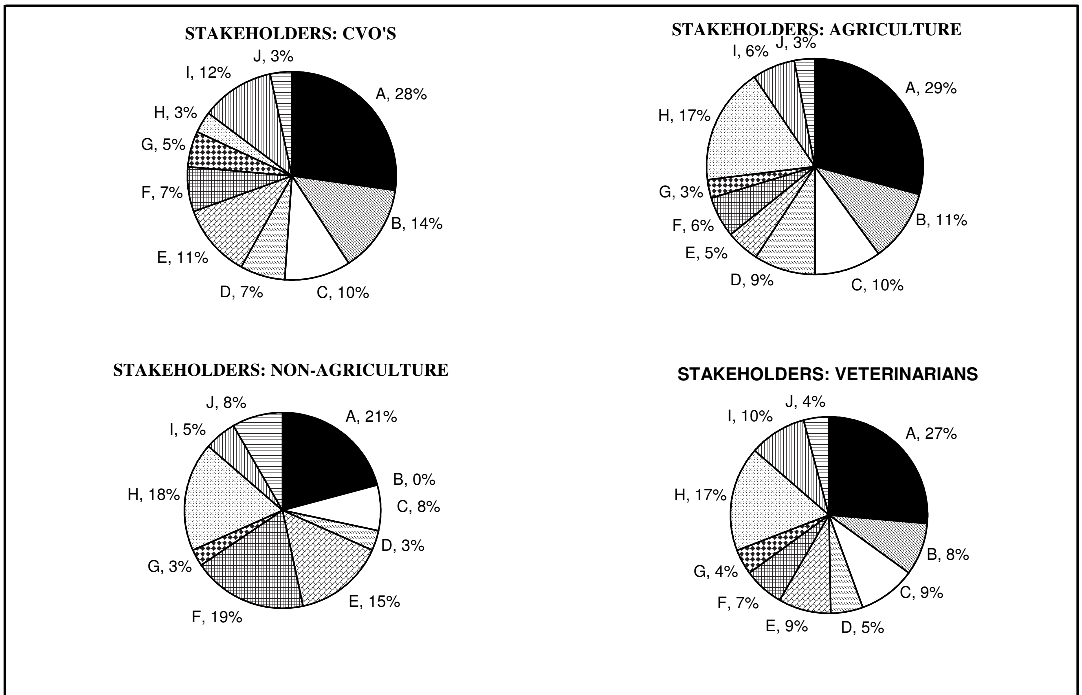


Figure 3.6: Preferred weights per criterion for all respondents.



Social-ethical indicators in support: A: Efficacy, B: Socio-economic factors, C: Macro-economic factors, D: Commercially interested parties, E: Animal health, F: Animal welfare, G: Tourism, H: Human health, I: Governmental policy, J: Non-farm animals

Figure 3.7A: Preferred weights stakeholders of social-ethical indicators.

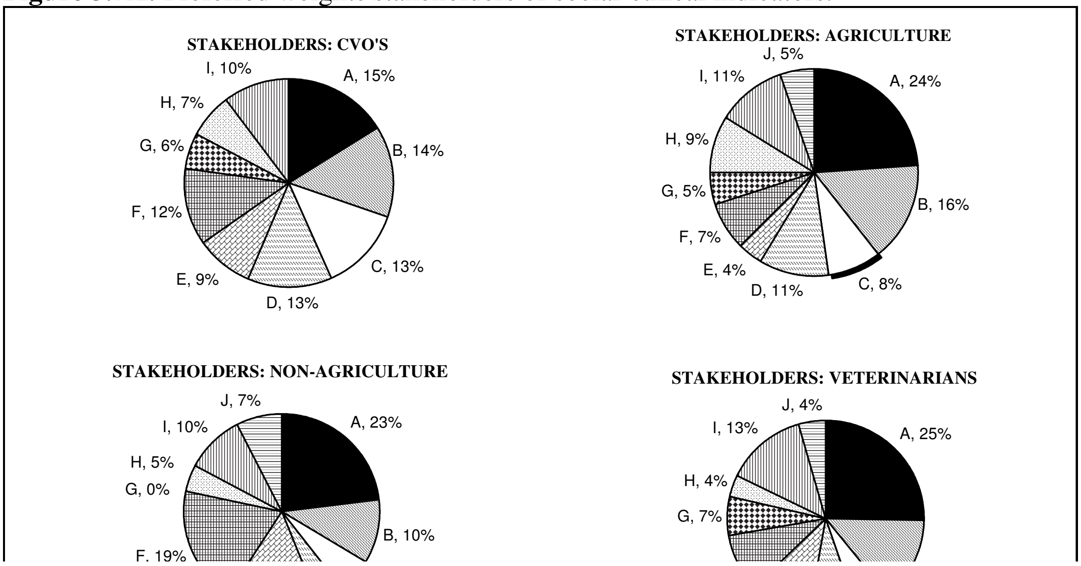


Figure 3.7B: Preferred weights stakeholders of social-ethical indicators.

Also the relative weights for the social-ethical indicators differed between the clusters. In general, non-agricultural stakeholders have weighed the indicators animal health (11%) and animal welfare (13%) as more important than agricultural stakeholders (3% and 5% respectively). With respect to the animal health and welfare indicators the two cluster comprising CVOs and veterinarians were almost alike and in between the other two clusters. Note that grand averages of the two social-ethical questions combined are not presented. Grand means are derived by averaging the weights of the social-ethical indicators for or against a control strategy.

3.3.2.2 Stakeholders influence and priority aspects

Differences between agricultural stakeholders, non-agricultural stakeholders and veterinarians concerning their view about the influence of stakeholders on the choice of the applied control strategy are marginal (Appendix II). The three categories of stakeholders considered that National or European government and governmental organisations (45%), farmers unions (13%) and veterinarians (13%) had the most influence in the decision making process.

With respect to the priority aspects to be addressed in the decision-making process differences between the clusters was observed (Appendix II). Non-agricultural stakeholders address animal welfare and related ethical aspects (28%) as much more important than agricultural stakeholders (12%). Agricultural stakeholders prioritised the reputation and position of the agricultural sector (17%) as much more important than non-agricultural stakeholders (5%). With respect to these priority issues the cluster comprising veterinarians was in between the other two clusters. The overall results for the other three priority aspects did not differ substantially between the clusters. Communication and information procedure was rated with a score of 23%, social, psychological, and financial consequences for the farmers, their relatives and other workers directly involved was rated with a score of 24%, and preventive measures was rated with a score of 25%.

3.3.3 Discussion stakeholders' survey

Despite the efforts made to ensure a random selection of potential stakeholders in the EU member states, national representatives of the European organisations organised in the Groupe Permanent "Questions Veterinaires", is the dominant responding group in all countries. Respondents represented in this category, mainly belong to subcategories COPA, COGECA, CELCAA and FVE. Furthermore, the total number respondents from member states which experienced a major outbreak recently (e.g., United Kingdom and The Netherlands) outnumbered the number of respondents from other member states. Because many EU member states have not experienced recent outbreaks, and therefore in these member states involvement of a broad spectrum of stakeholders in a discussion about alternative strategies did not had a sense of emergency, response rate was as expected marginally. Still, one could argue that this could be a fair representation, if one accepts that the national stakeholders organised in the European organisations, reflect the distribution of the national parties involved in the discussion about animal diseases in their country. However, this assumption is not likely to be valid for member states that differ substantially from those member states which experienced a major outbreak with respect to epidemiological, economic and social-ethical characteristics.

Defining three conflicting indicators and decomposing them into indicators is an arbitrary process. In general, criteria and indicators are defined by help of the stakeholders in an iterative way. However, within the scope of this research, it was not possible to conduct such an extensive, iterative process. The definitions of criteria and indicators are therefore based on 1) the results of a former study in which Dutch stakeholders were interviewed by means of a Group Decision Room session and on 2) additional expert consulting. As a result of this procedure, a uniform interpretation of the definitions is not entirely ensured. Moreover, because a preset framework of criteria and indicators had to be weighed, views of stakeholders about additional criteria and indicators could not be taken into account.

For some criteria and indicators substantial heterogeneity in relative weights between stakeholders was observed. Explaining differences in the preferred relative weights of the CVOs by explanatory variables describing epidemiological characteristics and trade characteristics was hardly possible because of the limited number of observations. Moreover, a causal relationship between the characteristics and preferences cannot be proven, merely a quantification of the association. In order to summarize relative weights stakeholders were clustered according to the number of responses into an agricultural, non agricultural and veterinarian cluster. Regionalization of the clusters and decomposing the current applied clusters into more specific organisational entities according to their mission and representation was not possible because of the limited number of observations.

3.3.4 Main conclusions stakeholders' survey

A first insight into the preferences of stakeholders is presented. The relative importance weights of conflicting criteria and indicators per criterion were elicited.

By means of clustering the spectrum of preferred relative weights of the three criteria under research was explored. For the stakeholders sample as a whole the epidemiological criterion was the most important one. CVOs preferred the epidemiological criterion with relative importance of 53%, with a standard deviation of 17%. Corresponding average weights for the economic and social-ethical criteria were 30% and 17% *respectively* (and standard deviations of 10% and 9% respectively). The social-ethical criterion was more important for the non-agricultural stakeholders (35%) then for the agricultural stakeholders (18%). As a result, the economic criterion is weighted as less important (15%) compared to agricultural stakeholders (33%). The two cluster comprising CVOs and veterinarians were almost alike.

Only CVOs weighed epidemiological and economic indicators. Duration of the epidemic (28%) and the size of the affected region (25%) were regarded as the two most important epidemiological indicators. Direct farm losses (15%) and consequential farm losses in affected region (14%) were regarded as the two most important economic indicators.

The relative weights for the social-ethical indicators differed between the clusters. In general, non-agricultural stakeholders weighed the indicators animal health (11%) and animal welfare (13%) as more important than agricultural stakeholders (3% and 5% respectively) and CVOs (10% and 9% respectively).

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Part III: Country studies

This chapter aims to describe the methods and materials necessary to quantify the impact of current and possible future control strategies against FMD, CSF and AI under various conditions, taking into account a broad set of decision criteria. Subsequently, a comprehensive state-of-the-arts integrated methodology with respect to epidemiological, economic, and social-ethical aspects is provided. First the epidemiological module simulating the spread of FMD, CSF and AI epidemics under different control strategies is described (4.1) followed by the paragraph in which the methodology to estimate monetary losses in the economic module is elaborated on (4.2). Subsequently, the method of trade off analysis is addressed in the MCA module (4.3).

4.1 Part IIIA: Epidemiological analysis

Thomas Hagenaars, Dörte Döpfer, Gert Jan Boender and Mart de Jong

4.1.1 Epidemiological analysis: methods and materials

4.1.1.1 Approach chosen for the epidemiological analysis

The epidemiological analysis carried out for each of the six selected EU member states comprises the following three parts for each of the three diseases:

1. Identification of those areas within the member state where the density of relevant farms and thus the estimated potential for between-farm disease transmission is relatively high.
2. Selection of one particular but representative high-density area, where the potential impact of an epidemic is expected to be relatively large both due to the size of the area and due to the average farm size.
3. Epidemiological scenario analysis: mathematical modelling analysis of a number of different intervention strategies to combat an epidemic in that area.

The intervention strategies fall into two groups based on the results of the scenario analysis: strategies that, once implemented, achieve quick control, and strategies that do not do so. The first group of scenarios will be also considered in the economic analysis and the MCA discussed in this report. The second group of strategies is not considered in these further analyses as they are simply unsuccessful. We note that in some high-density areas even the most severe intervention strategies compatible with capacities may not manage to save part of the area from disease and subsequent killing of animals.

As already discussed in Chapter 2, we investigate three types of intervention strategies:

4. *EUdef*. Standard (EU) strategy: stamping-out of infected herds and contact herds, and implementing surveillance and protection zones (3 km and 10 km).
5. *EUdef+Pre*. EU + pre-emptive slaughter (ring culling within a 1-km or larger radius around infected/contact herds)
6. *EUdef+Vac*. EU + vaccination. (ring vaccination within a 1-km or larger radius around infected/contact herds).

For each scenario to be considered also in the economic analysis and MCA the epidemiological analysis provides a number of intermediate modelling results.
Results required for the economic analysis take the form of:

- A large independent sample from the multivariate distribution of total duration of the interventions, total number of infected farms, total number of culled farms, total number of vaccinated farms, and the total number of farms under standstill at a number of time points during the epidemic.

Results required for the MCA are:

- Summary statistics of the above sample to serve as (a basis for) indicators for intervention duration, total number of infected farms, total number of farms on which animals are culled, size of the region affected by standstill, total number of culled animals.

4.1.1.2 Modelling approach used in the epidemiological scenario analysis

The epidemiological analyses apply mathematical models to data obtained from the six selected EU member states. These analyses, as all mathematical model analyses, are based on abstractions that aim to capture the essential ingredients of complex reality (de Jong, 1995). Still, in mathematical modelling there is a choice between a range of levels of detail. Here we choose to work with a parsimonious model that does not attempt to take into account a number of heterogeneities. One reason for this is that the analyses performed here are dealing with the properties of potential future epidemics in livestock areas in which there has not been a large epidemic in the past. Therefore the models can only be calibrated by using information from recent large outbreaks *elsewhere*, where the detailed transmission conditions may well be slightly different. It is then important to avoid a level of modelling detail that suggests more precision than is reasonably possible in this situation. Furthermore, it is important to study the sensitivity of the scenario outcomes to changes in key parameters, in order to assess if and how hypothesized country-specific parameter adjustments would change the epidemiological conclusions. The main sensitivity properties of our calculations will be discussed below.

One particular heterogeneity that is ignored in the transmission models used here is that of farm type: the probability of acquiring infection and the potential for infecting other farms may both depend on the defining properties of the farm in question, notably its size and species content. For evidence of a farm-size dependence of the probability of acquiring FMD infection in the 2001 epidemic in Great Britain we refer to Ferguson et al. (2001b). Keeling et al. (2001) show that for this same epidemic a model ignoring the heterogeneities of farm type and size performs almost as well as an extended model that does take these heterogeneities into account.
In addition, our models refrain from distinguishing the individual contributions of the different transmission routes alluded to in Section 2., namely transmission via humans, via transports of animals or of manure, via shared instruments, and via air flow. Instead we model the overall transmission intensity resulting from all these contributions together, an approach in common with most of the successful modelling studies of List-A epidemics in the literature (for a comparative review of FMD modeling see Kao (2002), Moutou and Durand (2002)).

4.1.1.3 Definition of the mathematical models

The mathematical models used are both spatial (in order to capture the spatial nature of the transmission process between nearby herds) and stochastic (i.e. describing the variability due to chance). Individual model units are farms, which differ from each other only by their locations. The model calculates the evolution in time of the infection status of these farms. The transmission process is governed by a transmission kernel $p(r)$, which describes the transmission rate between two farms as a function of the distance r between these farms. If farm i is currently susceptible, the rate λ_i at which is becoming infected is given by

$$\lambda_i = \sum_j p(r_{ij}), \quad \text{with } j \text{ running over all infectious farms.}$$

Here r_{ij} is the distance between farms i and j.

Transmission kernels for each of the three diseases are based on kernels estimated for past epidemics in The Netherlands and Great Britain (Ferguson et al., 2001a, b; Keeling et al., 2001; Stegeman et al., 1999; Stegeman et al., 2002).

A simple choice for the transmission kernel p(r) is rectangular:
$p(r)=\lambda \ (r<r_I)$
$p(r)=0 \ (r>r_I)$
with λ a constant transmission rate and r_I a characteristic radius of neighbourhood transmission. The kernels used apply to the transmission process during the disease-combat period. Transmission during the HRP, as discussed above, is more intense and frequently covers larger distances. However, as we are interested in describing epidemic spread within a given high-density area, we do not describe the potential spread to other areas and approximate the remaining transmission potential by the DCP transmission kernel.

The input requirements for the model calculations include data on all locations (two-dimensional coordinates) of the relevant farms in the selected representative high-density areas. All of the six selected member states have kindly supplied us with data on numbers of farms within administrative areas, with the spatial resolution ranging from NUTS-2 up to NUTS-5 level. Unfortunately however, in none of these countries it has been possible to obtain farm location data within the framework of the current project. We have resolved this problem by developing a phenomenological model that samples farm locations based on the number of farms and the area of the relevant region. This model was constructed through an extensive analysis of the spatial structure of the Dutch sectors. This analysis has shown that, for all three diseases under study, the true spatial structure of farms can be approximately mapped onto a model structure in a rescaled space in which the number of farms within a given distance of a random farm is Poisson distributed. The spatial rescaling process roughly corresponds to what can be phrased intuitively as "taking away the area of the pieces of land without farms". In detail however this process is more subtle, and the value of the rescaling factor depends on the disease.

We note that the phenomenological model can only partly alleviate the unavailability of detailed location data. For example, if the true farm-clustering patterns are more pronounced than assumed in the model, our calculations underestimate the potential for disease transmission.

Given a spatial distribution of farms and the location of the first infected farm, the state of the simulated epidemic is updated sequentially. At each time, the infection hazard λ_i for every susceptible farm i follows from the above equation and by drawing random numbers the model decides if and when farm i gets infected. Within this model framework, the modelling of intervention strategies based on ring culling or vaccination is conceptually straightforward.

For each given set of model parameter values (including parameters describing interventions) hundreds of realizations are performed, each realization corresponding to a different farm being the first infected farm and to a different sequence of random numbers. For most scenarios we calculate 1000 realizations; for a few computationally intensive ones we restrict the calculations to 200 realizations. Each realization is a different epidemic that could occur for the given scenario (=parameter set); the set of realizations gives insight into the expected epidemic outcome and the variation (due to chance) around it. The model output for each model realization (='simulated epidemic') includes the total number of infected farms, the total number of farms stamped-out, the total number of farms vaccinated, the time evolution of the total number of farms in a protection zone, and the duration of the epidemic (HRP+DCP).

Due to the stochastic nature of the transmission models used, in which each single scenario is evaluated hundreds of times, the results themselves give much information on their own sensitivity to changes in parameter values: model results displaying narrow outcome distributions are relatively insensitive to small changes in parameter values, and wide outcome distributions indicate relatively strong sensitivity.

4.1.2 Epidemiological analysis: results

4.1.2.1 Distinction between DPLA and MPLA countries

The results of epidemiological scenario analyses can be categorized as follows. Due to the intrinsic threshold behaviour of epidemics as discussed in section 4.1.1.1 the model outcome for each particular intervention strategy falls into one of only three categories:

1. Relatively swift control of the outbreak: occurrence of relatively short and small epidemics only.

2. Elaborate control of the outbreak: epidemics may last for several months during which a large number of herds are culled or vaccinated.
3. Failure to control the outbreak: a high probability that the outbreak spreads throughout most of the region included in the calculation.

Scenarios in the first categories occur for countries in which the farm density in the selected high-density region is (still) below a threshold level for the disease in question. Below that threshold density, the minimal intervention effort (EUdef) suffices for achieving disease control. In that case, the other scenarios with additional intervention effort also yield swift control. For structuring the presentation of the results, we label countries with category-1 results with the acronym MPLA (moderately populated livestock area), e.g. the category CSF_MPLA contains those countries that have no regions in which the density of farms with pigs exceeds the threshold for CSF. The model parameters and assumptions used in our analyses produce the following threshold values for the (naïve) farm density: FMD: 1.2 farms/km^2; CSF: 3.6 farms/km^2; highly-pathogenic AI: 0.68 farms/km^2.

Scenarios in the second category occur for countries in which the farm density in the selected region is above the threshold level introduced above. Minimal intervention then is insufficient for control, but a certain amount of additional (ring) culling or emergency (ring) vaccination is sufficient. Here the standard EU strategy falls in the third category above. With a high probability it fails to control transmission of the virus, such that the epidemic spreads throughout the whole region considered. The strategies with sufficient additional culling or emergency vaccination succeed in saving part of the region considered from the epidemic spread; however the epidemics may last several months during which a large number of herds are culled or vaccinated. Below, we label countries with category-2 and category-3 results with the acronym DPLA (densely populated livestock area), e.g. the category CSF_DPLA contains those countries that have at least one high-risk region in which the density of farms with pigs exceeds the threshold for CSF, such that standard EU intervention is in sufficient for achieving control.

4.1.2.2 Epidemiological results for FMD

Our results indicate that in all of the six countries included in these calculations livestock areas are present in which the standard EU control strategy would fail to achieve control of Foot-and-Mouth Disease outbreaks; i.e. all six countries have at least one DPLA for FMD. The more limited data available for the other EU member states indicates that this conclusion applies to the whole EU. In most of the six selected countries, large areas exist in which the density of FMD-sensitive farms is as high or higher than in the regions in Britain affected by the 2001 FMD epidemic. Our calculations suggest that in some of these areas even strategies with ring culling within a 4-km radius around infected farms would fail to halt the epidemic spread.

In Figure 4.1.1 we present example results with elaborate epidemic control obtained by a strategy comprising standard EU measures and ring-culling within a radius of 2 km.

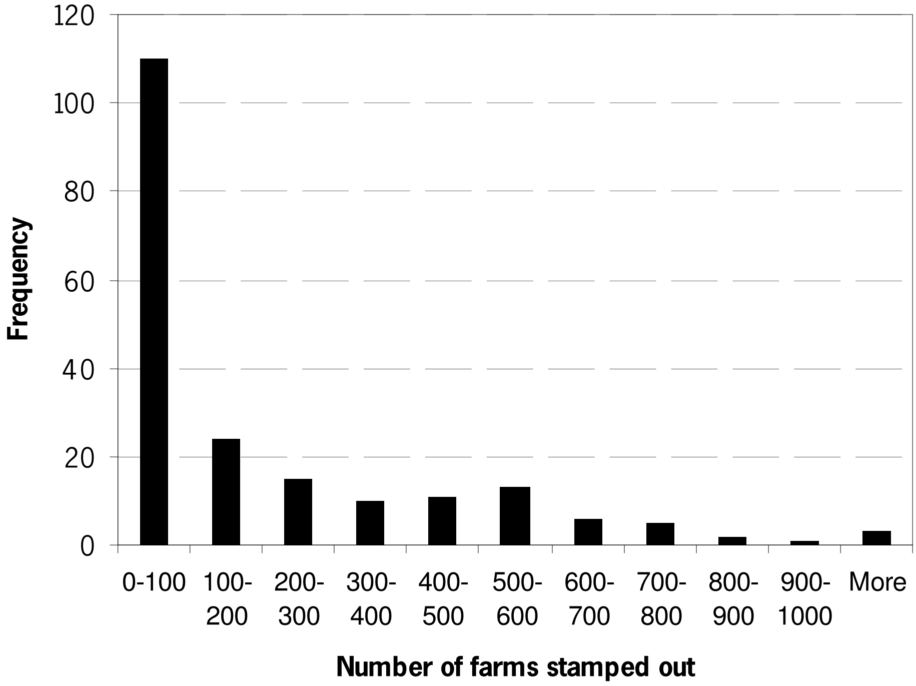

Figure 4.1.1: FMD example of category-2 results (elaborate control), showing that the area in question (RegionD_FMD) is a DPLA. Histogram of outbreak size based on 200 realizations for a 2-km radius ring culling strategy (EUdef+Pre) in a region with 1.6 farms per km^2.

4.1.2.3 Epidemiological results for CSF

For CSF we find both "MPLA countries" that do not have high-risk areas, and "DPLA countries" that do have such areas. In Figure 4.1.2 we present example results for both types of areas. The comparison between the two illustrates the vast difference in impact of epidemics in MPLA versus DPLA.

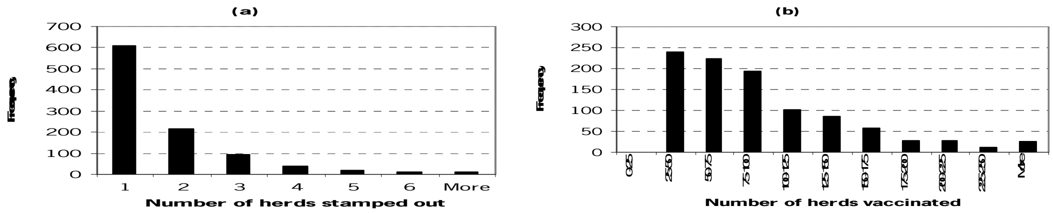

Figure 4.1.2: CSF histograms based on 1000 realizations. (a) Example of category-1 results (swift control of the outbreak) obtained for standard EU strategy of intervention (EUdef) in a region (RegionB_CSF) with 1.15 farms per km^2 (MPLA). (b) Example of category-2 results (elaborate control, DPLA) for a 1-km radius ring vaccination strategy (EUdef+Vac) in a region (RegionC_CSF) with 4.5 farms per km^2.

4.1.2.4 Epidemiological results for AI

For (highly-pathogenic) AI we also find both "MPLA countries" that do not have high-risk areas, and "DPLA countries" that do have such areas. In Figure 4.1.3 we present example MPLA results showing that the "relatively small" epidemics seen in MPLA situations may still comprise tens of farms. These results are obtained when the farm density is not much below the threshold density.

In Figure 4.1.4 we compare two different ring-culling strategies in a DPLA example: a high-risk area for AI in one of the six countries analyzed. These results show how a more aggressive pre-emptive culling strategy can reduce the number of farms affected in the largest possible epidemics at the expense of lowering the probability of epidemics in which relatively few farms are stamped out.

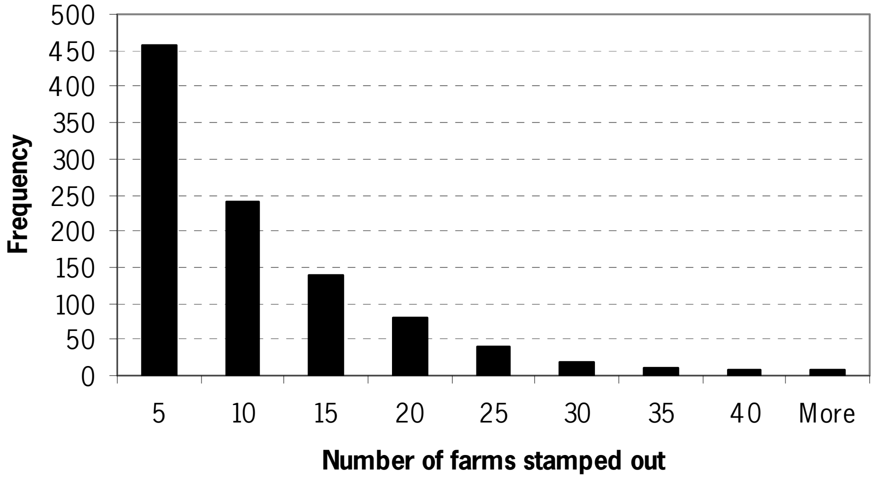

Figure 4.1.3: AI example of category-1 results (MPLA). Histograms of EUdef outbreak size based on 1000 realizations in a region (RegionB_AI) with 0.4 farms per km^2.

Figure 4.1.4: AI example of category-2 results (elaborate control). Histograms of outbreak size based on 200 realizations in a DPLA (RegionA_AI) with 1.24 farms per km^2. Comparison between two ring-culling strategies (EUdef+Pre) that differ in ring radius.

4.1.3 Conclusions of the epidemiological analysis

We conclude by listing the main general conclusions of the epidemiological analyses.

The threshold behaviour of epidemic spread naturally leads to the notion of high-risk areas (DPLA) where the density of farms (i.e. the number of farms per km^2) exceeds a critical value. In such areas the potential for epidemic spread is such that, unless the epidemic terminates early by chance, it cannot be controlled by the standard EU intervention strategy. The critical value for the density of farms depends on the disease.

Our results indicate that, for most EU countries, achieving control of Foot-and-Mouth Disease outbreaks presents an even bigger challenge than controlling outbreaks of CSF and highly-pathogenic AI. Most or even all EU have (large) high-risk areas (DPLA) for spread of FMD.

Our results further indicate that in several of the six countries analysed, CSF and AI epidemics can be controlled by employing the minimum EU requirements for intervention. However an important caveat here is that the model scenarios might underestimate the amount of farm clustering at a local level. This caveat arises due to the fact that the unavailability of farm location data prevented us from accounting for detailed clustering patterns.

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Stegeman, J.A., Elbers, A.R.W., Bouma, A., de Jong, M.C.M., 2002. Rate of inter-herd transmission of classical swine fever virus by different types of contact during the 1997-8 epidemic in The Netherlands. Epidemiology and Infection 128, 285-291.

4.2 Part IIIB: Economic analysis

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This section describes the definitions, methods, materials and results of the economic analysis of the simulated outbreaks of AI, CSF and FMD.

The countries studied in the economic analysis are either net importers or net exporters of the relevant products, for example milk, beef, pork and mutton. This distinction was of importance for the analysis because producers in net exporting countries are more likely to be affected by export bans than producers in net importing countries are. In every country, a certain region was chosen in order to reduce the need for data on farm structure and to select regions in which the relevant animals are present in adequate numbers. However, the regions differ in size – expressed as the number of animals as a percentage of the total herd in the country – by between 0.033% and 30%, although in most cases the difference is only 2-5%. This implies that the results of the economic analysis cannot be compared between different regions; only the effects of different control strategies within the same region are comparable. The results given in section 4.2.4 have to be taken as examples of the possible outcomes of an outbreak of AI, CSF and FMD.

4.2.1 Definitions

The total costs associated with an outbreak of a disease can be divided into direct and indirect (or consequential) costs. In this research, direct and indirect costs are based on Huirne et al. (2002). Direct costs include:

a. Direct farm losses resulting from the destruction of animals. This includes the value of killed and destroyed animals on infected farms, pre-emptively cleared farms and vaccinated farms[1].
b. Operational costs of control measures, such as the organization costs of eradication and pre-emptive slaughter (taxation, killing and destruction, cleaning and decontamination), clinical examination, clinical inspection, emergency vaccination (teams and vaccine), animal welfare measures (teams and equipment), crisis centres, control of the movement standstill, and tracing and tracking.

Indirect (or consequential) costs are the result of reduced economic activities. These costs occur not only in the agricultural sector but also in such sectors as recreation and services. In this study, indirect costs include:

a. Effects of price differences on farms in and outside the infected area, both during the outbreak and after the transportation ban has been lifted;
b. Farmers' loss resulting from temporary vacancy of stables;
c. Farmers; loss resulting from the movement restrictions inside movement standstill areas;
c. Farmers' loss of the market value of vaccinated animals that are sold[2];
d. Effects on income for other agribusiness firms, such as dairy factories, slaughterhouses, meat wholesalers, egg wholesalers / processing firms, and mixed feed factories;
e. Effects on income in the recreation, catering, hotel, restaurant, transport, and food wholesale & retail sectors.

Costs resulting from a higher animal density on non-cleared farms during a movement standstill (extra feeding costs resulting from a higher feed conversion ratio and extra

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[1] For killed and destroyed animals, a fixed price was used based on the cost of the young animal and 50% of the variable costs (Meuwissen et al., 1999). For destroyed feed, a fixed surcharge of 1.29% of former calculated total costs was used (based on the surcharge calculated in Meuwissen et al. (1999)).
[2] We supposed a 50% reduction of the market price.

mortality) are also an indirect cost. Because of the lack of information, these costs were not calculated.

The costs were calculated for the affected sector and firms. No account was taken of income transfers, such as compensation payments for destroyed animals or social security payments to temporarily unemployed persons.

4.2.2 Materials

Data for the economic analysis was gathered by means of a questionnaire distributed in six European countries. The questionnaire included questions on zootechnical data (annual production numbers, e.g. piglet production per sow, egg production per hen, milk yield per cow), financial data (revenue prices, feed prices, production costs) of all the relevant animals[3] present in the selected regions. Further information was gathered on the average farm structure in the selected regions, and on the control measures and costs for CSF, AI and FMD in the selected countries. In addition to the questionnaire, country visitors conducted interviews at various specialized technical and economic institutes to gather country-specific background data and to help respondents to complete the questionnaire.

Models for calculating the economic consequences of (simulated) outbreaks of CSF (Meuwissen et al., 1999) and FMD (Tomassen et al., 2002) are available. However, these models need detailed epidemiological input about the events a farm is confronted with on specified days. In this research the level of detail of the epidemiological data was restricted. Lack of time made it impossible to alter the information to the needed level of detail. Furthermore, a similar model for AI is lacking. As this research compares control strategies across diseases, a similar model for all diseases is a requisite. Thus, a new static deterministic economic calculation model was developed in Excel to estimate direct farm losses, the operational costs of control measures and the indirect costs of farms inside MSS areas. The model used the scenario runs from the epidemiological analysis (section 4.1) and the data gathered by the questionnaire.

Mangen & Burell (2003) developed a partial equilibrium model (DuPiMa) to estimate the consequences of a reduced pig flow of the Dutch pig market price. These effects are used to calculate changes in producer surplus inside and outside MSS areas. Tomassen et al. (2003) developed a partial equilibrium model to explore national effects of FMD control on producer surplus in FMD-free regions and a micro-economic model to calculate changes in producer surplus in the recreational sector due to movement bans. However, a similar model to calculate the effects of AI control is missing. To compare control strategies across diseases a similar model for all three diseases is a requisite. In this research, to calculate net income effects outside the primary sector in the MMS areas (income effects of farms outside the MMS areas, the supply chain and the recreational sector) and to calculate the effects of an export ban, the Global Trade Analyses Project (GTAP) model was used (see Hertel (1997) for an extended description of the model). An international consortium of 18 members including WTO, World Bank, Unctad, EC, OECD and LEI own and maintain this general worldwide trade model.

GTAP is a multi-region, multi-sector computable general equilibrium model, with perfect competition and constant returns to scale.[4] The model is fully described in Hertel (1997). In the GTAP model, firms combine intermediate inputs and the primary factors land, labour (skilled and unskilled) and capital. Intermediate inputs are composites of domestic and foreign components, and the foreign component is differentiated by region of origin (Armington assumption). On factor markets, we assume full employment, with labour and capital being fully mobile within regions, but immobile internationally. Labour and capital

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[3] Laying hens, broilers, turkeys, diary cattle, beef cattle (cows, bulls, heifers), sows, fattening pigs, milk and meat goats (ewes), fattening goats, milk and meat sheep (ewes), and fattening sheep were distinguished.

[4] For an overview of agricultural world trade models and their design choices, see van Tongeren et al. (2001).

remuneration rates are endogenously determined at equilibrium. In the case of crop production, farmers make decisions on land allocation. Land is assumed to be imperfectly mobile between alternative crops, and hence allows for endogenous land rent differentials. Each region is equipped with one regional household that distributes income across savings and consumption expenditures. Further, there is an explicit treatment of international trade and transport margins, and a global banking sector, which intermediates between global savings and consumption. The model determines the trade balance in each region endogenously, and hence foreign capital inflows may supplement domestic savings.

The GTAP database contains detailed bilateral trade, transport and protection data characterising economic linkages among regions, linked together with individual country input-output databases which account for intersectoral linkages among the 57 sectors (including the pig and poultry primary sector and the pig and poultry food processing sector) in each of the 85 regions (including all EU25 countries). All monetary values of the data are in USD million and the base year for the version used in this study (version 6, public release) is 2001 (Dimaranan & McDougall, 2004). We used an exchange rate of \$1 = € 0.83 to transform the output of GTAP to euros[5].

The following sectors were used in the present research:

- Live bovine cattle, sheep and goats, horses, asses, mules and hinnies
- Live pigs, poultry (including eggs) and other animals
- Raw milk
- Meat of bovine animals, fresh or chilled
- Meat of pigs, fresh or chilled
- Wheat and other grain (as an indicator for mixed feed supply)
- Agricultural manufacturing and other services
- Transport sector (land and water)
- Recreation, cultural and sport sectors
- Trade (retail and wholesale).

This model provides information about the effects of changes in production and export on the incomes in the different sectors (primary sector, agribusiness, trade, transport, recreation). The normal EU and OIE rules were used to calculate the impact of export bans. So, only live animals and their associated products from the infected region are subject to the export ban and not the whole country.

4.2.3 Method

A gross margin calculation model developed in Excel was used to combine the zootechnical and financial data of the six countries gathered by the questionnaire and to calculate annual animal productivity, animal production costs and animal gross margins. Only some of the countries completed the questionnaires on the zootechnical and price data. Therefore, Dutch experts in the international comparison of animal production numbers and costs verified and, where necessary, completed and adjusted these data.

Only two of the six countries answered or partly answered the questions about control measures and the costs thereof. By combining these data with Dutch information on the recent FMD, CSF and AI outbreaks in the Netherlands, the missing data were completed. As no further data were available, the economic data on control measures and costs were assumed to be comparable for all six countries.

Epidemiological calculations were performed for each control strategy, disease and country. For failing control strategies, no epidemiological data were provided and thus no economic analysis was performed. The data for each effective control strategy include the total number of infected, pre-emptively cleared and vaccinated farms, the duration of the

[5] If the exchange rate changes, the income effects in agribusiness and the recreation sector will change; for example, an exchange rate of \$ 1 = € 0.75 will lead to about 10% smaller income effects.

epidemic, the number of farms, and the time evolution of the total number of farms in a protection zone. This data consists of a large number of simulated outbreaks (200 for FMD and 1000 for AI and CSF). As in these data no distinction is made between farm types, the economic model used only the average number of animals over all farms in a region (as recorded in the farm structure data).

A deterministic economic calculation model developed in Excel combined the simulated outbreaks per control strategy per disease per country with the corresponding zootechnical, financial and control measure and costs data. The model calculated for each simulated outbreak, as well as for the 50% and 95% percentile[6] of the simulated outbreak size, the total direct costs, farm losses resulting from the vacancy of stables and a movement standstill, the loss of market value of sold vaccinated animals (50% of normal market value) and the volume loss in animal production.

The loss of production and export volume was calculated with help of the Excel model for the 50% and 95% percentile of the epidemiological data. This information about changes in production and export was used to calculate the remaining part of the indirect costs with the GTAP model. GTAP used production shocks and, in the case of exporting countries, also an export shock to calculate the net income effect in the different agribusiness sectors, in recreation and in the different primary sectors. Shocks in production and export were calculated in terms of the percentage of the total national production volume, respectively the total national export volume.

Normally the values of exports and production are obtained as outcomes from the GTAP model. In this particular analysis some of the production volumes and export volumes are fixed and shocked appropriately to simulate the production and trade effects of the disease outbreak. In order to accommodate the fixing of some variables, some other variables have to be freed up to allow the model to find a new equilibrium solution. In our case, we have chosen to free up the import tariff to compensate for the drop of production for the livestock product concerned. The rationale behind this approach is that net importing countries will have to import more in order to fulfil domestic demand at reduced levels of domestic supply. A virtual prohibitive non-tariff barrier to exports accomplishes a ban of exports.

The results for recreation and tourism provide only a partial estimate (lower bound) of the potential impacts for two reasons:

1. The simulated disease outbreaks are always local and confined to a relatively restricted area. Hence a widespread crisis such as the one experienced in the UK during the FMD outbreak in 2001 is not taken in to account. While a nationwide crisis can lead to an almost complete standstill of rural tourism during certain periods of time, the regionalized outbreaks have much more limited effects since the drop in recreation demand in one region can be compensated by demand in other regions.
2. The model used is not a specialized model of the recreation sector, but an economy-wide model that includes recreation and tourism as one of its sectors. The simulation study did not include specific tourism demand effects, such as a drop in demand as a consequence of a disease outbreak. The small effects on the tourism sector are more indirectly obtained through backward and forward linkages between the recreation sector and agricultural activities.

The results of the economic calculations are presented for both the 50% and 95% percentile of the size of an outbreak (see also Appendix C).

4.2.4 Results

This section presents, as examples of possible results, the main outcomes of the economic analysis for different scenarios; Appendix C provides additional information. A distinction is made between DPLAs and MPLAs and between net importing and net exporting countries in

[6] To determine the 50% and the 95% percentile, the total distribution of the results of the 1000 and 200 simulated outbreaks were arranged from small to large and divided into 100 equal parts. The 50% percentile is the result of the 50th equal part, and the 95% percentile of the 95th equal part.

order to illustrate the impact of circumstances on the total costs of an outbreak. Results are available for six scenarios, namely:

1) FMD, DPLA and net importing (2 countries)
2) CSF, DLPA and net exporting (2 countries)
3) CSF, MPLA and net importing (3 countries)
4) CSF, MPLA and net exporting (1 country)
5) AI, DPLA and net exporting (1 country)
6) AI, MPLA and net importing (3 countries).

The results are presented for FMD, CSF and AI separately, and as the mean value of the countries in each scenario. Positive income effects are indicated as (+ 1100) to distinguish them from costs and negative income effects. The effects on income in the recreational and agribusiness (processing and trade) sectors can differ per country, as the importance of theses sectors is different in each country. Therefore, only a comparison between the income effects per control strategy for the same region is valid. It should also be noted that these calculations are intended to illustrate the effects of particular situations with respect to diseases, regions and international trade on the choice of the optimal strategy. In reality, however, the economic effects of an outbreak could differ widely from the results of these case studies.

4.2.4.1 FMD in DPLAs and MPLAs

This subsection describes the economic results for control strategies of FMD outbreaks in DPLAs and MPLAs. An effective control strategy was calculated only for outbreaks in a DPLA.

FMD in DPLAs

The following are the economic results for control strategies of FMD outbreaks in DPLAs. An effective control strategy was calculated only for net importing countries.

FMD in large DPLAs in net importing countries D and F

The loss of primary production volume resulting from an FMD outbreak in a DPLA depends on the control strategy (Table 4.2.1) and the size of the chosen region. Production losses are the highest for the control strategy 'vaccination and destruction', namely about 2.5 times higher than losses for the control strategy 'pre-emptive slaughter'. The control strategy 'vaccination and living' shows the lowest production losses.

Table 4.2.1: Mean loss of primary production volume (95% percentile) resulting from an FMD outbreak in a DPLA in the net importing countries D and F (in percentages of total production).

	EU def + Pre	EU def + Vac_kill	EU def + Vac_live
Dairy milk	0.2%	0.6%	0.04%
Beef	2.2%	5.3%	0.3%
Pork	0.7%	1.1%	0.08%
Sheep meat	0.9%	2.3%	0.14%

Countries D and F are net importing countries for the products of FMD-sensitive animals. Thus, the production loss affects only the national production level. The loss of national production in terms of percentages was used to calculate income effects in agribusiness (processing industries and trade) and the recreational sector. Table 4.2.2 gives the mean costs and income effects of an FMD outbreak in a DPLA in the net importing countries D and F.

Table 4.2.2: Mean costs and income effects (95 % percentile) of an FMD outbreak in a DPLA in the net importing countries D and F (in € 1000).

	EU def + Pre	EU def + Vac_kill	EU def + Vac_live
Farmers' direct costs	36,592	85,855	5,149
Framers' indirect costs	21,457	32,966	72,200
Organizational costs	20,325	61,834	27,470
Income effects in agribusiness and recreation	(+ 24,798)	(+ 42,336)	(+ 845)
Total costs	53,576	138,319	103,974

Table 4.2.2 shows that in this example of an FMD outbreak in large DPLAs in net importing countries D and F, the total costs are the lowest (€ 53,576,000) for the control strategy 'pre-emptive slaughtering'. The total costs for the control strategy 'vaccination and destruction' are the highest. Further, the strategies differ in the distribution of their effects. Farmers' direct costs are the highest for the control strategy 'vaccination and destruction', while the control strategy 'vaccination and living' has the highest indirect costs. The organizational costs are the highest for the control strategy 'vaccination and destruction'.

The study of the FMD outbreak in the Netherlands has already made it clear that in some sectors positive income effects might occur. These effects are mostly the result of changes in consumer demand (e.g. in the case of FMD, for broilers) and the consequently higher prices and margins thereof. In this particular example, we found positive effects on income[7] in recreation and agribusiness, with the exception of the afflicted farmers.

These positive effects especially in net importing countries are connected to the chosen method to calculate the effects of the outbreaks in agribusiness (see 4.2.3 Method). In importing countries this method results in cheaper imports, which has a positive effect on the agribusiness as a whole (cheaper intermediary inputs). Net exporting countries will also import more, but the effect is smaller than in net importing countries. This also explains why in the importing countries D and F the positive effect is the largest for the control strategy 'vaccination and destruction', the strategy with the largest loss in primary production. A further effect of the diminishing of production is a smaller demand for feed. This will lead to lower prices for animal feed and lower costs for inputs in other than the afflicted sector(s). In the countries D and F the positive effects on recreation and tourism are the result of the linkages of this sector with agriculture and agribusiness and especially the calculated cheaper imports.

However, in general the persons and firms/farms with costs and those with positive effects are not the same: the firms/farms in infected regions have negative effects, while those in other parts of the country have positive effects.

4.2.4.2 CSF in DPLAs and MPLAs

This subsection describes the economic results for control strategies of CSF outbreaks in DPLAs and MPLAs.

CSF in DPLAs

The following are the economic results for control strategies of CSF outbreaks in DPLAs. An effective control strategy was calculated only for two net exporting countries.

[7] In the GTAP model, income in agribusiness was calculated as the sum of all incomes in the relevant sectors. The income concept used is gross value added at market prices. Therefore, a loss in a specific farming sector can be compensated for by a gain in mixed feed production or in another farming sector. In addition, it is of importance that income is the result of quantity and price, both of produce sold and of the intermediate products (e.g. feedstuffs) bought.

CSF in DPLAs in net exporting countries C and E
The loss of primary production volume resulting from a CSF outbreak in a DPLA depends on the control strategy (Table 4.2.3). Production loss is the lowest for the control strategy 'vaccination and living'. The highest production loss is found for the control strategy 'vaccination and destruction'.

Table 4.2.3: Mean loss of primary production and export volume (95% percentile) resulting from a CSF outbreak in a DPLA in the net exporting countries C and E (in percentages of total production).

	EU def +pre	EU def + vacc_kill	EU def + vacc-Live
Pork production	0.112%	0.16%	0.01%
Pork export	0.6%	0.675%	1.95%

C and E are net pig/pork exporting countries. Besides production losses they are also affected by export bans. In this example, the export losses[8] are the highest (1.95%) for the control strategy 'vaccination and living'. This strategy results in lengthy export bans[9]. The losses of national production and of export in terms of percentages are used to calculate the income effects in agribusiness (processing industries and trade), the recreational sector and the primary sector. Table 4.2.4 gives the mean costs and income effects of a CSF outbreak in a DPLA in the net exporting countries C and E.

Table 4.2.4: Mean costs and income effects (95% percentile) of a CSF outbreak in a DPLA in the net exporting countries C and E (in € 1000).

	EU def + pre	EU def + vacc_kill	EU def + vacc_live
Farmers' direct costs	757	945	65
Farmers' indirect costs	234	133	565
Organizational costs	677	817	117
Income effect in agribusiness and recreation	(+ 278)	(+265)	676
Income effect in the primary pig sector of an export ban	0	0	0
Total costs	1390	1630	1414

Table 4.2.4 shows that the total costs of a CSF outbreak in a DPLA of a net exporting country for the control strategy 'vaccination and destruction' are the highest (€ 1,630,000), while the lowest cost are found for the control strategy 'pre-emptive slaughter' (€ 1,390,000). However, the division of the total costs is different between the different control strategies: the control strategy 'vaccination and destruction' has the highest direct costs for farmers, the control strategy 'vaccination and living' the highest indirect costs, and the control strategy 'vaccination and destruction' the highest organizational costs.

The income effects in recreation and tourism in these net exporting countries are negative for all control strategies (see Appendix C, Table A 4.2.4). Agribusiness income effects are negative for the 'vaccination and living' strategy (€ 676,000), and positive for the other two strategies. The reason for the negative income effect in agribusiness is the longer

[8] The export loss was determined as the time the export bans is effective (standstill period + number of days to last infected farm + OIE rules for export) expressed in years times the percentage of the region in the national annual export. This percentage is supposed to be the same as the percentage of the region in the national production.
[9] OIE rules that the duration of an export ban, in the case of a control strategy with destruction of vaccinated and infected animals, is 30 days after the last infection or the destruction of the last vaccinated animal. In the case of vaccination without destruction of the vaccinated animals the export ban continues until the last vaccinated animal is slaughtered. In this example we based our calculations on a period of one year.

duration of the export ban in the case of the control strategy 'vaccination and living': the longer export ban leads to a larger inland supply for a longer period, and consequently to lower prices and smaller margins in both processing and trade firms. These effects are much larger than the positive effect of cheaper imports. The control strategies 'pre-emptive slaughter' and 'vaccination and destruction' lead to a smaller growth in inland supply (more animals destroyed) and a shorter export ban. In this particular case, the gains in other sectors (mixed feed processing, poultry, beef) are greater than the losses in the pork sector because, for example, people demand more poultry meat or beef at higher prices and the cheaper imports have a relatively large impact, because of the relatively short duration of the export ban.

Because the DPLA regions contribute only a relatively small proportion of the total production in the net pork/pig exporting countries C and E, the effects of an export ban on the national farm income in the pig sector are practically zero.

CSF in MPLAs

The following are the economic results for control strategies of CSF outbreaks in MPLAs. An effective control strategy was calculated for three net importing countries and one net exporting country.

CSF in MPLAs in net importing countries B, D and F

The loss of primary production volume resulting from a CSF outbreak in an MPLA depends on the control strategy (Table 4.2.5). The strategy 'EU measures' results in the lowest pork production loss, while 'vaccination and destruction' results in the highest production loss.

Table 4.2.5: Mean loss of primary production volume (95% percentile) resulting from a CSF outbreak in an MPLA in the net importing countries B, D and F (in percentages of total production)/

	EU def	EU def + pre	EU def + vacc_kill	EU def + vacc_live
Pork production	0.014%	0.047%	0.06%	0.0135%

Countries B, D and F are net pork/pig importing countries. Thus, there is no effect of an export ban: the production loss affects only the national production level. The income effects in agribusiness (processing industries) and in the recreational sector were calculated using the losses of national production in terms of percentages. Table 4.2.6 gives the mean costs and income effects of a CSF outbreak in an MPLA in the net importing countries B, D and F.

Table 4.2.6: Mean costs and income effects (95% percentile) of a CSF outbreak in an MPLA in the net importing countries B, D and F (in € 1000).

	EU def	EU def + pre	EU def + vacc_kill	EU def + vacc_live
Direct farmers' costs	190	634	700	169
Indirect farmers' costs	132	157	126	387
Organizational costs	113	386	391	190
Income effect in agribusiness and recreation	2,618	13,226	14,990	2,601
Total costs	3,053	14,403	16,207	3,347

Table 4.2.6 shows the highest costs for the control strategy ‘vaccination and destruction’ (€ 16,207,000), while the control strategy ‘EU measures’ has the lowest total effect (€ 3,053,000). The organizational costs for an MPLA in net importing country are the highest for the control strategy ‘vaccination and destruction’. The direct costs are the highest for the control strategy ‘vaccination and destruction’, and the indirect costs are the highest for the control strategy ‘vaccination and living’.

Negative income effects in agribusiness and in the recreational sector were calculated for all control strategies, because with these relatively small losses of production (see table 4.2.5) no large effects of cheaper imports can be expected. In these sectors, the highest income losses are found for the strategy ‘vaccination and destruction’ (combined € 14,990,000) and the lowest for the strategies ‘EU measures’ and ‘vaccination and living’ (combined around € 2.6 m). Because B, D and F are net pork importing countries, no effects of an export ban on national farm income were calculated.

CSF in MPLAs in net exporting country A

The loss of primary production volume resulting from a CSF outbreak in an MPLA depends on the control strategy (Table 4.2.7). The production effect is the highest for the control strategy ‘vaccination and destruction’ and the lowest for the control strategies ‘EU measures’ and ‘vaccination and living’.

Table 4.2.7: Loss of primary production volume (95% percentile) resulting from a CSF outbreak in an MPLA in the net exporting country A (in percentages of total production).

	EU def	**EU def + pre**	**EU def + vacc_kill**	**EU def + vacc_live**
Pork production	0.0033%	0.013%	0.015%	0.0033%
Pork export	0.87%	0.84%	0.87%	4.7%

Country A is a net pork/pig exporting country. Thus, in addition to a production loss, it is also affected by an export ban[10]. The export effect is the highest for the control strategy ‘vaccination and living’; it is more than five times the effect of other control strategies (Table 4.2.7). The loss of national production and of export in terms of percentages was used to calculate income effects in agribusiness (processing industries and trade), the recreational sector and the primary sector. Table 4.2.8 gives the costs and income effects of a CSF outbreak in an MPLA in the net exporting country A.

Table 4.2.8 Costs and income effects (95% percentile) of a CSF outbreak in an MPLA in the net exporting country A (in € 1000)

	EU def	**EU def + pre**	**EU def + vacc_kill**	**EU def + vacc_live**
Direct farmers’ costs	53	216	243	54
Indirect farmers’ costs	33	55	39	100
Organizational costs	90	220	222	87
Income effect in agribusiness and recreation	(+ 2,493)	(+ 2,473)	(+ 2,471)	(+13,474)
Income effect in the primary pig sector of an export ban	1	1	1	8
Total	(+ 2,316)	(+ 1,981)	(+ 2,101)	(+ 13,225)

Table 4.2.8 shows that an outbreak of CSF in this MPLA country in a restricted area results not only in costs but also in positive effects, but mainly in other parts of agribusiness. The effects on the recreation sector are mixed, slightly positive or slightly negative. These

[10] The effect of the export ban is calculated as describe in footnote 8 en 9.

income effects become negative as more animals are destroyed. In this case the positive effects of cheaper imports are compensated by negative effects of a much smaller inland production. The explanation for the positive income effect in agribusiness is that in this particular case, the positive effect on income of the larger inland supply is larger than the negative effect of the small reduction in production (see table 4.2.7). Processing and trade firms can increase their margins by passing on only a part of the price reduction at farm level to the consumer. This effect is especially large for the control strategy ‘vaccination and living’, because in that case the reduction in production is very small and the price of vaccinated animals is supposed to drop to 50% of the value of non-vaccinated animals. Besides this there may be an effect of cheaper imports. However, we have to bear in mind that this is the result for a specific region in a country with specific characteristics; for other regions and countries, the outcome will be different.

The direct costs for the farmers are the highest for the control strategy ‘vaccination and destruction’, and the indirect costs are the highest for ‘vaccination and living’. The highest organizational costs are associated with ‘pre-emptive slaughter’.

Because the MPLA regions contribute only a relatively small proportion of the total production in the net pork exporting country A, the effects of an export ban on farmer income at the national level are small, namely a maximum a loss of € 8000 for the control strategy ‘vaccination and living’.

4.2.4.3 AI in DPLAs and MPLAs

This subsection describes the economic results for control strategies of AI outbreaks in DPLAs and MPLAs.

AI in DPLAs

The following are the economic results for control strategies of AI outbreaks in DPLAs. An effective control strategy was calculated only for one net exporting country.

AI in DPLAs in net exporting country A

The loss of production volume on farms resulting from an AI outbreak in a DPLA depends on the control strategy (Table 4.2.9). ‘Vaccination and living’ results in the lowest production loss of poultry products, and ‘vaccination and destruction’ in the highest production loss of poultry products.

Table 4.2.9: Loss of primary production and export volume (95% percentile) resulting from an AI outbreak in a DPLA in the net exporting country A (in percentages of total production).

	EU def + pre	**EU def + vacc_kill**	**EU def + vacc_live**
Production of eggs	0.48 %	0.9%	0.046%
Production of poultry meat	1.25%	2.38%	0.13%
Export of eggs	0%	0%	0%
Export of poultry meat	0.022%	0.022%	0.022%

Country A is a net poultry products exporting country. In addition to production losses, it is affected by export bans[11]. The export loss is in all control strategies the same (0% for eggs, 0.022% for poultry meat). The loss of national production and of export in terms of percentages was used to calculate income effects in agribusiness (processing industries), the

[11] The effect on export is calculated as the time the export ban is effective (standstill period + the number of days to last infected farms + OIE rules for export) expressed in years times the percentage of the region in the national annual production. OIE rules that the duration of an export ban is 60 days after the last infection or the destruction of the last vaccinated animal, in case of export to other EU-countries and 183 days after the last infection or the destruction of the last vaccinated animal, in case of export to third countries.

recreational sector and the primary sector. Table 4.2.10 gives the costs and income effects of an AI outbreak in a DPLA in the net exporting country A.

Table 4.2.10: Costs and income effects (95% percentile) of an AI outbreak in a DPLA in the net exporting country A (in € 1000).

	EU def + pre	EU def + vacc_kill	EU def + vacc_live
Direct farmers' costs	10,826	20,837	1,055
Indirect farmers' costs	7,378	5,758	15,312
Organizational costs	9,245	16,071	6,030
Income effect in agribusiness and recreation	(+12,571)	(+19,720)	(+1,292)
Income effect in the primary poultry sector of an export ban	0	0	0
Total	12,691	22,946	15,678

Table 4.2.10 shows that the control strategy 'vaccination and destruction' leads to the highest total loss, while the control strategy 'pre-emptive slaughter' leads to the lowest total loss. The direct farmers' costs of AI outbreaks in a DPLA are the highest for the control strategy 'vaccination and destruction', while the indirect farmers' costs are the highest for the control strategy 'vaccination and living'. The highest organizational cost are found for the control strategy 'vaccination and destruction'

Positive income effects (larger margins) on agribusiness and trade were calculated for all control strategies. These effects are mainly the result of the diminishing demand for mixed feed, especially in control strategies with the destruction of large numbers of poultry and the gains in other sectors like pork and beef because of a switch in demand from poultry to these products. Positive effects of cheaper imports may also play a role. In this particular case, the control strategy 'vaccination and destruction' has the highest positive income effect. For the income in the recreation sector, the negative effects of an AI outbreak in a DPLA were calculated for all control strategies. For the combined effects on income in agribusiness and in recreation, positive effects were calculated. The highest positive effect was for the control strategy 'vaccination and destruction', and the lowest for 'vaccination and living'.

Because the DPLA region in the net exporting country A contributes only a relatively small proportion of total production, the effects of an export ban on the income of poultry farmers at the national level are almost zero for all control strategies.

AI in MPLAs

The following are the economic results for control strategies of AI outbreaks in MPLAs. An effective control strategy was calculated for three net importing countries.

AI in MPLAs in net importing countries B, D and F

The loss of primary production volume resulting from an AI outbreak in an MPLA depends on the control strategy (Table 4.2.11). The control strategy 'EU measures' results in the lowest production loss of poultry products, while 'vaccination and destruction' results in the highest production loss of poultry products.

Table 4.2.11: Mean loss of primary production volume (95% percentile) resulting from an AI outbreak in an MPLA in the net importing countries B, D and F (in percentages of total production).

	EU def	EU def + Pre	EU def + vacc_kill	EU def + vacc_live
Production of eggs	0.03%	0.074%	0.09%	0.036%
Production of poultry meat	0.095%	0.26%	0.31%	0.12%

B, D and F are net poultry products importing countries. Thus, the production loss affects only the national production level. The loss of national production in terms of percentages was used to calculate income effects in agribusiness (processing industries) and in the recreational sector. Table 4.2.12 gives the mean costs and income effects of an AI outbreak in an MPLAs in the net importing country B, D and F.

Table 4.2.12: Mean costs and income effects (95% percentile) of an AI outbreak in an MPLA in the net importing countries B, D and F (in € 1000).

	EU def	**EU def + pre**	**EU def + vacc_kill**	**EU def + vacc_live**
Direct farmers' costs	1,167	3,039	3,401	996
Indirect farmers' costs	2,579	2,408	2,868	4,035
Organizational costs	519	801	963	1,789
Income effect in agribusiness and recreation	3,518	10,321	15,807	3,976
Total	7,783	16,559	23,039	10,796

Table 4.2.12 shows that the total costs of AI outbreaks in these MPLA regions in net importing countries are the highest for the control strategy 'vaccination and destruction' and the lowest for 'EU measures'. The division of the total costs over the different types of costs is not the same for all control strategies. The indirect farmers' costs are relatively important for the control strategy 'vaccination and living' and the direct costs for 'vaccination and destruction'. The strategy 'vaccination and living' also has relatively high organizational costs.

Negative income effects in agribusiness were calculated for all control strategies, because the effects of cheaper imports are smaller than the effects of the relatively large production loss. The highest agribusiness income loss occurs for the strategy 'vaccination and destruction', while the lowest agribusiness income loss is for the strategy 'EU measures'. For the incomes in the recreational sector, also negative effects were calculated for all control strategies. Recreational income loss is the highest for the control strategy 'vaccination and destruction' (see Appendix C). Because B, D and F are net poultry products importing countries, no effects of an export ban on farmer income on national level were calculated.

4.2.5 Discussion

Only for available epidemiological scenarios the economic consequences were calculated. The epidemiological model focused on the regional control of contagious animal diseases. If a specified control strategy failed to regionally control the spread of the disease no epidemiological data was available for calculating the economic consequences. This means that only for regionally controlled outbreaks the economic losses are presented. Economic losses of outbreaks that are not regionally controllable will be higher than the presented 95% percentile. For a large CSF outbreak in the Netherlands Mangen & Burell (2003) calculate total welfare effects to be as high as €863 mln, when export is allowed from non-quarantine zones. Tomassen et al. (2003) calculate total welfare effects of simulated FMD outbreaks to be as high as €949.2 mln for the most effective control strategy of EU -measures and ring culling within a 1-km radius of the infected herd. For other strategies welfare effects are higher, with a maximum of €1.346 mln for EU-measures and vaccination and culling within a 4-km radius of the infected herd.

Regional circumstances (animal density) and national circumstances (net import or net export) are important economic determinants in deciding on the economically optimal strategy to control an outbreak (Huirne et al., 2003; Tomassen et al., 2002; Wilpshaar et al., 2002). This economic analysis focused on the influence of these circumstances on the choice for an optimal control strategy for outbreaks of FMD, CSF or AI. Therefore, it is sufficient to present the mean effects and costs of comparable regions over countries. This means that no country-specific results are presented in this chapter. The results show that the economically optimal control strategy can differ with these circumstances.

A static deterministic calculation model combined the epidemiological outbreak with the zootechnical, price and control measure and costs data and converted them into estimates of direct and indirect farmers' and organizational costs. Because an outbreak can also influence other sectors, further calculations were made with the GTAP model to calculate the effects on the food processing, trade and recreational sectors. The current GTAP model is not equipped to deal with compensation payments to farmers. Effects outside the food processing and recreational sectors due to, for example, changing consumption patterns were also not included in the analysis. Furthermore, no changes in the demand for recreational services were assumed. In the Netherlands the negative effects of the FMD outbreak in 2001 on the turnover in the recreation sector are estimated at about €184 million (Huirne et al., 2002). In this Dutch study also the net effect of a smaller number of visitors was included.

Lack of information on the underlying zootechnical, price and control measure data of the six countries made it impossible to determine the distribution functions (or even only minimum, most likely and maximum values) of the main economic parameters. Thus no stochastic simulation model could be developed. For a number of missing country data it was possible to make assumptions on the basis of the available data from the other countries and in the Netherlands. Thus, at least sufficient information was made available on the average value of the economic parameters to construct a deterministic simulation model. Although sufficient user-friendly software and scientific methods are available to execute a stochastic economic risk analysis, their application is severely limited because of the poor quality of the underlying data.

The costs and possible gains are not evenly distributed over all sectors and all parts of the country. The infected, pre-emptively cleared farms and the vaccinated farms bear the most of the costs, while elsewhere in the economy a gain can be made.

The specific examples used here cannot be compared with each other. Therefore, the importance of the regions and the characteristics of the countries differ too much. This means that it is not possible to draw general conclusions or to compare the results in different countries; only a comparison of the effects of different control strategies for the same region can be made.

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4.3 Part IIIC: Multi Criteria Analysis

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Decision making in controlling animal contagious diseases is a complex, conflicting process, characterized by epidemiological, economic and socio-ethical value judgements. The objective of this study is to develop an integral evaluation framework to support policy makers in choosing the control strategy that best meets all these conflicting judgements by applying a multi-criteria analysis (MCA).

MCA can be effective in increasing the understanding, acceptability and robustness of a decision problem. Although it is one of the most frequently applied tools within operations research and management science, MCA methods are hardly applied in the management of animal disease control even though it generally improves the quality and transparency of the decision making process. This section describes the development and application of such a MCA-framework to order the various control strategies according to the preferences of the various stakeholders.

4.3.1 Definition MCA

The general purpose of a MCA is to serve as an aid to thinking and decision making, but not to take the decision. The MCA technique deals with complex problems that are characterized by any mixture of quantitative and qualitative objectives, by breaking the problem into more manageable pieces to allow data and judgements to be brought to bear on the pieces. Then the technique reassembles the pieces to present a coherent overall picture to decision makers.

Multi criteria analysis establishes preferences between alternatives to an explicit set of objectives and measurable criteria to assess the extent to which the objectives have been achieved. A key feature of MCA is its emphasis on the judgement of the stakeholders involved, in establishing objectives and criteria and estimating the relative importance weights of each criterion.

There are many different MCA methods. The principal difference between the main MCA methods is the way in which each alternative's performance across all criteria is aggregated to form an overall assessment of each alternative. Most MCA applications use the simple linear additive evaluation method, which is also the basis of the multi criteria analysis performed in the project. This method combines the alternative's values into one overall value by multiplying the value score on each criterion by the weight of that criterion, followed by a summation of all those weighted scores.

4.3.2 Method applied MCA

The applied MCA involves eight steps, as represented by Table 4.3.1 and described below.

Table 4.3.1: The 8 steps within the applied Multi Criteria Analysis.

1. Establish the decision context
2. Identify the alternatives to be appraised
3. Identify objectives and criteria
4. 'Scoring'
5. 'Weighting'
6. Calculate overall value.
7. Examine the results
8. Sensitivity analysis

Step 1: Establish the decision context

Within this first step the objective of the MCA should be clearly defined along with an identification of the key players or so-called stakeholders; i.e., decision makers as well as people who may be affected by the decision.

Objective
MCA is all about multiple conflicting objectives. There are ultimately trade-offs to be made. Nonetheless, in applying MCA it is important to identify a single high level objective for which there will be sub-objectives. The aim of this MCA is to make best use of data currently available to support the decision on controlling contagious animal diseases as FMD, CSF and AI.

Stakeholders
A key player or stakeholder is anyone who can make a useful and significant contribution to the MCA. Stakeholders are chosen to represent all the important perspectives on the subject of the analysis. One important perspective in the field of controlling contagious animal diseases is that of the final decision maker and the animal health authority to whom that person is accountable. Within this analysis the Chief Veterinary Officers were approached to express these governmental values by their questionnaire responses (see Chapter 3). Those responses were given by a written questionnaire, so there was no interaction or exchange of information/experiences between the various participating CVOs.

To account for the perspectives of various groups of people within society that may be affected by the ultimate control decision, numerous other stakeholders were approached with a comparable questionnaire to reflect their values (see Chapter 3).

Step 2: Identify the alternatives to be appraised

The appraised alternatives per contagious animal disease consisted of the default EU measures (Eudef) and one or more of the following additional control measures:

PRE	= pre-emptive slaughter of neighbouring farms within a predefined radius around a detected farm. The evaluated radius depends on its epidemiological control efficiency as described in paragraph 4.1.2.1.
VAC _kill	= suppressive vaccination within a radius of XX km around a detected farm. Vaccination is applied as a suppressive measure, all vaccinated animals will therefore be slaughtered as soon as the epidemic is under control. The evaluated radius per disease depends on its epidemiological control efficiency as described in paragraph 4.1.2.1.
VAC _live	= protective vaccination within a radius of XX km around a detected farm. Vaccination is applied as a protective measure, all vaccinated animals will therefore stay on the farm as soon as the epidemic is under control. The evaluated radius per disease depends on its epidemiological control efficiency as described in paragraph 4.1.2.1.

The 4 alternative control strategies were evaluated per disease (n=3) and per detailed surveyed EU member state (n=6).

Step 3: Identify objectives and criteria

Assessing alternatives requires thought about the consequences of the alternatives, for strictly speaking it is the consequences that are being assessed not the alternatives themselves. Criteria and sub-criteria or indicators are the measures of performance by which the alternative control strategies are judged. Criteria are specific, measurable objectives. They are children of higher-level parent objectives, who themselves may be the children of even higher-level parent objectives.

This research is centered on 3 high-level objectives or main criteria, viz. epidemiology, economics, and social-ethics. Each criterion is broken down into lower level objectives or indicators to facilitate the scoring process. These clusters of indicators are the same as presented in the questionnaire (Chapter 3).

In general, criteria and indicators are defined by help of the stakeholders in an iterative way. However, within the scope of this research, it was not possible to conduct such an extensive, iterative process. The definitions of criteria and indicators are therefore based on 1) the results of a former study in which Dutch stakeholders were interviewed by means of a Group Decision Room session to define the criteria by which animal control strategies should be evaluated and on 2) additional expert consultation.

Step 4: 'Scoring'.

By determining criterion scores, attention should be paid to the measurement scale. A distinction can be made between a quantitative and a qualitative measurement scale. In case of a quantitative scale the measurement unit is known, i.e. a quantity has been defined as a standard by which the magnitude of differences can be expressed. Examples of measurement units are animals, farms, days, and so forth. Two different quantitative scales can be distinguished: a ratio scale and an interval scale. In a ratio scale the origin, indicated by the number 'zero' is known or defined. In an interval scale, however, the origin is neither known nor defined.

The measurement unit of a qualitative measurement scale is unknown. Three qualitative measurement scales can be distinguished. Table 4.3.2 gives an illustration of the various measurement scales. The ordinal scale contains most information, since the numbers of this scale give a rank order. Whether a choice-possibility is worse or better than any other choice possibility can be expressed by means of an ordinal scale; no information is available about 'how much' such is the case. The nominal scale contains the least information since this scale concerns only the adjudication of a label or name. A special kind of nominal scale is the binary scale, which may express a partial order since this scale only represents 'yes / no' information.

Table 4.3.2: Illustration of various measurement scales.

Scale	Example			Comments
Nominal	South	Middle	North	areas within a country
Binary	1	1	0	1 = farm density more than 5 per km2 0 = farm density less than 5 per km2
Ordinal	2	1	3	ranking on farm density
Ratio	6.9	12.7	0.6	actual farm density per km2
Interval	South – Middle : 5.8 South – North : 6.3 Middle- North : 12.1			difference in farm density

Even if the criterion scores have been determined on a ratio scale for all criteria, these scores are mutually incomparable since most of the measurement units will differ from each other. One criterion might be expressed in number of farms, whereas another criterion is measured in days. To make the various criterion scores comparable it is necessary to transform them into one common measurement unit, by taking care that for each criterion the scores will get a range from 0 to 1. This kind of transformation is called standardization. The method of standardization used for the scores in this study can be written as:

Standardized score i = (score i / maximum score)

or each score is divided by the highest score of the criterion concerned. An example is given in Table 4.3.3.

Table 4.3.3: A numerical example of the method of standardization.

Criterion expected length epidemic	Alternative			
	A	B	C	D
Score (days)	76	235	178	156
Standardized score	0.32	1.00	0.76	0.66
Directed standardized score	0.68	0.00	0.24	0.34

Related to standardization is the issue of the direction of the criterion scores. For some criteria a higher score implies a 'better' score, whereas for other criteria higher score implies a 'worse' score. The example criterion 'length epidemic' from Table 4.3.3 is an example of the latter. Each standardization should therefore be accompanied by a consideration of the direction of the scores. In this study the worst criterion score is given a standardized value of 0, whereas the best criterion score has a standardized values of 1.

The standardized scores of the example criterion Length epidemic can simply be redirected according to:

Redirected standardized score = 1 - Standardized score

Criterion scores can be derived in many different ways. In this study all quantitative scores are based on the results of the model studies (Chapter 4.1 and 4.2). The presented MCA analyses are directed towards the 95 percentile values, assuming a risk-averse attitude with respect to the contagious animal disease control. The scores of qualitative indicators are obtained by ranking the alternatives per criterion by its expected effectiveness. These effectiveness rankings are based on the insights obtained by the questionnaires, personal interviews and model studies.

Step 5: 'Weighting'.

A criterion's weight should depend on the range of difference in the criterion scores and on how much the stakeholders care about the difference. For instance, most stakeholders consider length of the epidemic an important decision criterion. However, when alternative strategies would result in an expected duration difference of only a few days, length would not longer be an important decision criterion. In this study, stakeholders were asked to express their judgements (= weights) on grounds of their subjective knowledge on possible ranges of criterion scores.

The weighting factors applied in this study coincide with the results of the questionnaire as described in Chapter 3. By this questionnaire various groups of stakeholders expressed their judgements using comparative scales (see 3.3.1.1 and 3.3.2). The weighting factors for the 3 main criteria correspond to the questionnaire results as expressed in Figures 3.1A and 3.5. The weighting factors for the epidemiological and economic indicators are equal to the questionnaire results as expressed in Figures 3.1B and 3.1C.

The weighting factors of the 2 sets with 10 social-ethical indicators *in support* and *against* an applied control strategy (see Figures 3.1D, 3.1E, 3.6A and 3.6B) are re-scaled in one set of 12 indicators in total (see Table 4.3.4). The key assumption in this re-scaling process is that the indicators *in support* and *against* are of equal importance in the final social-ethical judgement on a control strategy.

Table 4.3.4: Example of re-scaling the original 2 sets of indicators (in support and against) into one combined set.

Indicators	**Set**		
	In support	**Against**	**Combined**
Efficacy	25.9	18.2	17.8
Socio-economic factors	14.1	13.6	11.2
Macro-economic factors	9.5	8.7	7.4
Commercially interested parties	6.6	12.3	7.7
Animal health	10.9	8.7	7.9
Animal welfare	6.5	10.8	7.0
Tourism	3.7	5.9	3.9
Non-farm animals	3.6	2.7	2.5
Human health	13.5	N.P	10.9
Governmental policy	10.4	N.P	8.4
Natural life-cycle	N.P.	7.7	6.2
Food source	N.P.	11.4	9.2

N.P. = not present

Step 6: Combine the weights and scores for each alternative to derive an overall value

The overall weighted scores can be obtained by multiplying an alternative's score on a criterion by the importance weight of the criterion (Figures 3.1A and 3.5), carried out for all criteria, followed by summing the products to give the overall preference for that alternative.

This procedure is used for the determination of the overall values of the three main criteria, epidemiology, economics and social ethics. In general the higher the overall value, the better the alternative control strategy scores within the concerned criteria.

However, the performed multi criteria evaluation is based on criteria, which are partially assessed on a **quantitative** scale as well as partially on a **qualitative** scale. To account for the specific characteristics of both measurement scales, a mixed data multi criteria technique is applied to determine an overall score per alternative.

In this mixed data evaluation technique differences in alternatives are expressed in a condensed way by means of **paired comparisons**. Standardized scores of each indicator are compared in pairs of the evaluated alternatives, resulting in so-called dominance scores. A positive score implies dominance of one strategy tin relation to another while a negative value implies submission. A dominance measure of 0 implies an indifference between the compared strategies. By weighting these dominance scores per criteria, overall dominance scores of the three main criteria are obtained.

To compare the outcomes of the quantitative and qualitative dominance scores, the scores of the individual main criteria are standardized into the same unit. In this way the dominance scores of the quantitative criteria epidemiology and economics are comparable to the dominance score of the qualitative criterion social-ethics. By weighting these standardized dominance measures with the aggregated weights of the constituent criteria the overall dominance score per alternative is calculated, which represents the degree in which an alternative is better (or worse) than another alternative.

Step 7: Examine the results

The aggregation of the dominance scores of the three main criteria (viz. epidemiology, economics and social-ethics) into one overall dominance score per alternative gives an indication of how much an alternative is appreciated over another. These overall dominance scores are also determinative in the overall ordering of the evaluated control strategies.

Step 8: Sensitivity analysis

Sensitivity analysis provides a means of examining the extent to which the relative importance weights of each criterion/indicator makes any difference in the final results. Interest groups often differ in their views of the relative importance of the criteria (or weights) and of some scores, though weights are often the subject of more disagreement than scores. In this study special attention is given to the comparison between the ranking of alternatives based on the preferences expressed by the CVOs and the ranking based on the preferences expressed by the representatives of the general public.

Using the MCA model to examine how ranking of options might change under different weighting systems can show that for instance, two options always come out best, though their order may shift. If the differences between these best options under different weighting systems are rather small, accepting a second best option can be shown to be associated with little loss of overall benefit.

4.3.3 Results MCA

Within the performed MCA, the scoring and weighting process of the various indicators and criteria per control alternative has been subdivided in four interrelated parts:

1) scoring and weighting of **epidemiological** indicators to determine one overall value per alternative, representing the individual score of the epidemiological criterion,
2) scoring and weighting of **economic** indicators to determine one overall value per alternative, representing the individual score of the economic criterion,
3) scoring and weighting of **social-ethical** indicators to determine one overall value per alternative, representing the individual score per alternative of the economic criterion,
4) combined weighting of the three individual criterion scores to determine the **overall** dominance score per alternative.

For each of the evaluated regions and diseases, the MCA results of these four interrelated parts are described in detail in Appendices D.1 till D.3. The following paragraph describes the overall results of the performed multi criteria analyses. In conformance with the earlier paragraphs a distinction is made according to herd density (DPLA versus MPLA) and trade characteristics (export versus import) of the evaluated regions.

4.3.3.1 MCA results FMD

This subparagraph describes the overall MCA results based on the evaluation of FMD control alternatives for 2 net importing, DPLA countries (regions D and F).

- *Overall scores main criteria*

Table 4.3.5 demonstrates the overall weighed scores of the three main criteria. The separate scores of the underlying epidemiological, economic and social-ethical indicators are presented in Appendix D.1.

The absolute values of the scores should not be compared ‘between row’-wise; only ‘within row’ wise. A between rows comparison would be inaccurate due to the fact that the total values per criterion result from the differences between the alternative strategies evaluated on a specific country base.

Based on the overall epidemiological score, the Pre strategy is preferred best, followed by the Vac_live strategy. The overall 0 score on the Vac_kill strategy indicates that – compared to the other 2 alternatives – Vac_kill scores worst on all epidemiological indicators. However, the efficiency with which this strategy controls an FMD epidemic is comparable with the efficiency of the Vac_live strategy. Due to the fact that the vaccinated animals will be killed afterwards, Vac_kill scores worst on all indicators involving number of destroyed herds or animals. These indicators do not strictly reflect epidemiological efficiency; they also reflect a social-ethical element.

Table 4.3.5: Overall weighed scores of three evaluated FMD control alternatives per main criterion and region. Bold printed values reflect alternatives with highest scores (= highest rank).

Region	**Control alternative**			
	Overall epidemiological score			Difference second best alternative
	Pre	Vac_live	Vac_kill	
Region D, import, DPLA	**36**	27	0	9
Region F, import DPLA	**48**	27	0	21
	Overall economic score			
	Pre	Vac_live	Vac_kill	
Region D, import, DPLA	58	53	**63**	5
Region F, import DPLA	**64**	59	52	5
	Overall social/ethical score			
	Pre	Vac_live	Vac_kill	
Region D, import, DPLA	21	**55**	33	22
Region F, import DPLA	24	**55**	31	24

The ranking of the alternatives based on the economic criterion differs for the 2 regions; for Region D the Vac_kill strategy is preferred above the others, while for Region F the Pre strategy is preferred best. However differences in overall economic values among the alternatives are rather small, as reflected by the small difference in overall value between the first and second ranked alternatives (viz. 5 points).

From a social-ethical point of view, alternative Vac_live is evaluated to exceed the other 2 alternatives. With a difference of at least 22 points, Vac_kill is evaluated as the second best option.

- *Overall strategy value*

The combined weighting of the three main criteria resulted in paired dominance scores. A positive score implies dominance of a strategy in relation to another while a negative value implies submission (see Appendix D.1). Figure 4.3.1 illustrates the overall dominance scores of the FMD control alternatives per evaluated region. These overall scores result from the summation of the separate paired comparison dominance score as illustrated in Appendix D.1.

The course in dominance scores reflects the overall mutual ranking of the 3 control alternatives, which has the same pattern for the 2 evaluated regions (Figure 4.3.1). Based on the overall weighting factors obtained from the CVOs, the Pre strategy is favoured over the other 2 alternatives. Vac_kill is completely dominated by the other strategies as reflected by its negative dominance score.

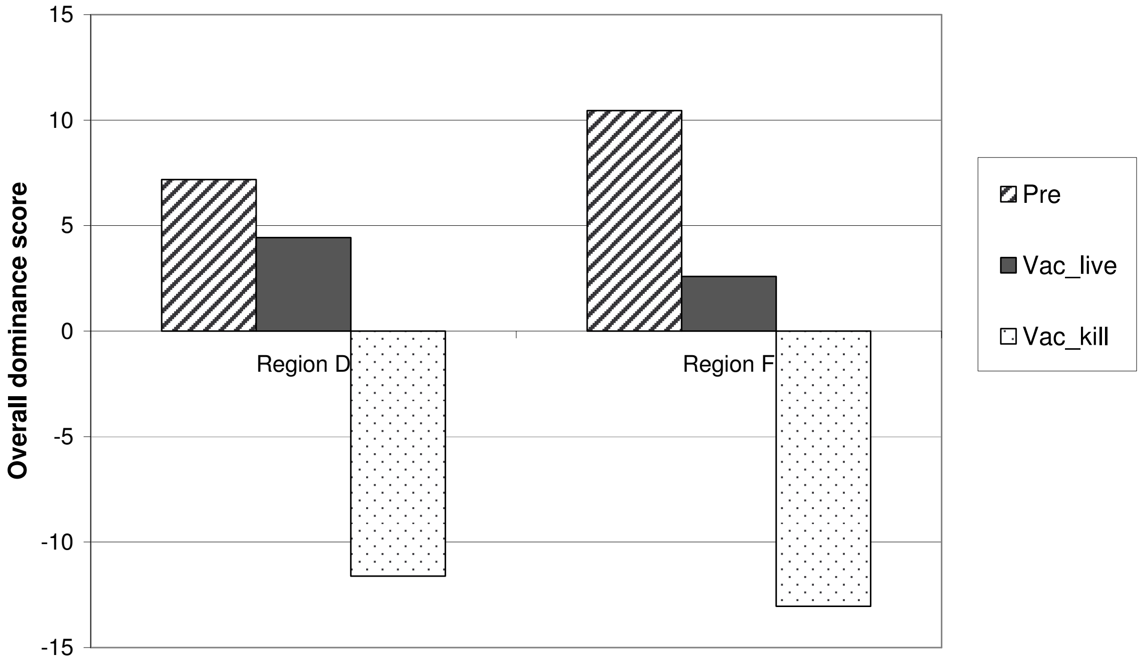

Figure 4.3.1: Overall dominance scores of FMD control alternatives per evaluated region.

4.3.3.2 MCA results CSF

This subparagraph describes the overall MCA results based on the evaluation of CSF control alternatives for 3 net importing MPLA countries, 2 net exporting DPLA countries and 1 net exporting MPLA country.

- *Overall scores main criteria*

Table 4.3.6 demonstrates the overall weighed score of the three main criteria. The separate scores of the underlying epidemiological, economic and social-ethical indicators are presented in Appendix D.2. The absolute values of the scores should not be compared 'between row'-wise; only 'within row' wise. A between rows comparison would be inaccurate due to the fact that the total values per criterion result from the differences between the alternative strategies evaluated on a specific country base.

Based on the overall epidemiological score, the Vac_live strategy is preferred best in 5 of the 6 evaluated regions. Only the EU strategy scores better for region F, followed - with a difference of only 5 points in overall score - by the Vac_live strategy as second best alternative. Again the Vac_kill strategy is evaluated worst in all evaluated country situations, as a consequence of a low ranking on the indicators involving number of destroyed herds or animals.

Table 4.3.6: Overall weighed scores of four evaluated CSF control alternatives per main criterion and region. Bold printed values reflect alternatives with highest scores (= highest rank).

Region	Control alternative				Difference with second best alternative
	Overall epidemiological value				
	EU	Pre	Vac_live	Vac_kill	
Region B, import, MPLA	23	16	**31**	6	8
Region A, export, MPLA	48	30	**51**	27	3
Region F, import, MPLA	**72**	51	67	46	5
Region D, import, MPLA	33	38	**41**	20	3
Region E, export DPLA	n.a.	17	**28**	0	11
Region C, export, DPLA	n.a.	21	**28**	0	7
	Overall economic value				
	EU	Pre	Vac_live	Vac_kill	
Region B, import, MPLA	**77**	41	71	48	6
Region A, export, MPLA	**62**	36	45	45	17
Region F, import, MPLA	**62**	57	54	61	1
Region D, import, MPLA	**67**	51	55	50	12
Region E, export DPLA	n.a.	36	**43**	**43**	0
Region C, export, DPLA	n.a.	51	32	**61**	10
	Overall social-ethical value				
	EU	Pre	Vac_live	Vac_kill	
Region B, import, MPLA	47	36	**67**	30	20
Region A, export, MPLA	44	31	**53**	27	9
Region F, import, MPLA	**51**	39	46	28	5
Region D, import, MPLA	49	33	**53**	27	4
Region E, export DPLA	n.a.	34	**55**	23	21
Region C, export, DPLA	n.a.	34	**55**	23	21

n.a. = not analysed due to restricted control efficiency of the strategy

The ranking of the alternatives based on the economic criterion differs for the 2 density clusters; for the MPLA regions the EU strategy is appreciated over the other alternatives, while for DPLA regions the Vac_kill strategy is preferred best. A clear difference in ranking between importing and exporting regions is lacking. This can be a consequence of the fact that weighting factors reflect the “average CVO judgement”; weighting the scores separate by the weighting factors reflecting the economic judgements of CVOs from exporting countries and by the weighting factors reflecting the economic judgements of CVOs from importing countries may result in different rankings.

From a social-ethical point of view, alternative Vac_live is evaluated to exceed the other alternatives in 5 of the 6 country situations. Only the EU strategy scores better for Region F, followed - with a difference of only 5 points in overall score - by the Vac_live strategy as second best alternative.

- *Overall strategy value*

The combined weighting of the three main criteria resulted in paired dominance scores. A positive score implies dominance of a strategy in relation to another while a negative value implies submission (see Appendix D.2). Figure 4.3.2 illustrates the overall dominance scores of the CSF control alternatives per evaluated region. These overall scores result from the summation of the separate paired comparison dominance score as illustrated in Appendix D.2 .

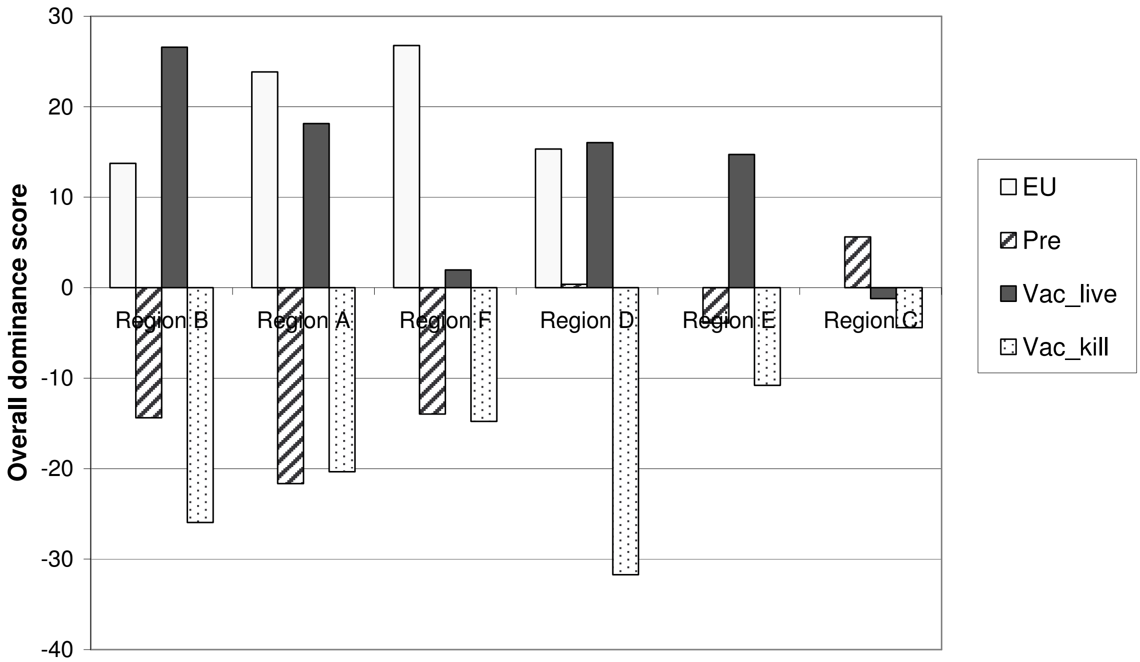

Figure 4.3.2: Overall dominance scores of CSF control alternatives per evaluated region.

The course in dominance scores reflects the overall mutual ranking of the evaluated control alternatives. Based on the overall weighting factors obtained from the CVOs and the 6 evaluated situations, the Vac_live strategy is favoured 3 times as best option and 3 times as second best. Although the EU strategy was pre-defined as not effective in the DPLA regions E and C, the strategy is preferred 2 times as best and 2 times as second best within the 4 remaining evaluated regions. Vac_kill is – again - completely dominated by the other strategies as reflected by its negative dominance score.

For Regions B, A, and D the losses of overall benefit associated with the acceptance of the second best alternative are small as indicated by the differences in column heights of Figure 4.3.2. This is in contrast to the situations of Regions F and E, where acceptance of the second best alternative is associated with rather high overall benefit losses. The ranking of alternatives for Region C is rather specific; the Pre strategy is favoured over the other 2 alternatives based on a small difference in dominance score.

4.3.3.2 MCA results AI

This subparagraph describes the overall MCA results based on the evaluation of AI control alternatives for 2 net importing MPLA countries, 1 net importing DPLA country and 1 net exporting MPLA country.

- *Overall scores main criteria*

Table 4.3.7: Overall weighed scores of four evaluated AI control alternatives per main criterion and region. Bold printed values reflect alternatives with highest scores (= highest rank).

Region	**Control alternative**				Difference second best alternative
	Overall epidemiological value				
	EU	Pre	Vac_live	Vac_kill	
Region A, export, DPLA	n.a.	26	**29**	0	3
Region F, import, MPLA	24	23	**25**	3	1
Region B, import, MPLA	19	13	**22**	2	3
Region D, import, DPLA	22	15	**26**	4	4
	Overall economic value				
	EU	Pre	Vac_live	Vac_kill	
Region A, export, DPLA	n.a.	**55**	36	33	19
Region F, import, MPLA	**56**	37	48	46	8
Region B, import, MPLA	**57**	38	52	30	5
Region D, import, DPLA	**56**	55	48	52	1
	Overall social-ethical value				
	EU	Pre	Vac_live	Vac_kill	
Region A, export, DPLA	n.a.	22	**59**	37	22
Region F, import, MPLA	52	29	**54**	30	2
Region B, import, MPLA	48	32	**64**	28	16
Region D, import, DPLA	**52**	35	49	31	3

n.a. = not analysed due to restricted control efficiency of the strategy

Table 4.3.7 demonstrates the overall weighed score of the three main criteria. The separate scores of the underlying epidemiological, economic and social-ethical indicators are presented in Appendix D.3.

The absolute values of the scores should not be compared ‘between rows’-wise; only ‘within row’ wise. A between rows comparison would be inaccurate due to the fact that the total values per criterion result from the differences between the alternative strategies evaluated on a specific country base.

Based on the overall epidemiological score, the Vac_live strategy is preferred in all of the four evaluated regions. However, differences in overall epidemiological scores are small in relation to the second best alternatives (max. difference = 4 points). Again the Vac_kill strategy is evaluated worst in all evaluated country situations, as a consequence of a low ranking on the indicators involving number of destroyed herds or animals.

From an economic point of view, the EU strategy is ranked first for those regions where the EU alternative is evaluated as an effective control strategy. For Region A, where the EU is not considered to be an effective strategy (see Chapter 4.1), the best alternative is the Pre control strategy.

From a social-ethical point of view, alternative Vac_live is evaluated to exceed the other alternatives in 3 of the 4 country situations. Only the EU strategy scores better for Region D, followed - with a difference of only 3 points in overall score - by the Vac_live strategy as second best alternative.

- *Overall strategy value*

The combined weighting of the three main criteria resulted in paired dominance scores. A positive score implies dominance of a strategy in relation to another while a negative value implies submission (see Appendix D.3). Figure 4.3.3 illustrates the overall dominance scores of the AI control alternatives per evaluated region. These overall scores result from the summation of the separate paired comparison dominance score as illustrated in Appendix D.3.

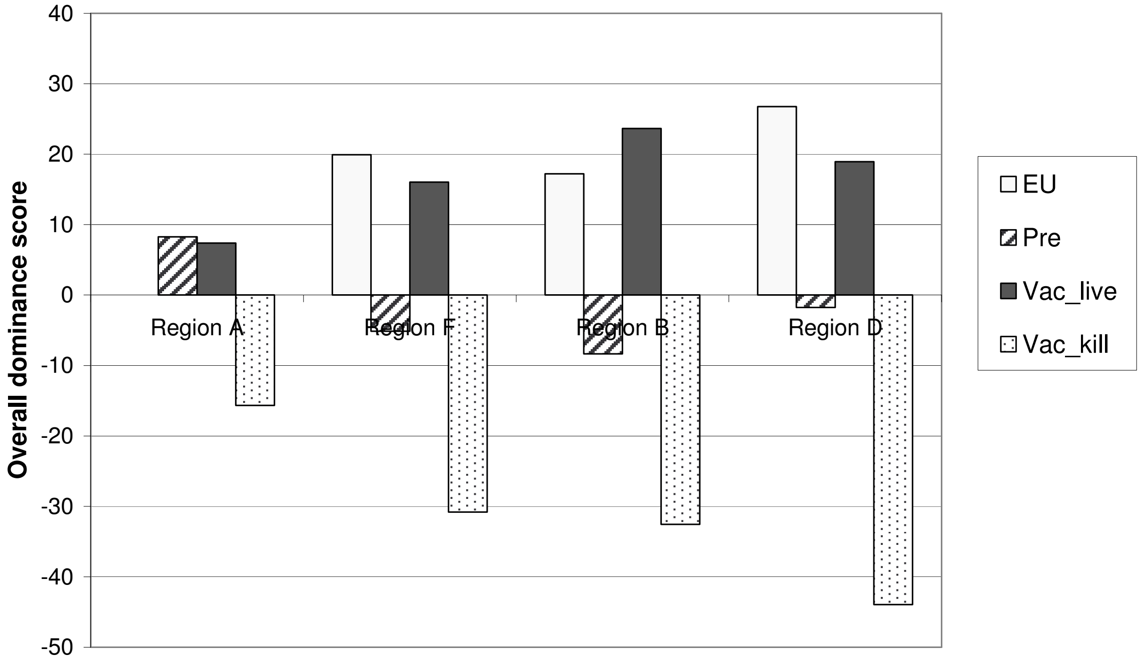

Figure 4.3.3: Overall dominance scores of AI control alternatives per evaluated region.

The course in dominance scores reflects the overall mutual ranking of the evaluated control alternatives. Based on the overall weighting factors obtained from the CVOs and the 4 evaluated situations, the Vac_live strategy is favoured 1 time as the best option and 3 times as the second best option. Although the EU strategy was pre-defined as not effective in the DPLA region A, the strategy is preferred 2 times as best and 1 time as second best alternative within the 3 remaining evaluated regions. Vac_kill is – again - completely dominated by the other strategies as reflected by its negative dominance score.

For all evaluated regions the losses of overall benefit associated with the acceptance of the second best alternative are small as indicated by the differences in column heights of Figure 4.3.3. This is in contrast to the acceptance of the third best alternatives, which is associated with high overall benefit losses.

4.3.4 Discussion MCA

The applied MCA serves as an illustrative example. A sound MCA is typically conducted in an iterative fashion, with much looping back to previous steps, revising the model, gaining insights, further modifying the model, until a requisite representation of the problematic situation is attained. Within the scope of this research, it was not possible to conduct such an intensive, iterative process.

The performed MCAs are based on the judgement values of the CVOs. Results show a general tendency towards the ranking of alternatives, which in most of the cases appears to be independent of the evaluated disease. The general tendency can be described as follows:

- From an epidemiological point of view, the Vac_live strategy is preferred as strategy to control epidemics of CSF or AI. For the control of FMD, the Pre strategy is appreciated over the other alternatives. Vac_live is, however, the second best option.
- From an economic point of view, the EU strategy is ranked as best option for those situations where the EU strategy is evaluated as a control strategy. There is no unambiguous ranking of alternatives, which characterises the preference in the other situations (i.e. situations in which the EU strategy has a restricted control efficiency).
- From a social ethical point of view, the Vac_live strongly dominates the other control alternatives.
- From a multi criteria point of view:
  - o In the MPLA regions, the Vac_live and EU strategies are generally prefered over the other control strategies, independent of the specific disease.
  - o In the DPLA situations, preference is mostly given to the Pre strategy, followed by the Vac_live strategy as second best option.

The economic ranking based on the MCA may differ from the economic ranking as described in paragraph 4.2, which is the result of adding all the losses to one overall value. By utilizing subjective weighting factors, the MCA ranking is not only accounting for the height of the losses but also for, for instance, value judgements on topics as ‘who is bearing the losses’.

Difference in ranking between clusters, comprising regions with comparable density and/or trade characteristics, are possibly underexposed due to the use of ‘average’ CVO judgements. Disaggregating the panel of CVOs into subgroups conform the density and trade characteristics of the country the CVOs represent, followed by an analysis per cluster would provide better insight into the possible presence of alternative rankings.

Individual CVOs - or in general – individual interest groups often differ in their views of the relative importance of the various criteria. Using the MCA framework to examine how ranking of alternatives might change under different preferences or weighting systems can show that, for instance, two alternatives always come out best. Their order, however, may shift. If the differences between these best alternatives under different weighting systems are rather small, accepting a second best option can be shown to be associated with little loss of overall benefit, as demonstrated by the following illustration.

As illustrated by the results of the questionnaire (paragraph 3.3.2), preferences among the criteria varied between the four studied interest groups or stakeholders (viz. CVO group, agricultural interest group, non-agricultural interest group and veterinarian group). Table 4.3.8 summarizes the indicated preference weights for the main criteria per interest group. This overview stresses the contrast in perspectives of the non-agricultural interest group in comparison to the other interest groups.

Table 4.3.8: Criterion preference weights (%) per interest group.

Interest group	**Criterion**		
	Epidemiology	Economics	Social-ethics
CVO	53	30	17
Agriculture	49	33	18
Non-Agriculture	51	15	35
Veterinarian	53	26	21

An evaluation of the overall dominance scores based on the preference weights of these individual interest groups makes it possible to examine differences in ranking of alternatives. Table 4.3.9 demonstrates - for instance - the interest group specific overall scores of the AI control alternatives in region A. Based on the preferences of the CVO and the Agricultural interest groups the Pre strategy is ranked first followed by the Vac-live strategy as second best alternative. From the Non-agricultural and Veterinarian point of view, the ranking of these two alternatives is just the opposite. However, differences between first and second best alternatives are rather small. The loss of overall benefit associated with the acceptance of the second best alternative is highest for the Non-agricultural interest group (difference of 5.8).

Table 4.3.9: Overall dominance scores of AI control alternatives in region A based on the criterion weights of the individual interest groups. Bold printed values reflect alternatives with highest scores (= highest rank).

Interest group	**Control alternative**			Difference with second best alternative
	Pre	Vac_live	Vac_kill	
CVO	**8.3**	7.4	-15.6	0.9
Agriculture	**8.2**	6.8	-15.0	1.4
Non-Agriculture	4.2	**10.0**	-14.2	5.8
Veterinarian	7.4	**8.0**	-15.4	0.6

Generally, when opposing stakeholders discuss alternative options, they quickly focus on their differences of opinions, ignoring the effect of many criteria on which there is an agreement. The MCA technique provides a more balanced approach to ensure that all criteria enter the evaluation, with the result that overall differences are not as great as they seem in an unstructured, face-to-face meeting.

The applied integral evaluation framework illustrates the potential use of the MCA technique within the complex decision making process of controlling contagious animal diseases. Nevertheless, people make the decisions, not models. MCA models can assist people in decision making by providing structure to debates, ensuring quality conversations, documenting the process of analysing the decision, separating matters of fact from matters of judgement, making value judgments explicit, bringing judgements about trade-offs between conflicting objectives to the attention of decision makers, creating shared understanding about the issues, generating a sense of common purpose, and, often gaining agreement. MCA can do any or all of these, but it does not give ‘the’ answer.

4.3.5 Conclusion MCA

The performed analyses demonstrate that MCA technique can support policy makers in choosing the control strategy that best meets all the conflicting epidemiological, economic and social-ethical judgements. The MCA technique provides a balanced approach to ensure that all criteria enter the strategy evaluation, with the result that overall differences between opposing stakeholders turn out to be not as great as they seem in an unstructured, face-to-face meeting.

The presented MCA is based on the average judgement values of the CVOs, as elicited by the survey. Results show a general tendency towards the ranking of control alternatives, which in most of the cases appears to be independent of the evaluated disease. In the moderate populated livestock areas, the default EU control strategy and the protective vaccination (EU+Vac_live) strategy are generally appreciated over the other control strategies. In the densely populated livestock area situations, preference is mostly given to the pre-emptive slaughter (EU+Pre) strategy, followed by the protective vaccination (EU+Vac_live) strategy as second best option.

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Appendix A: Questionnaire part I

QUESTION 1A: The efficacy of a control strategy to eradicate the epidemic disease can be described by a number of indicators.
Imagine an epidemic of a contagious animal disease in your country in the near future. Which indicators do you think are more important to describe the efficacy of a control strategy? Please divide 100 points per disease (in grey areas). More points indicate a more important indicator.

Indicator	Epidemiological indicators	Score
A.1	Total duration of the epidemic*: does a shorter outbreak improve the efficacy of the control strategy?	_ _ _ _
A.2	Total number of infected farms: does a lower number of infected farms improve the efficacy of the control strategy?	_ _ _ _
A.3	Size of the affected region: does a smaller affected size improve the efficacy of the control strategy?	_ _ _ _
A.4	Total number of destroyed animals: does a lower number of destroyed animals improve the efficacy of the control strategy?	_ _ _ _
A.5	Total number of herds on which animals are destroyed: does a lower number of herds on which animals are destroyed improve the efficacy of the control strategy?	_ _ _ _
A.6	Total number of non-farm animals destroyed**: does a lower number of destroyed non-farm animals improve the efficacy of the control strategy?	_ _ _ _
Total		100

* Period between first infection until the lifting of the last restriction.
** Non-farm animals: farm animals, such as poultry or cattle or related species, kept for non-farming purposes, in for instance zoos, sanctuaries, nature reservations, or in the domestic environment as pets or backyard animals.

QUESTION 1B: The impact of a control strategy on local and national economy can be described by a number of indicators.
Imagine an epidemic of a contagious animal disease in your country in the near future. Which indicators do you think are more important to describe the impact of a control strategy on local and national economy? Please divide 100 points per disease. More points indicate a more important indicator.

Indicator	Economic indicators	Score
B.1	Direct farm losses: are direct farm losses (e.g. value of animals) an important economic indicator?	_ _ _ _
B.2	Consequential farm losses in affected region: are consequential farm losses (e.g. revenue losses as a result of a period without production) an important economic indicator?	_ _ _ _
B.3	Consequential farm losses outside affected region: are consequential farm losses (e.g. price effects) an important economic indicator?	_ _ _ _
B.4	Losses other participants: are losses for other participants in the production chain (e.g. slaughterhouses, processing plants) an important economic indicator?	_ _ _ _
B.5	Losses non agricultural sectors: are losses in non agricultural sectors (e.g. tourism) an important economic indicator?	_ _ _ _
B.6	Organisation costs: are organisation costs to control the epidemic an important economic indicator?	_ _ _ _
B.7	Export restrictions EU markets: are losses on the domestic market due to export restrictions imposed by EU markets an important economic indicator?	_ _ _ _
B.8	Export restrictions non-EU markets: are losses on the domestic market due to export restrictions imposed by non-EU markets an important economic indicator?	_ _ _ _
B.9	Tax payer: is the amount that tax payers have to contribute to cover losses in the agricultural sector an important economic indicator?	_ _ _ _
Total		100

QUESTION 1C: The impact of a control strategy on social and ethical issues can be described by a number of indicators.
Imagine an epidemic of a contagious animal disease in your country in the near future. Which in your opinion are relevant arguments in support of the applied control strategy during an outbreak of a disease? Please divide 100 points per disease. More points indicate a more important indicator.

Indicator	Arguments in support of the applied control strategy	Score
C.1	Efficacy: the applied strategy has been efficient and successful in controlling the disease outbreak.	_ _ _ _
C.2	Socio-economic factors: the applied strategy is ultimately for the benefit of the farmers and their business	_ _ _ _
C.3	Macro-economic factors: the applied strategy protects export interests	_ _ _ _
C.4	Commercially interested parties: the applied strategy protects the interests of commercially interested parties, such as slaughterhouses or retailer	_ _ _ _
C.5	Animal health: the applied strategy is for the benefit of the health of the animals involved	_ _ _ _
C.6	Animal welfare: the applied strategy is for the benefit of the welfare of the animals involved	_ _ _ _
C.7	Tourism: the applied strategy protects the interests of tourism	_ _ _ _
C.8	Human health: the applied strategy protects human health	_ _ _ _
C.9	Governmental policy: the applied strategy is consistent with the European and national governmental policy	_ _ _ _
C.10	Non-farm animals*: the applied strategy protects the health and welfare of non-farm animals	_ _ _ _
	Total	100
	Extra indicator	Extra score
Other:	_ _ _ _ _ _ _	_ _ _ _

* Non-farm animals: farm animals, such as poultry or cattle or related species, kept for non-farming purposes, in for instance zoos, sanctuaries, nature reservations, or in the domestic environment as pets or backyard animals.

QUESTION 1D: The impact of a control strategy on social and ethical issues can be described by a number of indicators.
Imagine an epidemic of a contagious animal disease in your country in the near future. Which in your opinion are relevant arguments against the applied control strategy during an outbreak of a disease? Please divide 100 points per disease. More points indicate a more important indicator.

Indicator	Arguments against the applied control strategy	Score
D.1	Efficacy: the applied strategy has not been efficient and has been unsuccessful in controlling the disease outbreak	_ _ _ _
D.2	Socio-economic factors: the applied strategy has a major social and psychological impact on the people involved	_ _ _ _
D.3	Macro-economic factors: the applied strategy has a negative influence on export interests	_ _ _ _
D.4	Commercially interested parties: the applied strategy jeopardises the interests of commercially interested parties, such as slaughterhouses or retailers	_ _ _ _
D.5	Animal health: the applied strategy is harmful to the health of the animals involved	_ _ _ _
D.6	Animal welfare: the applied strategy is harmful to the welfare of the animals involved	_ _ _ _
D.7	Tourism: the applied strategy is harmful to the interests of tourism	_ _ _ _
D.8	Natural life-cycle: the applied strategy is disrespectful of the natural course of the life-cycle of the animals involved	_ _ _ _
D.9	Food source: the applied strategy destroys healthy animals and products that could have been used for human consumption	_ _ _ _
D.10	Non-farm animals*: the applied strategy jeopardises the health and welfare of non-farm animals	_ _ _ _
	Total	100
	Extra indicator	Extra score
Other:	_ _ _ _ _ _ _	_ _ _ _

* Non-farm animals: farm animals, such as poultry or cattle or related species, kept for non-farming purposes, in for instance zoos, sanctuaries, nature reservations, or in the domestic environment as pets or backyard animals.

QUESTION 1E: The outcome of a control strategy can be evaluated according to various criteria. The important criteria are epidemiological, economic and social-ethical aspects. Each stakeholder can weigh these criteria differently.

Imagine an epidemic of a contagious animal disease in your country in the near future. Which criteria do you think are more important to determine the control strategy to be applied per disease? Please divide 100 points per disease. More points indicate a more important criterion.

Criteria	Description	Score
A	Epidemiological criterion: efficacy of a control strategy to eradicate the epidemic disease	_ _ _ _
B	Economic criterion: impact of a control strategy on local and national economy	_ _ _ _
C+D	Social - ethical criterion: impact of a control strategy on social and ethical issues	_ _ _ _
Total		100

Appendix B: Questionnaire part II

QUESTION 2A: In <u>your opinion</u> which stakeholders in your country have an important influence on the choice of the applied control strategy during an outbreak of a disease? Please divide 100 points per disease in the grey areas. More points indicate more influence.

Stakeholders' influence on the applied control strategy	Score
National or European government and governmental organisations	_ _ _
The professional farmers	_ __
The keepers of non-farm animals* and their social inner circle	_ _ _
The general public	_ _ _
Veterinarians	_ _ _
Animal welfare organisations, animal zoos, animal sanctuaries, organisations for nature preservation	_ _ _
Farmers unions	_ _ _
Commercially involved participants in the production chain for (e.g. slaughterhouses, processing plants)	_ _ _
Commercially involved parties in non agricultural sectors (e.g. tourism)	_ _ _
Media	_ _ _
TOTAL:	100
Extra indicator	Score

* Non-farm animals: farm animals, such as poultry or cattle or related species, kept for non-farming purposes, in for instance zoos, sanctuaries, nature reservations, or in the domestic environment as pets or backyard animals.

QUESTION 2B: Please prioritise issues to be addressed in *the decision-making process*. Please divide 100 points per disease. More points indicate a more important indicator.

Priority issues:	Score
Communication and information procedure	_ _ _
Social, psychological, and financial consequences for the farmers, their relatives and other workers directly involved	_ _ _
Animal welfare and related ethical issues	_ _ _
Preventive measures	_ _ _
Reputation and position of the agricultural sector	_ _ _
Other:	_ _ _
TOTAL:	100

Appendix C: Economic results

GTAP

GTAP is a multi-region, multi-sector computable general equilibrium model, with perfect competition and constant returns to scale.[12] The model is fully described in Hertel (1997). In the GTAP model, firms combine intermediate inputs and primary factors land, labour (skilled and unskilled) and capital. Intermediate inputs are composites of domestic and foreign components, and the foreign component is differentiated by region of origin (Armington assumption). On factor markets, we assume full employment, with labour and capital being fully mobile within regions, but immobile internationally. Labour and capital remuneration rates are endogenously determined at equilibrium. In the case of crop production, farmers make decisions on land allocation. Land is assumed to be imperfectly mobile between alternative crops, and hence allow for endogenous land rent differentials. Each region is equipped with one regional household that distributes income across savings and consumption expenditures. Furthermore, there is an explicit treatment of international trade and transport margins, and a global banking sector, which intermediates between global savings and consumption. The model determines the trade balance in each region endogenously, and hence foreign capital inflows may supplement domestic savings.

The GTAP database contains detailed bilateral trade, transport and protection data characterising economic linkages among regions, linked together with individual country input-output databases which account for intersectoral linkages among the 57 sectors (including the pig and poultry primary sector and the pig and poultry food processing sector) in each of the 85 regions (including all EU25 individual countries). All monetary values of the data are in USD million and the base year for the version used in this study (version 6, public release) is 2001 (Dimaranan and McDougall 2004).

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[12] For an overview of agricultural world trade models and their design choices, see Van Tongeren et al. (2001).

A 4.1 Economic effects: FMD control alternatives

Table A 4.1: Mean loss of primary production volume resulting from an FMD outbreak in a DPLA in the net importing countries D and F (in 1000 kg).

	EU measures + pre-emptive slaughter		EU measures + vaccination and destruction		EU measures + vaccination and living	
Percentile	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**
Dairy milk	3,785	25,448	11,021	74,938	512	4,437
Beef	5,167	20,241	12,751	48,760	606	2,910
Pork	874	7,692	2,604	18,196	83	1,020
Sheep meat	514	1,628	1,229	4,126	64	254

Production losses are the highest for the control strategy' vaccination and destruction'. Table A 4.1 also shows large differences between the 50 % and the 95% percentile.

Table A 4.2: Mean costs and income effects of an FMD outbreak in a DPLA in the net importing countries D and F (in € 1000).

	EU measures + pre-emptive slaughter		EU measures + vaccination and destruction		EU measures + vaccination and living	
Percentile	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**
Farmers' direct costs						
- Infected animals	672	2,548	1,191	5,149	1,191	5,149
- Preventively destroyed animals	9,509	34,044	-	-	-	-
- Vaccinated and destroyed animals	-	-	23,414	80,706	-	-
Organizational costs	4,861	20,325	16,976	61,834	8,002	27,470
Farmers' indirect costs						
- Costs of empty stables	1,135	6,338	95	748	95	748
- Costs of movement standstill	3,787	15,119	5,998	32,218	5,998	32,218
- Value loss of vaccinated animals	-	-	-	-	11,464	39,235
Total farmers' + org. costs	19,963	78,374	47,674	180,655	26,750	104,820
Income effect in agribusiness	(+9,321)	(+23,679)	(+17,491)	(+41,015)	(+187)	(+705)
Income effect in recreation sector	(+35)	(+1,119)	(+334)	(+1,321)	2	(+140)
Income effect in the primary sector of an export ban 1)	-	-	-	-	-	-
Total costs	10,607	53,576	29,064	138,319	26,565	103,975

1) not relevant because these are net importing countries

The results given as e.g. '(+35)' represent positive income effects.

A 4.2 CSF control strategies

Table A 4.3: Mean loss of primary production volume and export volume resulting from a CSF outbreak in a DPLA in the net exporting countries C and E (in 1000 Kg).

	EU measures + pre-emptive slaughter		EU measures + vaccination and destruction		EU measures + vaccination and living	
Percentile	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**
Pork production	437	1,360	484	1,818	23	121
Pork export	2,641	6,711	4,161	7,497	18,294	21,633

C and E are net pig/pork exporting countries. Therefore the outbreak of CSF influences both production and export.

Table A 4.4: Mean costs and income effects of a CSF outbreak in a DPLA in the net exporting countries C and E (in € 1000).

	EU measures + pre-emptive slaughter		EU measures + vaccination and destruction		EU measures + vaccination and living	
Percentile	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**
Farmers' direct costs						
- Infected animals	12	39	14	53	16	65
- Preventively destroyed animals	293	718	-	-	-	-
- Vaccinated and destroyed animals	-	-	312	892	-	-
Organizational costs	295	677	310	817	63	117
Farmers' indirect costs						
- Costs of empty stables	32	129	2	12	2	12
- Costs of movement standstill	48	105	55	121	55	121
- Value loss of vaccinated animals	-	-	-	-	150	423
Total farmers' + org. costs	680	1,668	693	1,895	286	738
Income effect in agribusiness	(+33)	(+289)	(+46)	(+278)	611	666
Income effect in recreation sector	3	11	4	13	8	10
Income effect in the primary pig sector of an export ban	0	0	0	0	0	0
Total costs	650	1,390	651	1,630	905	1,414

Table A 4.5: Mean loss of primary production volume resulting from a CSF outbreak in an MPLA in the net importing countries B, D and F (in 1000 kg).

	EU measures		EU measures + pre-emptive slaughter		EU measures + vaccination and destruction		EU measures + vaccination and living	
Percentile	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**
Pork	110	211	327	697	324	744	143	301

B, D and F are net pork/pig importing countries. Therefore, only the effects of the loss in production were calculated.

Table A 4.6: Mean costs and income effects of a CSF outbreak in an MPLA in the net importing countries B, D and F (in € 1000).

	EU measures		**EU measures + pre-emptive slaughter**		**EU measures + vaccination and destruction**		**EU measures + vaccination and living**	
Percentile	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**
Farmers' direct costs								
- Infected animals	114	190	114	135	114	190	114	169
- Preventively destroyed animals	-	-	198	499	-	-	-	-
- Vaccinated and destroyed animals	-	-	-	-	203	510	-	-
Organizational costs	79	113	197	386	200	391	153	190
Farmers' indirect costs								
- Costs of empty stables	11	21	32	73	11	21	11	21
- Costs of movement standstill	43	111	38	84	54	105	54	105
- Value loss of vaccinated animals	-	-	-	-	-	-	102	261
Total farmers' + org. costs	247	435	465	1,177	582	1,217	434	746
Income effect in agribusiness	456	2,147	4,619	10,813	5,005	12,263	470	2,133
Income effect in recreation sector	101	471	1,035	2,413	1,118	2,727	101	468
Income effect in the primary sector of an export ban 1)	-	-	-	-	-	-	-	-
Total costs	804	3,053	6,119	14,403	6,705	16,207	1,005	3,347

1) No effect, because the countries are net importers of pork and pork products

Table A. 4.7: Loss of primary production and export volume resulting from a CSF outbreak in an MPLA in the net exporting country A (in 1000 kg).

	EU measures		**EU measures + pre-emptive slaughter**		**EU measures + vaccination and destruction**		**EU measures + vaccination and living**	
Percentile	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**
Pork production	36	77	145	309	150	352	37	78
Pork export	4,017	4,838	4,017	4,792	4,336	4,838	19,626	20,138

A is a net pork/pig exporting country. Therefore the outbreak affects not only the production but also the export.

Table A.4.8: Costs and income effects of a CSF outbreak in an MPLA in the net exporting country A (in € 1000).

	EU measures		EU measures + pre-emptive slaughter		EU measures + vaccination and destruction		EU measures + vaccination and living	
Percentile	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**
Farmers' direct costs								
- Infected animals	27	53	27	54	27	54	27	54
- Preventively destroyed animals	-	-	81	162	-	-	-	-
- Vaccinated and destroyed animals	-	-	-	-	81	189	-	-
Organizational costs	50	90	116	220	117	222	51	87
Farmers' indirect costs								
- Costs of empty stables	3	7	11	26	3	7	3	7
- Costs of movement standstill	17	26	23	29	21	32	21	32
- Value loss of vaccinated animals	-	-	-	-	-	-	40	61
Total farmers' + org. costs	97	176	258	491	222	504	142	241
Income effect in agribusiness	(+2,010)	(+2,492)	(+2,010)	(+2,495)	(+2,153)	(+2,497)	(+13,208)	(+13,434)
Income effect in recreation sector	(+4)	(+1)	7	22	7	26	(+43)	(+40)
Income effect in the primary pig sector of an export ban	1	1	1	1	1	1	8	8
Total costs	(+1,916)	(+2,316)	(+1,744)	(+1,981)	(+1,923)	(+1,966)	(+13,101)	(+13,225)

A 4.2.4.3 AI

Table A 4.9: Loss of primary production volume resulting from an AI outbreak in a DPLA in the net exporting country A (in 1000 kg).

	EU measures + pre-emptive slaughter		EU measures + vaccination and destruction		EU measures + vaccination and living	
Percentile	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**
Egg production	398	4,732	1,158	8,944	32	453
Poultry meat production	3,451	25,820	8,720	49,286	243	2,738
Egg export	0	0	0	0	0	0
Poultry meat export	185	455	248	455	248	455

A is a net poultry meat exporting country. Therefore, a loss in export is calculated only for this product.

Table A 4.10: Costs and income effects of an AI outbreak in a DPLA in the net exporting country A (in € 1000).

	EU measures + pre-emptive slaughter		EU measures + vaccination and destruction		EU measures + vaccination and living	
Percentile	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**
Farmers' direct costs						
- Infected animals	77	581	124	1,055	124	1,055
- Preventively destroyed animals	1,789	10,245	-	-	-	-
- Vaccinated and destroyed animals	-	-	4,319	19,782	-	-
Organizational costs	1,746	9,245	3,508	16,071	1,263	6,030
Farmers' indirect costs						
- Costs of empty stables	204	2,430	17	232	17	232
- Costs of movement standstill	541	4,948	827	5,526	827	5,526
- Value loss of vaccinated animals	-	-	-	-	2,124	9,554
Total farmers' + org. costs	4,357	25,262	8,795	42,666	4,355	16,970
Income effect in agribusiness	(+1,749)	(+14,763)	(+5,420)	(+25,686)	(+169)	(+1,383)
Income effect in recreation sector	156	2,192	506	5,966	26	91
Income effect in the primary sector of an export ban	0	(+0)	0	0	0	0
Total costs	2,764	12,691	3,881	22,946	4,192	15,678

Table A 4.11: Mean loss of primary production volume resulting from an AI outbreak in an MPLA in the net importing countries B, D and F (in 1000 kg).

	EU measures		EU measures + pre-emptive slaughter		EU measures + vaccination and destruction		EU measures + vaccination and living	
Percentile	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**
Eggs	39	224	129	543	155	653	46	204
Poultry meat	494	2,316	1,677	5,892	1,865	6,995	524	2,019

B, D and F are net poultry products importing countries. Thus, only production losses were calculated.

Table A 4.12: Mean costs and income effects of an AI outbreak in an MPLA in the net importing countries B, D and F (in € 1000).

	EU measures		**EU measures + pre-emptive slaughter**		**EU measures + vaccination and destruction**		**EU measures + vaccination and living**	
Percentile	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**	**50%**	**95%**
Farmers' direct costs								
- Infected animals	269	1,167	273	896	275	996	275	996
- Preventively destroyed animals	-	-	642	2,143	-	-	-	-
- Vaccinated and destroyed animals	-	-	-	-	721	2,405	-	-
Organizational costs	169	519	308	801	347	963	590	1,789
Farmers' indirect costs								
- Costs of empty stables	29	167	98	404	34	152	34	152
- Costs of movement standstill	782	2,412	779	2,004	1,107	2,716	1,107	2,716
- Value loss of vaccinated animals	-	-	-	-	-	-	361	1,167
Total farmers' + org. costs	1,249	4,265	2,100	6,248	2,484	7,080	2,367	6,820
Income effect in agribusiness	(+62)	3,500	3,038	8,446	147	12,940	925	3,249
Income effect in recreation sector	167	18	676	1,875	671	2,867	206	727
Income effect in the primary sector of an export ban 1)	-	-	-	-	-	-	-	-
Total costs	1,354	7,783	5,814	16,569	3,302	23,039	3,498	10,796

1) No effect of an export ban, because the countries are net importers of the relevant products.

Appendix D: MCA results

Appendix D.1 – MCA results FMD control alternatives

D.1.1 MCA results region D, FMD

- Scoring and weighting of epidemiological indicators

Table D.1.1.1 demonstrates the redirected, standardised and weighed scores of the epidemiological indicators per evaluated FMD control strategy based on the member state characteristics of Region D. The higher the value, the 'better' the score in relation to the other alternatives (max score=100). The scores are derived from the epidemiological modelling results as described in Chapter 4.1. Within this analysis only 3 alternatives are evaluated (viz. Pre 2km and Vac_live/kill 4 km) due to the restricted control efficiency of the EU strategy as explained in Chapter 4.1.

Table D.1.1.1: Standardised and weighed scores of the epidemiological indicators per evaluated FMD control strategy.

Indicator	Control strategy			
	EU	Pre	Vac live	Vac kill
Duration epidemic	n.a	5.31	0.00	0.00
Number infected farms	n.a.	10.87	0.00	0.00
Size affected region	n.a.	4.79	0.00	0.00
Number destroyed animals	n.a.	6.45	11.79	0.00
Number destroyed herds	n.a.	6.05	11.07	0.00
Number destroyed non-farm animals	n.a.	2.13	3.89	0.00
Overall criterion value	n.a.	35.60	26.74	0.00

n.a. = not analysed due to restricted control efficiency of the strategy

Summation of the indicator scores per control strategy results in the overall score of the criterion "Epidemiology". These overall scores demonstrate that – according to the average CVO-judgement on the various epidemiological indicators - the Pre strategy (overall score 35.6) is preferred compared to the other 2 alternatives. The overall criterion value of the Vac_kill is 0, due to the fact that of the three alternatives this alternative scores worst on all indicators. In terms of duration and number of infected farms, the Vac_kill strategy is just as effective as the Vac_live alternative. However, due to the fact that this strategy involves the slaughter of more animals (mainly vaccinated) than any other alternative, Vacc_kill is less preferred.

Figure D.1.1.1 gives a graphical overview of the contribution of each indicator within the overall criterion score. Again, the bigger the part the better the strategy scores on this indicator compared to the other 2 control alternatives. No score for an indicator means that – off all the evaluated control alternatives – the examined alternative scores worst for that specific indicator. As explained before Vac_kill scores worst on all the 6 epidemiological indicators, explaining the absence of any column in the Figure D.1.1.1.

- Scoring and weighting of economic indicators

Table D.1.1.2 demonstrates the standardised and weighed scores of the economic indicators per evaluated FMD control strategy based on the member state characteristics of Region D. The economic scores are derived from the economic modelling results as described in 4.2.

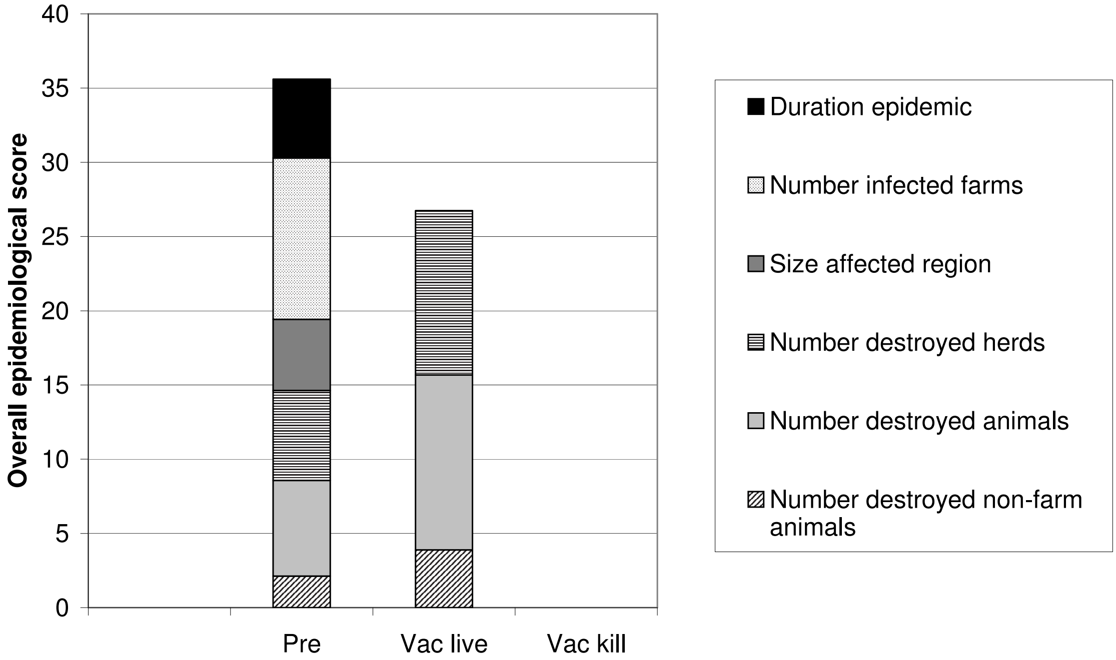

Figure D.1.1.1: Epidemiological indicator scores of each evaluated FMD control alternative.

Due to the lack of sufficient detailed information, it was not possible to score the specific indicator of '*consequential farm losses outside the affected region*'. The average weight factor of this indicator equals 7.6. To account for the possible influence of the indicator, all alternatives within the analysis 'score' the average indicator value, which is equal to the indicator weight factor multiplied by ½ (viz. 7.6 x ½ = 3.8). As a consequence, overall criterion values may contain some variation, varying from 0 to a maximum of 3.8.

Furthermore, the 2 indicators *'export restriction EU markets'* and *'export restrictions non-EU markets'* are aggregated into one general *'export restriction'* indicator, with a weighting factor equal to the sum of the two individual indicators (see Chapter 3).

Table D.1.1.2: Standardised and weighed scores of the economic indicators per evaluated FMD control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Direct farm losses	n.a	8.09	14.17	0.00
Cons farm losses in affected region	n.a.	11.27	0.00	9.82
Cons farm losses outside affected region	n.a.	3.80	3.80	3.80
Losses other participants	n.a.	5.65	0.70	11.79
Losses non agricultural sectors	n.a.	4.53	0.57	9.54
Organisation costs	n.a.	0.00	5.82	5.82
Export restrictions	n.a.	22.58	22.58	22.58
Tax payer:	n.a.	2.46	5.66	0.00
Overall criterion value	n.a.	58.39	53.31	63.36

n.a. = not analysed due to restricted control efficiency of the strategy

Figure D.1.1.2 demonstrates the variation in scores per indicator and alternative. Due to the fact that – independent of the evaluated control strategy - there are no consequences due to export restrictions, all alternatives receive the maximum score for this indicator (i.e. 100% x indicator weight).

Based on the overall economic criterion value, the Vac_kill control strategy (score = 63.4 ± 3.8) is preferred above the other 2 control alternatives. The Vac-live strategy (score = 53.3 ± 3.8) is ranked as last (see Table D.1.1.2 and Figure D.1.1.2). However, differences in overall values are rather small.

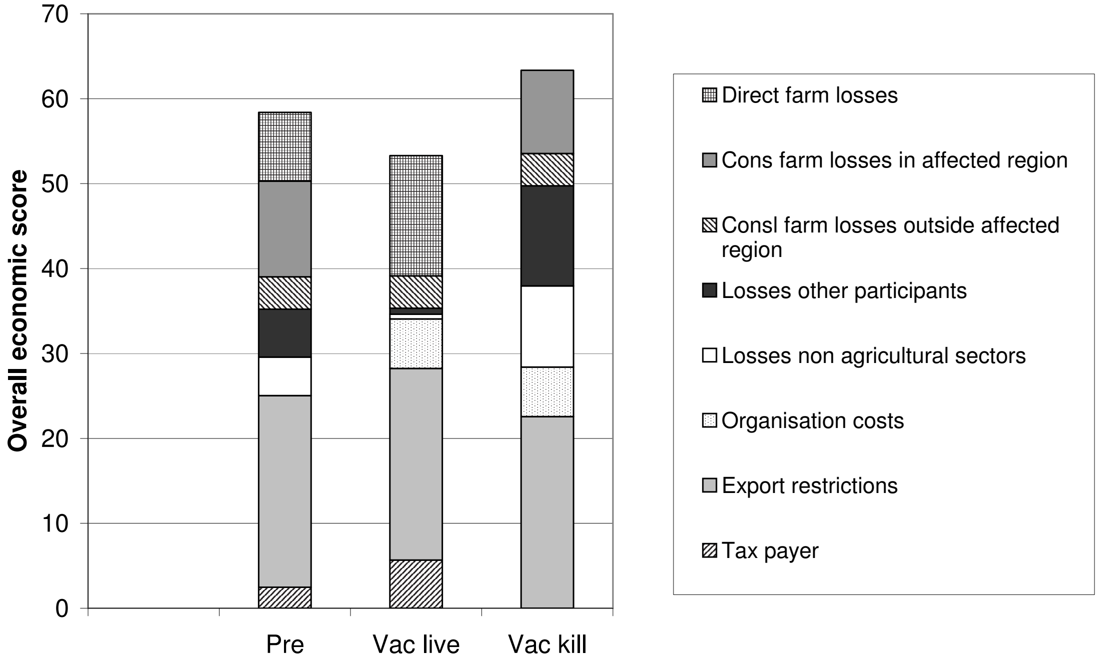

Figure D.1.1.2: Economic indicator scores of each evaluated FMD control alternative.

Scoring and weighting of social-ethical indicators

Table D.1.1.3 demonstrates the standardised and weighed scores of the social-ethical indicators per evaluated FMD control strategy based on the member state characteristics of Region D. The social-ethical scores are obtained by ranking the alternatives per criterion by its expected effectiveness. These effectiveness rankings are based on the insights obtained by the CVO questionnaires, personal interviews and model studies (Chapter 3 and 4.1 and 4.2).

Table D.1.1.3: Standardised and weighed scores of the social-ethical indicators per evaluated FMD control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Efficacy	n.a	6.72	0.00	0.00
Socio-economic factors	n.a.	2.69	5.39	0.00
Macro-economic factors	n.a.	7.34	7.34	7.34
Commercially interested parties	n.a.	0.00	2.00	3.99
Animal health	n.a.	0.00	2.90	0.00
Animal welfare	n.a.	0.00	3.59	1.80
Tourism	n.a.	0.00	1.45	2.90
Non-farm animals	n.a.	0.00	1.40	0.70
Human health	n.a.	0.00	3.31	3.31
Governmental policy	n.a.	2.16	2.16	2.16
Natural life-cycle	n.a.	0.00	21.54	10.77
Food source	n.a.	2.14	4.28	0.00
Overall criterion value	n.a.	21.05	55.35	32.97

n.a. = not analysed due to restricted control efficiency of the strategy

According to the average CVO judgements on the social-ethical indicators, the Vac_Live strategy is evaluated as the best alternative to control an FMD epidemic, as reflected by the highest overall social-ethical value (Table D.1.1.3).

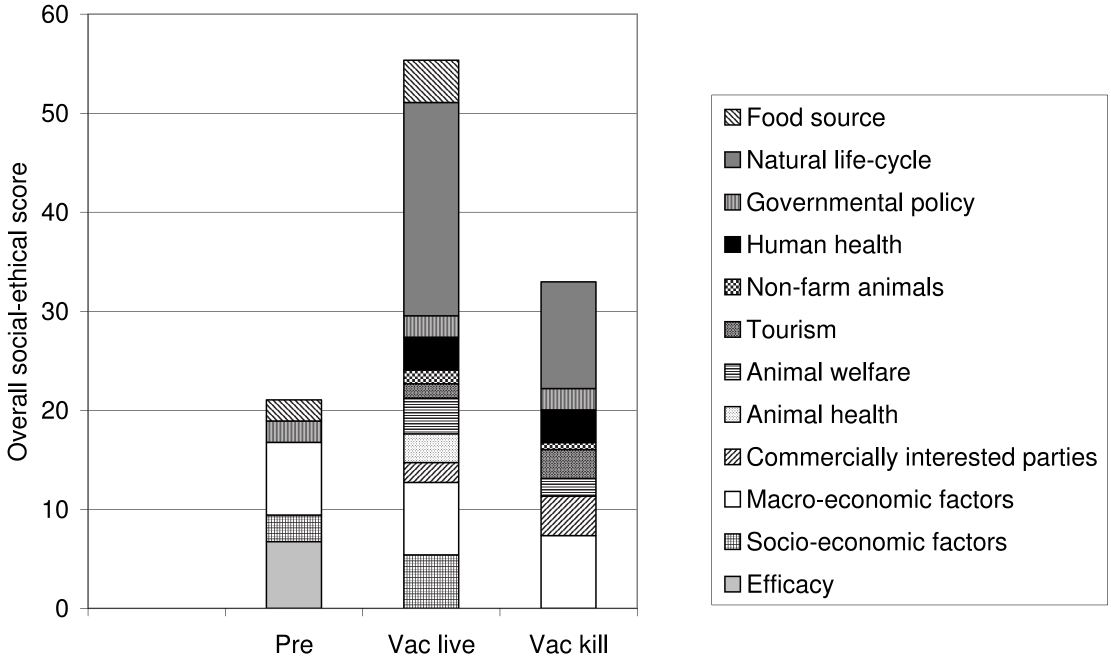

Figure D.1.1.3: Social-ethical indicator scores of each evaluated FMD control alternative.

Figure D.1.1.3 demonstrates the individual contribution of each indicator to the overall social-ethical value. Strategy Vac_live contributes to 11 of the 12 indicators, strategy Pre contributes only to 5 of the 12 indicators.

Combined overall weighting of the three main criteria

Standardized scores of all indicators are compared in pairs of the evaluated alternatives, resulting in so-called dominance scores. A positive score implies dominance of a strategy in relation to another while a negative value implies submission. A dominance measure of 0 implies indifference between the compared strategies. By weighting the dominance scores per criterion, overall dominance scores of the three main criteria are obtained.

Table D.1.1.4 demonstrates the dominance scores of the three main criteria as a result of paired comparisons of the 3 control alternatives. For instance, the third column in the lower half of the table, describes the results of the comparison between the Vac_live strategy and the Vac_kill strategy. As reflected by the positive scores, the Vac_live strategy dominates the Vacc_kill strategy on 2 of the 3 main criteria (viz. +5.19 on Epidemiology, +0.37 on Social-Ethics). However, regarding the Economic criterion, the Vac_live strategy is dominated by the Vac_kill strategy (economic dominance score = -0.57).

Figure D.1.1.4 illustrates the 'dominance course' of the evaluated alternatives. Concerning the three main criteria, a strategy dominates as long as the column representing the individual criterion score is situated above the zero-axes.

Table D.1.1.4: Criteria dominance scores of the paired comparisons of the evaluated FMD control alternatives (e.g. EU/Pre = EU strategy compared to the Preventive culling strategy)

Criterion	EU/Pre	EU/V_live	EU/V_kill	Pre/EU	Pre/V_live	Pre/V_kill
Epidemiology	n.a.	n.a.	n.a.	n.a.	1.75	6.95
Economics	n.a.	n.a.	n.a.	n.a.	0.28	-0.29
Social/Ethics	n.a.	n.a.	n.a.	n.a.	-1.12	-0.39
Total	n.a.	n.a.	n.a.	n.a.	0.92	6.26

Criterion	V_live/EU	V_live/Pre	V_live/V_kill	V_kill/EU	V_kill/Pre	V_kill/V_live
Epidemiology	n.a.	-1.75	5.19	n.a.	-6.95	-5.19
Economics	n.a.	-0.28	-0.57	n.a.	0.29	0.57
Social/Ethics	n.a.	1.12	0.73	n.a.	0.39	-0.73
Total	n.a.	-0.92	5.35	n.a.	-6.26	-5.35

n.a. = not analysed due to restricted control efficiency of the strategy

According to the total dominance scores the Pre strategy is favoured over the other 2 strategies; i.e. all total paired dominance scores are positive. The dominance difference with respect to the Vac_live strategy is, however, small (0.92). Vac_kill is completely dominated by the other strategies as reflected by its negative total dominance scores (Table D.1.1.4 and Figure D.1.1.4).

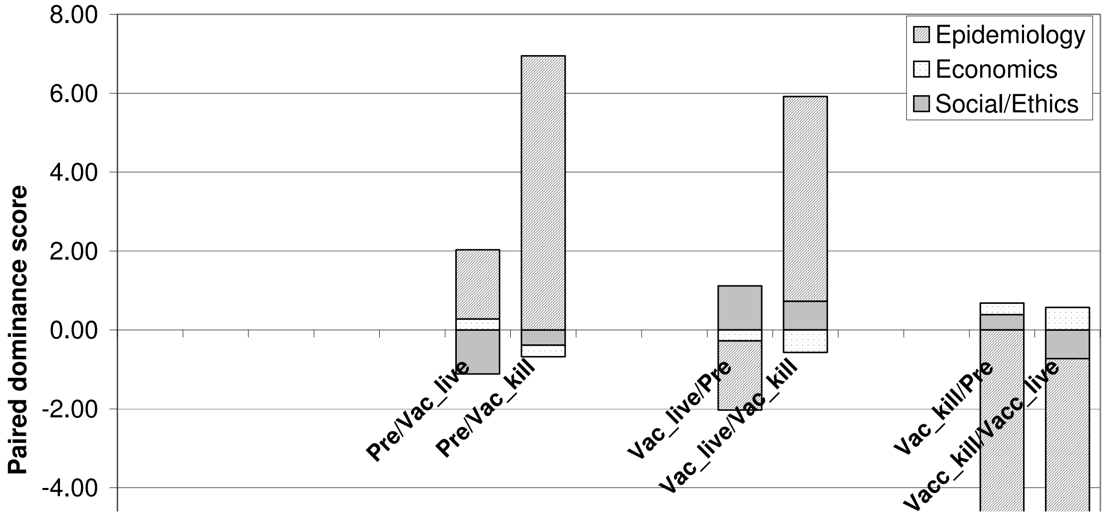

Figure D.1.1.4: Paired dominance scores of FMD control alternatives per main criterion.

D.1.2 MCA results region F, FMD

- Scoring and weighting of epidemiological indicators

Table D.1.2.1 demonstrates the redirected, standardised and weighed scores of the epidemiological indicators per evaluated FMD control strategy based on the member state characteristics of Region F. The higher the value, the 'better' the score in relation to the other alternatives (max score=100). The scores are derived from the epidemiological modelling results as described in Chapter 4.1.

Table D.1.2.1: Standardised and weighed scores of the epidemiological indicators per evaluated FMD control strategy.

Indicator	Control strategy			
	EU	Pre	Vac live	Vac kill
Duration epidemic	n.a	10.03	0.00	0.00
Number infected farms	n.a.	13.30	0.00	0.00
Size affected region	n.a.	8.73	0.00	0.00
Number destroyed animals	n.a.	6.97	11.76	0.00
Number destroyed herds	n.a.	6.55	11.05	0.00
Number destroyed non-farm animals	n.a.	2.30	3.88	0.00
Overall criterion value	n.a.	47.87	26.69	0.00

n.a. = not analysed due to restricted control efficiency of the strategy

Within this analysis only 3 alternatives are evaluated due to the restricted control efficiency of the EU strategy as explained in Chapter 4.1.

Summation of the indicator scores per control strategy results in the overall score of the criterion "Epidemiology". These overall scores demonstrate that – according to the average CVO-judgement on the various epidemiological indicators - the Pre strategy (overall score 47.9) is evaluated to exceed the other 2 alternatives. The overall criterion value of the Vac_kill is 0, due to the fact that this alternative scores worst on all indicators. In terms of duration and number of infected farms, the Vac_kill strategy is just as effective as the Vac_live alternative. However, due to the fact that this strategy involves the slaughter of more animals (mainly vaccinated) than any other alternative, Vacc_kill is less preferred.

Figure D.1.2.1 gives a graphical overview of the contribution of each indicator within the overall criterion score. Again, the bigger the part the better the strategy scores on this indicator compared to the other 2 control alternatives. No score for an indicator means that – off all the evaluated control alternatives – the examined alternative scores worst for that specific indicator. As explained before Vac_kill scores worst on all the 6 epidemiological indicators, explaining the absence of any column in the Figure D.1.2.1.

- Scoring and weighting of economic indicators

Table D.1.2.2 demonstrates the standardised and weighed scores of the economic indicators per evaluated FMD control strategy based on the member state characteristics of Region F. The economic scores are derived from the economic modelling results as described in Chapter 4.2.

Due to the lack of sufficient detailed information, it was not possible to score the specific indicator of '*consequential farm losses outside the affected region*'. The specific weight factor of this indicator equals 7.6. To account for the possible influence of this indicator, all alternatives within the analysis 'score' the average indicator value, which is equal to the indicator weight factor multiplied by ½ (viz. 7.6 x ½ = 3.8). As a consequence, overall criterion values may contain some variation, varying from 0 to a maximum of 3.8.

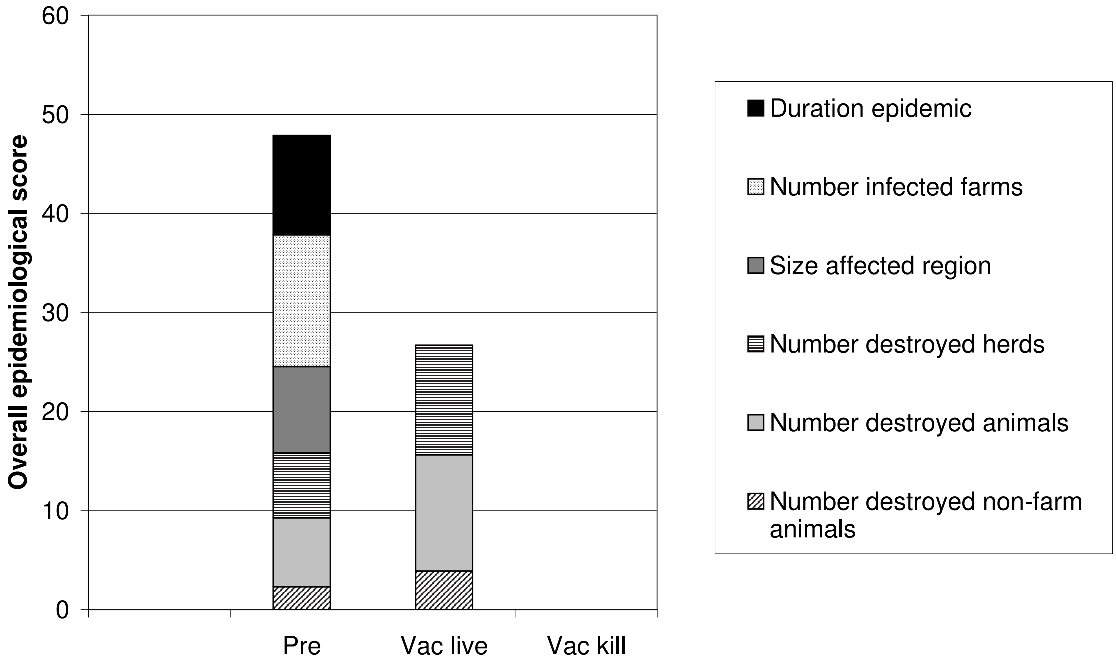

Figure D.1.2.1: Epidemiological indicator scores of each evaluated FMD control alternative.

Furthermore, the 2 indicators *'export restriction EU markets'* and *'export restrictions non-EU markets'* are aggregated into one general *'export restriction'* indicator, with a weighting factor equal to the sum of the two individual indicators.

Table D.1.2.2: Standardised and weighed scores of the economic indicators per evaluated FMD control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Direct farm losses	n.a	8.77	14.07	0.00
Cons farm losses in affected region	n.a.	12.21	0.00	9.11
Cons farm losses outside affected region	n.a.	3.80	3.80	3.80
Losses other participants	n.a.	7.06	0.09	11.79
Losses non agricultural sectors	n.a.	8.79	9.45	0.00
Organisation costs	n.a.	0.00	4.79	4.79
Export restrictions	n.a.	22.58	22.58	22.58
Tax payer:	n.a.	1.01	4.40	0.00
Overall criterion value	n.a.	64.23	59.19	52.07

n.a. = not analysed due to restricted control efficiency of the strategy

Figure D.1.2.2 demonstrates the variation in scores per indicator and alternative. Due to the fact that – independent of the evaluated control strategy - there are no consequences due to export restrictions, all alternatives received the maximum score for this indicator (i.e. 100% x indicator weight).

Based on the overall economic criterion value, the Pre control strategy (score = 64.2 ± 3.8) is preferred above the other 2 control alternatives. The Vac-kill strategy (score = 52.1 ± 3.8) is ranked as last (see Table D.1.2.2 and Figure D.1.2.2). However, differences in overall values are rather small.

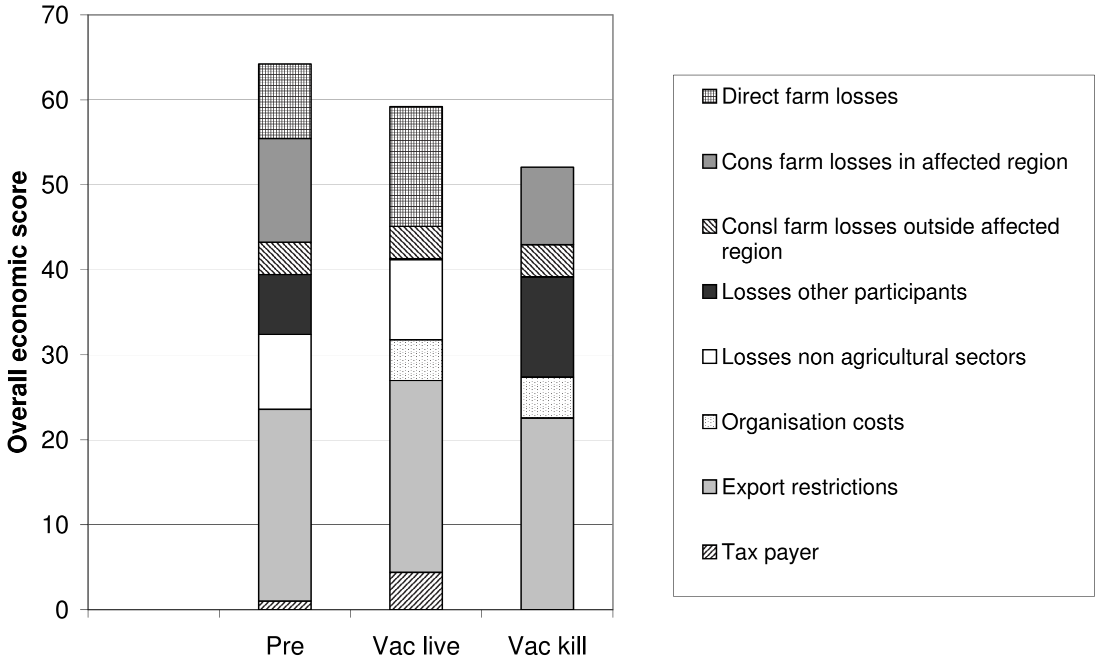

Figure D.1.2.2: Economic indicator scores of each evaluated FMD control alternative.

Scoring and weighting of social-ethical indicators

Table D.1.2.3 demonstrates the standardised and weighed scores of the social-ethical indicators per evaluated FMD control strategy based on the member state characteristics of Region F. The social-ethical scores are obtained by ranking the alternatives per criterion by its expected effectiveness. These effectiveness rankings are based on the insights obtained by the CVO questionnaires, personal interviews and model studies (Chapter 3 and 4.1 and 4.2).

Table D.1.2.3: Standardised and weighed scores of the social-ethical indicators per evaluated FMD control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Efficacy	n.a	6.72	0.00	0.00
Socio-economic factors	n.a.	2.69	5.39	0.00
Macro-economic factors	n.a.	7.34	7.34	7.34
Commercially interested parties	n.a.	2.00	0.00	3.99
Animal health	n.a.	0.00	2.90	0.00
Animal welfare	n.a.	0.00	3.59	1.80
Tourism	n.a.	1.45	2.90	0.00
Non-farm animals	n.a.	0.00	1.40	0.70
Human health	n.a.	0.00	3.31	3.31
Governmental policy	n.a.	2.16	2.16	2.16
Natural life-cycle	n.a.	0.00	21.54	10.77
Food source	n.a.	2.14	4.28	0.00
Overall criterion value	n.a.	24.50	54.81	30.06

n.a. = not analysed due to restricted control efficiency of the strategy

Based on the overall social-ethical values (Table D.1.2.3) the Vac_Live strategy is evaluated as the best alternative to control an FMD epidemic.

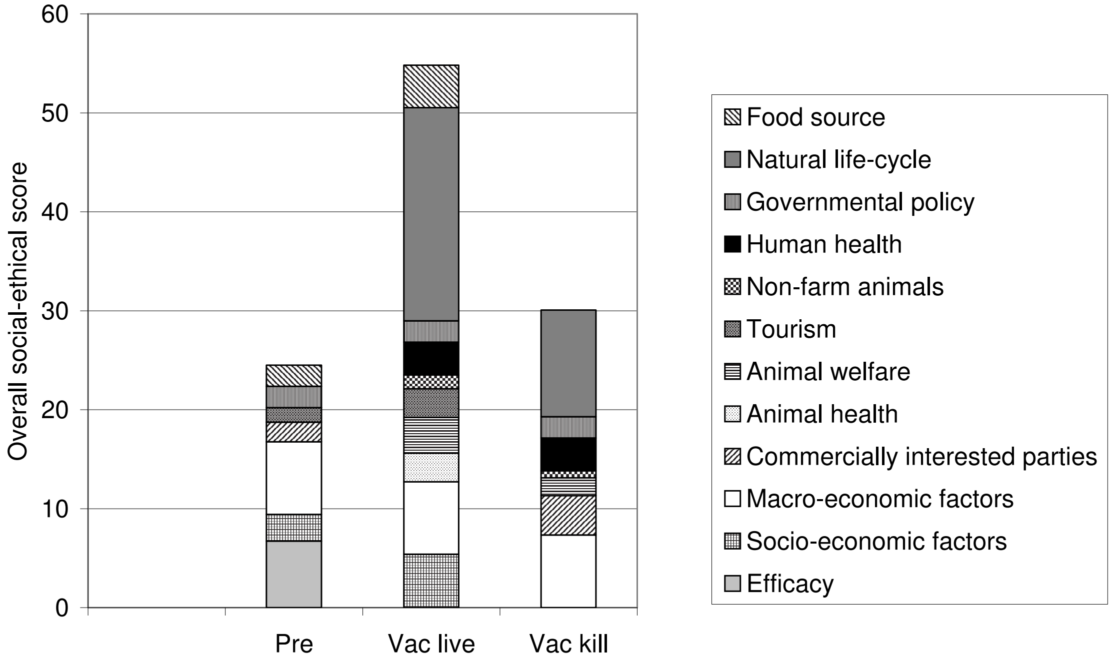

Figure D.1.2.3: Social-ethical indicator scores of each evaluated FMD control alternative.

Figure D.1.2.3 demonstrates the individual contribution of each indicator to the overall social-ethical value. Strategy Vac live contributes to 10 of the 12 indicators, strategies Pre and Vac_kill contribute only to 7 of the 12 indicators.

Combined overall weighting of the three main criteria

Standardized scores of all indicators are compared in pairs of the evaluated alternatives, resulting in so-called dominance scores. A positive score implies dominance of a strategy in relation to another while a negative value implies submission. A dominance measure of 0 implies indifference between the compared strategies. By weighting the dominance scores per criterion, overall dominance scores of the three main criteria are obtained.

Table D.1.2.4 demonstrates the dominance scores of the three main criteria as a result of paired comparisons of the 3 control alternatives. For instance, the third column in the lower half of the table, describes the results of the comparison between the Vac_live strategy and the Vac_kill strategy. As reflected by the positive scores, the Vac_live strategy dominates the Vacc_kill strategy on all the main criteria (viz. +4.08 on Epidemiology, +0.30 on Economics and +0.83 on Social-Ethics). The dominance scores based on the comparison of Vac_live with Pre (second column) demonstrate that, regarding the epidemiological and economic criteria (scores of –3.23 and –0.41), the Vac_live strategy is dominated by the Pre strategy. However, the opposite is true for the social-ethical element (social-ethical dominance score = 1.02).

Table D.1.2.4: Criteria dominance scores of the paired comparisons of the evaluated FMD control alternatives (e.g. EU/Pre = EU strategy compared to the Preventive culling strategy)

Criterion	EU/Pre	EU/V_live	EU/V_kill	Pre/EU	Pre/V_live	Pre/V_kill
Epidemiology	n.a.	n.a.	n.a.	n.a.	3.23	7.31
Economics	n.a.	n.a.	n.a.	n.a.	0.41	0.70
Social/Ethics	n.a.	n.a.	n.a.	n.a.	-1.02	-0.19
Total	n.a.	n.a.	n.a.	n.a.	2.62	7.83

Criterion	V_live/EU	V_live/Pre	V_live/V_kill	V_kill/EU	V_kill/Pre	V_kill/V_live
Epidemiology	n.a.	-3.23	4.08	n.a.	-7.31	-4.08
Economics	n.a.	-0.41	0.30	n.a.	-0.70	-0.30
Social/Ethics	n.a.	1.02	0.83	n.a.	0.19	-0.83
Total	n.a.	-2.62	5.21	n.a.	-7.83	-5.21

n.a. = not analysed due to restricted control efficiency of the strategy

According to the total dominance scores the Pre strategy is favoured over the other 2 strategies; i.e. all total paired dominance scores are positive. Vac_kill is completely dominated by the other strategies as reflected by its negative total dominance scores (Table D.1.2.4 and Figure D.1.2.4).

Figure D.1.2.4 illustrates the 'dominance course' of the evaluated alternatives. Concerning the three main criteria, a strategy dominates as long as the column representing the individual criterion score is situated above the zero-axes.

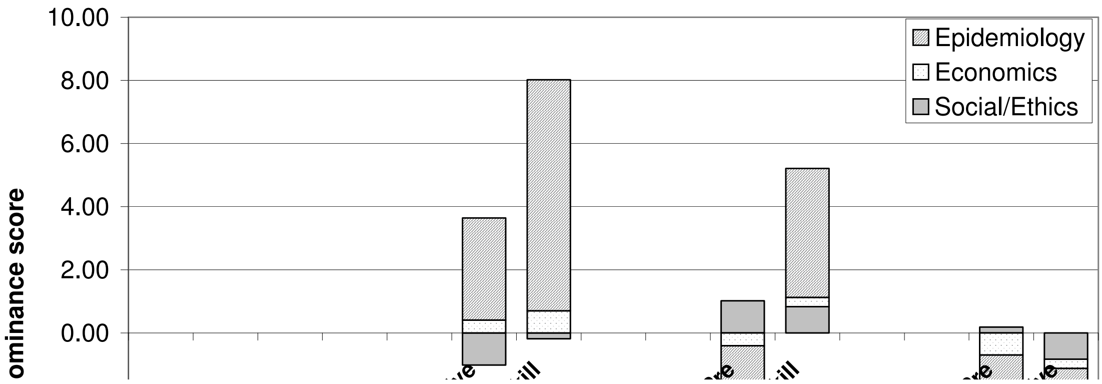

Figure D.1.2.4: Paired dominance scores of FMD control alternatives per main criterion.

Appendix D.2 – MCA results CSF control alternatives

D.2.1 Results MCA Region B, CSF

- Scoring and weighting of epidemiological indicators

Table D.2.1.1 demonstrates the redirected, standardised and weighed scores of the epidemiological indicators per evaluated CSF control strategy based on the member state characteristics of Region B. The higher the value, the 'better' the score in relation to the other alternatives (max score=100). The scores are derived from the epidemiological modelling results as described in Chapter 4.1.

Table D.2.1.1: Standardised and weighed scores of the epidemiological indicators per evaluated CSF control strategy.

Indicator	Control strategy			
	EU	**Pre**	**Vac live**	**Vac kill**
Duration epidemic	0.00	3.72	0.68	0.68
Number infected farms	0.00	6.70	0.00	0.00
Size affected region	0.00	5.42	5.03	5.03
Number destroyed animals	9.26	0.00	10.35	0.00
Number destroyed herds	9.86	0.00	11.02	0.00
Number destroyed non-farm animals	3.40	0.00	3.80	0.00
Overall criterion value	22.53	15.84	30.88	5.71

Summation of the indicator scores per control strategy results in the overall score of the criterion "Epidemiology". These overall scores demonstrate that – according to the average CVO-judgement on the various epidemiological indicators - the Vac_Live strategy (overall score 30.9) is evaluated to exceed the other alternatives. In terms of duration and number of infected farms, the Vac_kill strategy is just as effective as the Vac_live alternative. However, due to the fact that this strategy involves the slaughter of more animals (mainly vaccinated) than any other alternative, overall score of Vacc_kill is low (viz. 5.7).

Figure D.2.1.1 gives a graphical overview of the contribution of each indicator within the overall criterion score. Again, the bigger the part the better the strategy scores on this indicator compared to the other 3 control alternatives. No score for an indicator means that – off all the evaluated control alternatives – the examined alternative scores worst for that specific indicator. For instance, Vac_kill only scores on 2 of the 6 epidemiological indicators, meaning that for the other four indicators this strategy scores worst in comparison to the other alternatives.

- Scoring and weighting of economic indicators

Table D.2.1.2 demonstrates the standardised and weighed scores of the economic indicators per evaluated CSF control strategy based on the member state characteristics of Region B. The economic scores are derived from the economic modelling results as described in 4.2.

Due to the lack of sufficient detailed information, it was not possible to score the specific indicator of '*consequential farm losses outside the affected region*'. The specific weight factor of this indicator equals 8.5. To account for the possible influence of this indicator, all alternatives within the analysis 'score' the average indicator value, which is equal to the indicator weight factor multiplied by ½ (viz. 8.5 x ½ = 4.25). As a consequence, overall criterion values may contain some variation, varying from 0 to a maximum of 4.25.

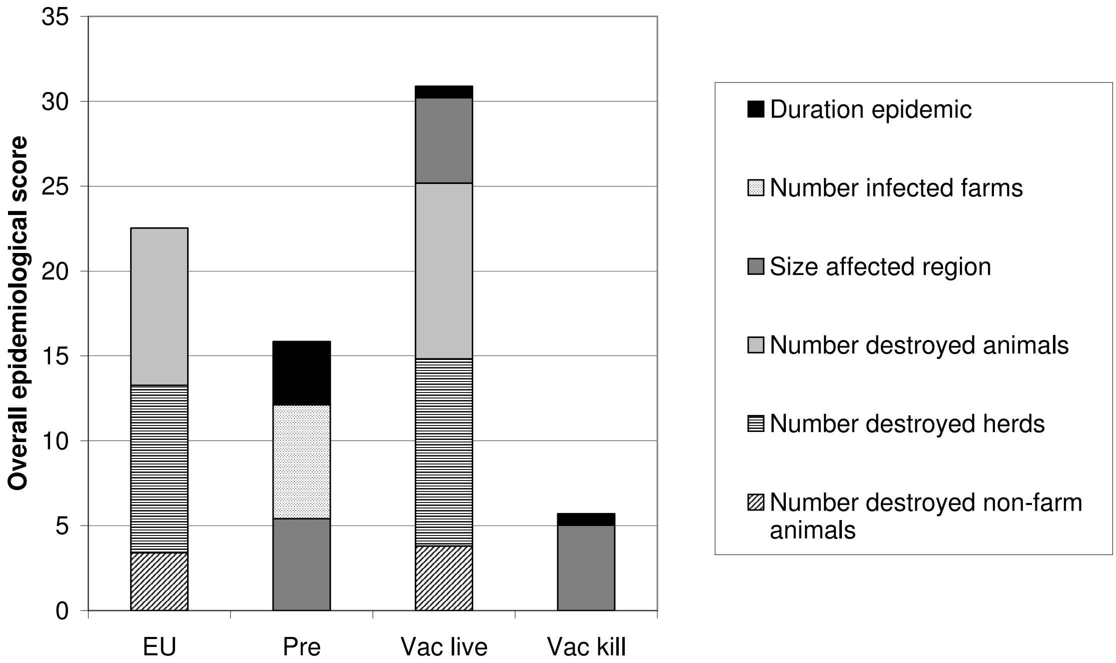

Figure D.2.1.1: Epidemiological indicator scores of each evaluated CSF control alternative.

Furthermore, the 2 indicators *'export restriction EU markets'* and *'export restrictions non-EU markets'* are aggregated into one general *'export restriction'* indicator, with a weighting factor equal to the sum of the two individual indicators.

Table D.2.1.2: Standardised and weighed scores of the economic indicators per evaluated CSF control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Direct farm losses	12.42	1.31	13.74	0.00
Cons farm losses in affected region	10.14	9.53	0.00	11.35
Cons farm losses outside affected region	4.25	4.25	4.25	4.25
Losses other participants	9.84	1.38	9.86	0.00
Losses non agricultural sectors	5.13	0.72	5.13	0.00
Organisation costs	6.58	0.00	8.27	7.01
Export restrictions	24.16	24.16	24.16	24.16
Tax payer:	4.75	0.00	5.58	1.70
Overall criterion value	77.28	41.35	70.99	48.47

Figure D.2.1.2 demonstrates the variation in scores per indicator and alternative. Due to the fact that – independent of the evaluated control strategy - there are no consequences due to export restrictions, all alternatives receive the maximum score for this indicator (i.e. 100% x indicator weight).

Based on the overall economic criterion value, the EU control strategy (score = 77.3 ± 4.3) is preferred above the other control alternatives. The Pre strategy (score = 41.4 ± 4.3) is ranked as last (see Table D.2.1.2 and Figure D.2.1.2).

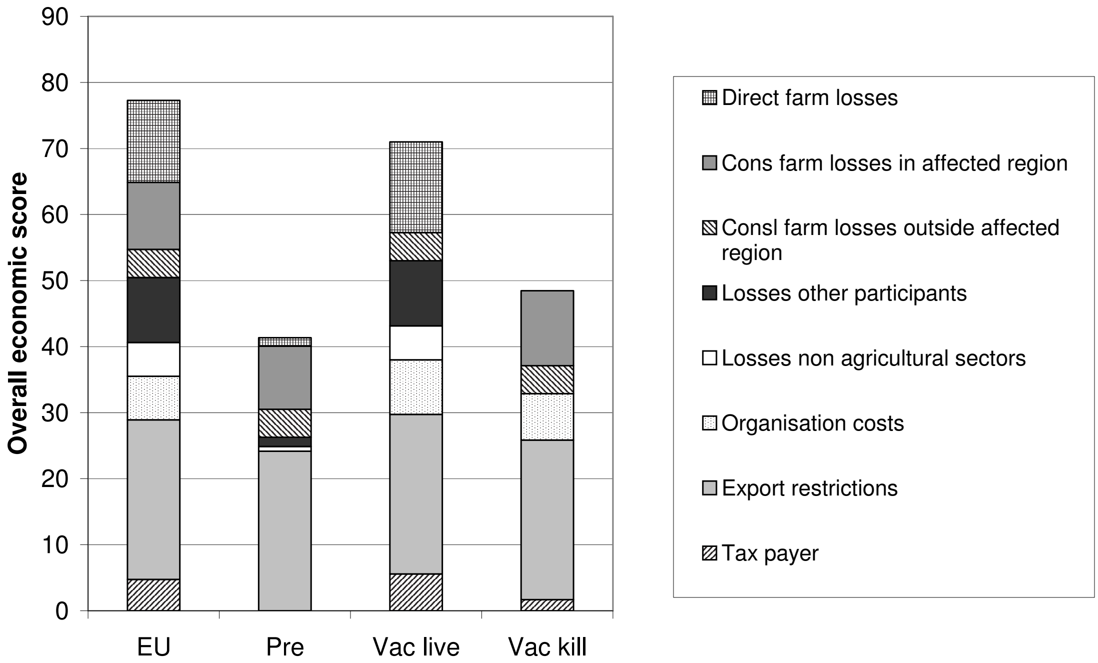

Figure D.2.1.2: Economic indicator scores of each evaluated CSF control alternative.

Scoring and weighting of social-ethical indicators

Table D.2.1.3 demonstrates the standardised and weighed scores of the social-ethical indicators per evaluated CSF control strategy based on the member state characteristics of Region B. The social-ethical scores are obtained by ranking the alternatives per criterion by its expected effectiveness. These effectiveness rankings are based on the insights obtained by the CVO questionnaires, personal interviews and model studies (Chapter 3 and 4.1 and 4.2).

Table D.2.1.3: Standardised and weighed scores of the social-ethical indicators per evaluated CSF control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Efficacy	0.00	12.90	6.45	6.45
Socio-economic factors	5.83	2.91	8.74	0.00
Macro-economic factors	10.89	10.89	10.89	10.89
Commercially interested parties	4.44	2.22	6.66	0.00
Animal health	2.73	0.00	5.45	0.00
Animal welfare	3.96	0.00	5.93	1.98
Tourism	2.88	1.44	2.88	0.00
Non-farm animals	1.21	0.00	1.82	0.61
Human health	3.21	0.00	6.42	6.42
Governmental policy	2.47	2.47	2.47	2.47
Natural life-cycle	3.21	0.00	3.21	1.61
Food source	6.32	3.16	6.32	0.00
Overall criterion value	47.14	35.99	67.24	30.42

Based on the overall social-ethical values (Table D.2.1.3) the Vac_Live strategy is evaluated as the best alternative to control a CSF epidemic.

Figure D.2.1.3 demonstrates the individual contribution of each indicator to the overall social-ethical value. Strategy Vac live contributes to all 12 indicators, strategy Pre and Vac_kill only contribute to 7 of the 12 indicators.

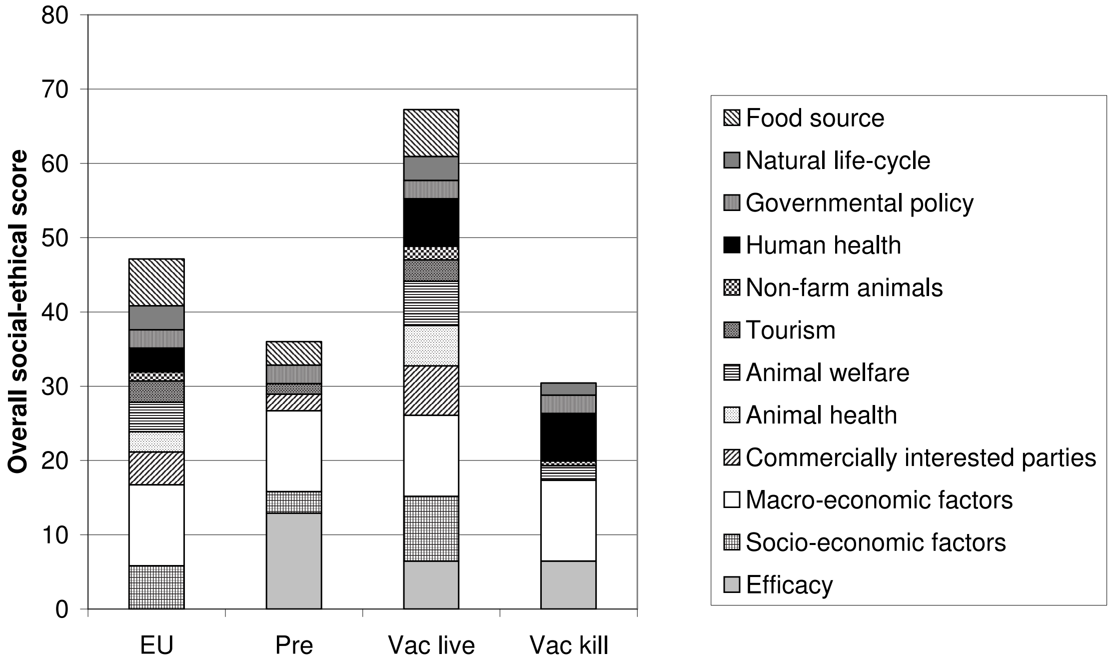

Figure D.2.1.3: Social-ethical indicator scores of each evaluated CSF control alternative.

Combined overall weighting of the three main criteria

Standardized scores of all indicators are compared in pairs of the evaluated alternatives, resulting in so-called dominance scores. A positive score implies dominance of a strategy in relation to another while a negative value implies submission. A dominance measure of 0 implies indifference between the compared strategies. By weighting the dominance scores per criterion, overall dominance scores of the three main criteria are obtained.

Table D.2.1.4 demonstrates the dominance scores of the three main criteria as a result of paired comparisons of the 4 control alternatives. For instance, the first column in the upper half of table, describes the results of the comparison between the EU strategy and the Pre strategy. As reflected by the positive scores, the EU strategy dominates the Pre strategy on all the main criteria (viz. + 2.16 on Epidemiology, + 4.17 on Economics and + 0.71 on Social-Ethics). The dominance scores based on the comparison of EU with Vac_live (second column) demonstrate that, regarding the epidemiological and social ethical criteria (scores of –2.69 and –1.46), the EU strategy is dominated by the Vac-Live strategy. However, the opposite is true for the economic element (economic dominance score = + 0.95).

Figure D.2.1.4 illustrates the 'dominance course' of the evaluated alternatives. Concerning the three main criteria, a strategy dominates as long as the column representing the individual criterion score is situated above the zero-axes.

Table D.2.1.4: Criteria dominance scores of the paired comparisons of the evaluated CSF control alternatives (e.g. EU/Pre = EU strategy compared to the Preventive culling strategy)

Criterion	EU/Pre	EU/V_live	EU/V_kill	Pre/EU	Pre/V_live	Pre/V_kill
Epidemiology	2.16	-2.69	5.42	-2.16	-4.85	3.27
Economics	4.17	0.95	3.32	-4.17	-3.22	-0.85
Social/Ethics	0.71	-1.46	1.17	-0.71	-2.16	0.47
Total	7.03	-3.21	9.92	-7.03	-10.24	2.89

Criterion	V_live/EU	V_live/Pre	V_live/V_kill	V_kill/EU	V_kill/Pre	V_kill/V_live
Epidemiology	2.69	4.85	8.12	-5.42	-3.27	-8.12
Economics	-0.95	3.22	2.38	-3.32	0.85	-2.38
Social/Ethics	1.46	2.16	2.63	-1.17	-0.47	-2.63
Total	3.21	10.24	13.13	-9.92	-2.89	-13.13

According to the total dominance scores the Vac_live strategy is favoured over all other strategies; i.e. all total paired dominance scores are positive. On the other hand Vac_kill is completely dominated by the other strategies as reflected by its negative total dominance scores (Table D.2.1.4 and Figure D.2.1.4).

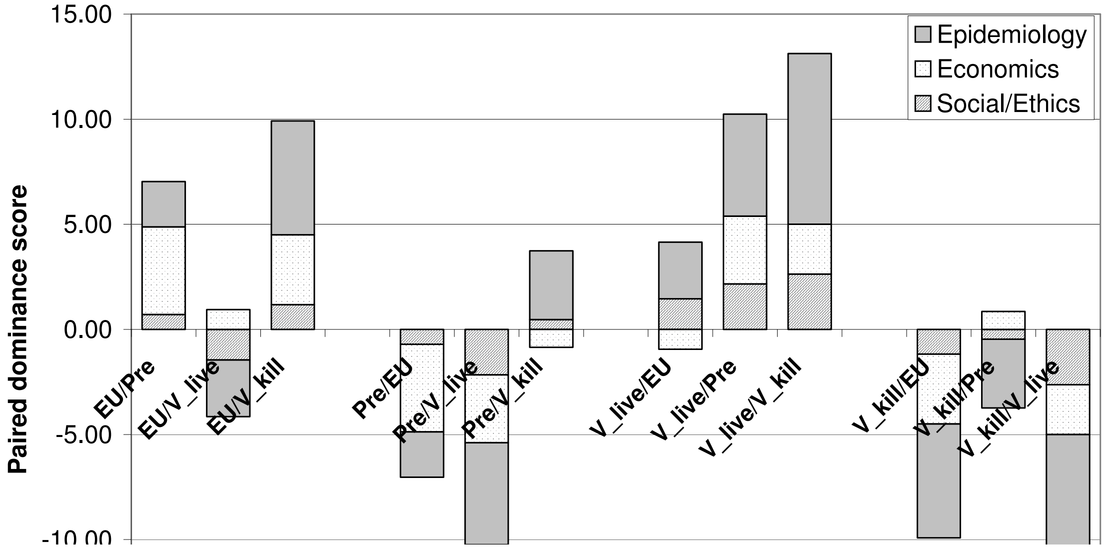

Figure D.2.1.4: Paired dominance scores of CSF control alternatives per main criterion.

D.2.2 MCA results Region A, CSF

- Scoring and weighting of epidemiological indicators

Table D.2.2.1 demonstrates the redirected, standardised and weighed scores of the epidemiological indicators per evaluated CSF control strategy based on the member state characteristics of Region A. The higher the value, the 'better' the score in relation to the other alternatives (max score = 100). The scores are derived from the epidemiological modelling results as described in Chapter 4.1.

Table D.2.2.1: Standardised and weighed scores of the epidemiological indicators per evaluated CSF control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Duration epidemic	0.00	1.72	0.00	0.00
Number infected farms	26.81	26.81	26.81	26.81
Size affected region	0.00	1.18	0.00	0.00
Number destroyed animals	8.58	0.00	10.01	0.00
Number destroyed herds	9.14	0.00	10.66	0.00
Number destroyed non-farm animals	3.15	0.00	3.68	0.00
Overall criterion value	47.69	29.72	51.16	26.81

Summation of the indicator scores per control strategy results in the overall score of the criterion "Epidemiology". These overall scores demonstrate that – according to the average CVO-judgement on the various epidemiological indicators - the Vac_Live strategy (overall score 51.2) is evaluated to exceed the other alternatives.

In terms of duration and number of infected farms, the Vac_kill strategy is just as effective as the Vac_live alternative. However, due to the fact that this strategy involves the slaughter of more animals (mainly vaccinated) than any other alternative, Vacc_kill is less preferred.

Figure D.2.2.1 gives a graphical overview of the contribution of each indicator within the overall criterion score. Again, the bigger the part the better the strategy scores on this indicator compared to the other 3 control alternatives. No score for an indicator means that – off all the evaluated control alternatives – the examined alternative scores worst for that specific indicator. For instance, Vac_kill only scores on 1 of the 6 epidemiological indicators, meaning that for the other five indicators this strategy scores worst in comparison to the other alternatives.

- Scoring and weighting of economic indicators

Table D.2.2.2 demonstrates the standardised and weighed scores of the economic indicators per evaluated CSF control strategy based on the member state characteristics of Region A. The economic scores are derived from the economic modelling results as described in 4.2.

Due to the lack of sufficient detailed information, it was not possible to score the specific indicator of '*consequential farm losses outside the affected region*'. The specific weight factor of this indicator equals 8.5. To account for the possible influence of this indicator, all alternatives within the analysis 'score' the average indicator value, which is equal to the indicator weight factor multiplied by ½ (viz. 8.5 x ½ = 4.25). As a consequence, overall criterion values may contain some variation, varying from 0 to a maximum of 4.25.

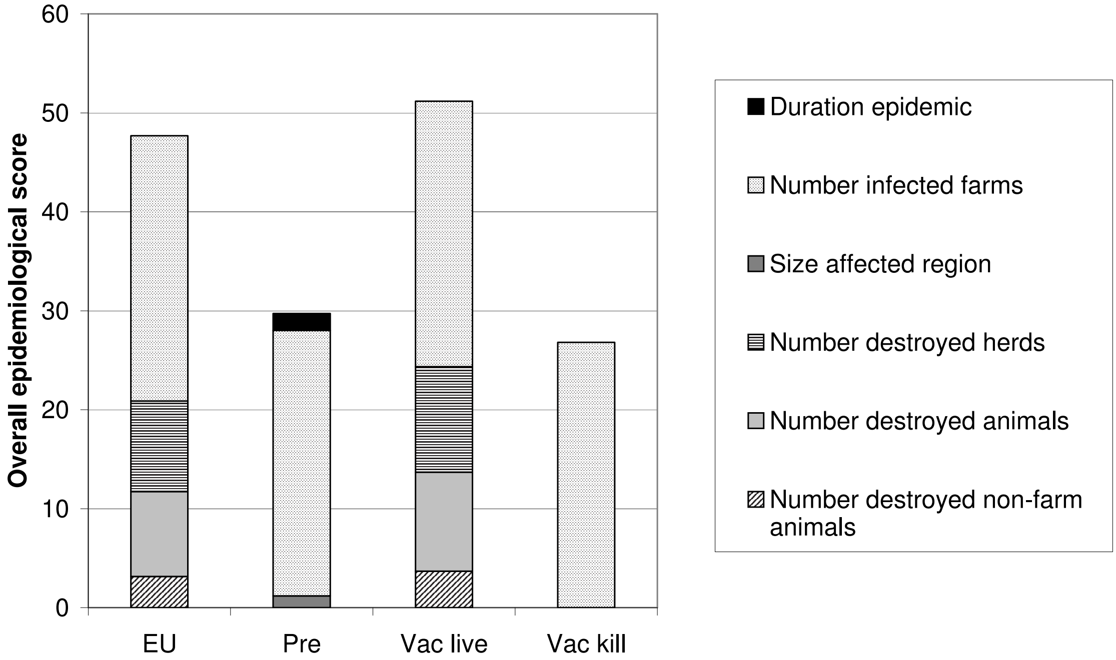

Figure D.2.2.1: Epidemiological indicator scores of each evaluated CSF control alternative.

Furthermore, the 2 indicators *'export restriction EU markets'* and *'export restrictions non-EU markets'* are aggregated into one general *'export restriction'* indicator, with a weighting factor equal to the sum of the two individual indicators.

Table D.2.2.2: Standardised and weighed scores of the economic indicators per evaluated CSF control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Direct farm losses	11.72	1.67	11.69	0.00
Cons farm losses in affected region	11.47	7.79	0.00	10.43
Cons farm losses outside affected region	4.25	4.25	4.25	4.25
Losses other participants	2.21	2.22	11.93	2.22
Losses non agricultural sectors	2.55	0.41	6.21	0.00
Organisation costs	6,20	0.00	6.35	6.35
Export restrictions EU markets	19.69	19.84	0.00	19.69
Tax payer:	4.40	0.00	4.44	1.60
Overall criterion value	62.49	36.18	44.88	44.53

Based on the overall economic criterion value, the EU control strategy (score = 62.5 ± 4.3) is preferred above the other control alternatives. The Pre strategy (score = 36.2 ± 4.3) is ranked as last (see Table D.2.2.2 and Figure D.2.2.2). Figure D.2.2.2 demonstrates the variation in scores per indicator and alternative.

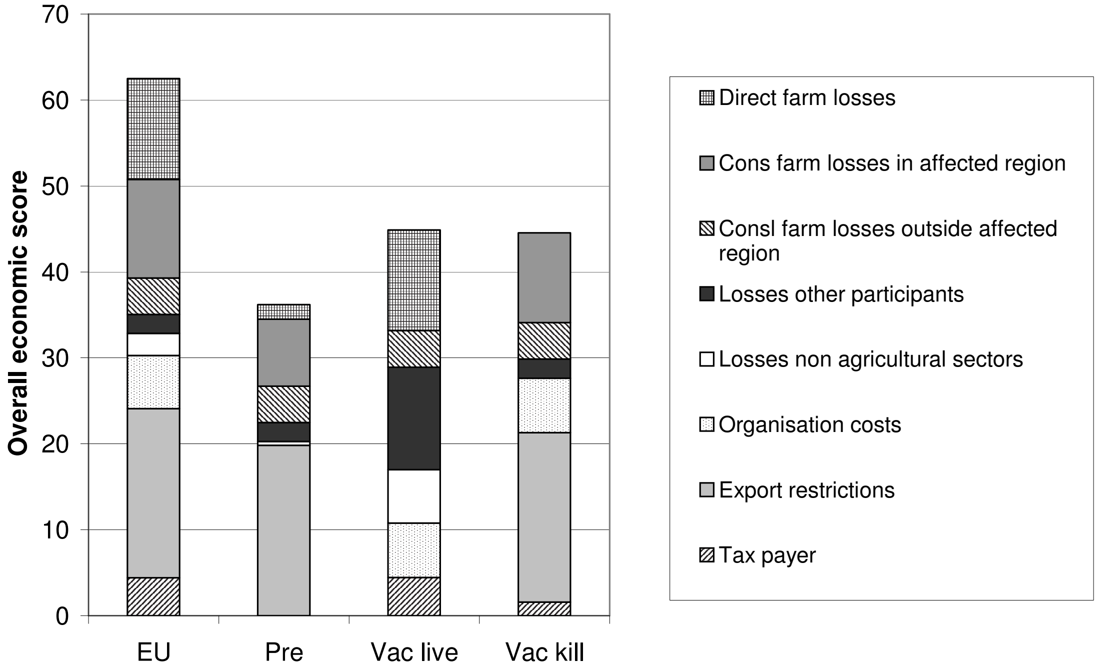

Figure D.2.2.2: Economic indicator scores of each evaluated CSF control alternative.

Scoring and weighting of social-ethical indicators

Table D.2.2.3 demonstrates the standardised and weighed scores of the social-ethical indicators per evaluated CSF control strategy based on the member state characteristics of Region A. The social-ethical scores are obtained by ranking the alternatives per criterion by its expected effectiveness. These effectiveness rankings are based on the insights obtained by the CVO questionnaires, personal interviews and model studies (Chapter 3 and 4.1 and 4.2).

Table D.2.2.3: Standardised and weighed scores of the social-ethical indicators per evaluated CSF control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Efficacy	0.00	9.68	0.00	0.00
Socio-economic factors	8.74	2.91	5.83	0.00
Macro-economic factors	10.89	10.89	10.89	10.89
Commercially interested parties	0.00	0.00	4.44	0.00
Animal health	2.73	0.00	5.45	0.00
Animal welfare	3.96	0.00	5.93	1.98
Tourism	1.08	2.16	0.00	3.24
Non-farm animals	1.21	0.00	1.82	0.61
Human health	3.21	0.00	6.42	6.42
Governmental policy	2.47	2.47	2.47	2.47
Natural life-cycle	3.21	0.00	3.21	1.61
Food source	6.32	3.16	6.32	0.00
Overall criterion value	43.81	31.26	52.78	27.21

Based on the overall social-ethical values (Table D.2.2.3) the Vac_Live strategy is evaluated as the best alternative to control a CSF epidemic.Figure D.2.2.3 demonstrates the individual contribution of each indicator to the overall social-ethical value. Strategies EU and Vac_live contribute both to 10 of the total of 12 indicators, strategy Pre contributes only to 6 of the 12 indicators.

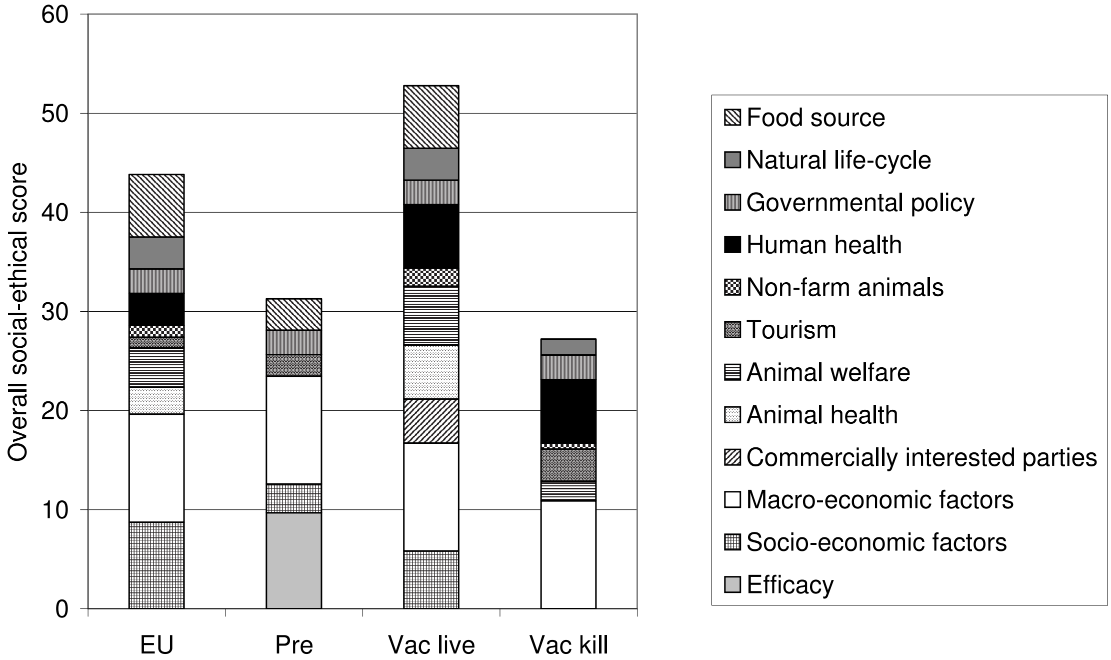

Figure D.2.2.3: Social-ethical indicator scores of each evaluated CSF control alternative.

Combined overall weighting of the three main criteria

Standardized scores of all indicators are compared in pairs of the evaluated alternatives, resulting in so-called dominance scores. A positive score implies dominance of a strategy in relation to another while a negative value implies submission. A dominance measure of 0 implies indifference between the compared strategies. By weighting the dominance scores per criterion, overall dominance scores of the three main criteria are obtained.

Table D.2.2.4 demonstrates the dominance scores of the three main criteria as a result of paired comparisons of the 4 control alternatives. For instance, the first column in the upper half of table, describes the results of the comparison between the EU strategy and the Pre strategy. As reflected by the positive scores, the EU strategy dominates the Pre strategy on all the main criteria (viz. + 5.23 on Epidemiology, + 4.94 on Economics and + 1.21 on Social-Ethics). The dominance scores based on the comparison of EU with Vac_live (second column) demonstrate that, regarding the epidemiological and social ethical criteria (scores of –1.01 and –0.86), the EU strategy is dominated by the Vac-Live strategy. However, the opposite is true for the economic element (economic dominance score = + 3.31).

Table D.2.2.4: Criteria dominance scores of the paired comparisons of the evaluated CSF control alternatives (e.g. EU/Pre = EU strategy compared to the Preventive culling strategy)

Criterion	EU/Pre	EU/V_live	EU/V_kill	Pre/EU	Pre/V_live	Pre/V_kill
Epidemiology	5.23	-1.01	6.08	-5.23	-6.25	0.85
Economics	4.94	3.31	3.37	-4.94	-1.63	-1.57
Social/Ethics	1.21	-0.86	1.60	-1.21	-2.07	0.39
Total	11.38	1.43	11.05	-11.38	-9.95	-0.33

Criterion	V_live/EU	V_live/Pre	V_live/V_kill	V_kill/EU	V_kill/Pre	V_kill/V_live
Epidemiology	1.01	6.25	7.09	-6.08	-0.85	-7.09
Economics	-3.31	1.63	0.06	-3.37	1.57	-0.06
Social/Ethics	0.86	2.07	2.46	-1.60	-0.39	-2.46
Total	-1.43	9.95	9.62	-11.05	0.33	-9.62

According to the total dominance scores the EU strategy is favoured over all other strategies; i.e. all total paired dominance scores are positive. The dominance difference with respect to the Vac_live strategy is, however, small (viz. 1.43).

Figure D.2.2.4 illustrates the 'dominance course' of the evaluated alternatives. Concerning the three main criteria, a strategy dominates as long as the column representing the individual criterion score is situated above the zero-axes. The Pre and Vac-Kill strategies are clearly overruled by the EU and Vac-Live alternatives; total dominance scores are < -9 (Table D.2.2.4 and Figure D.2.2.4).

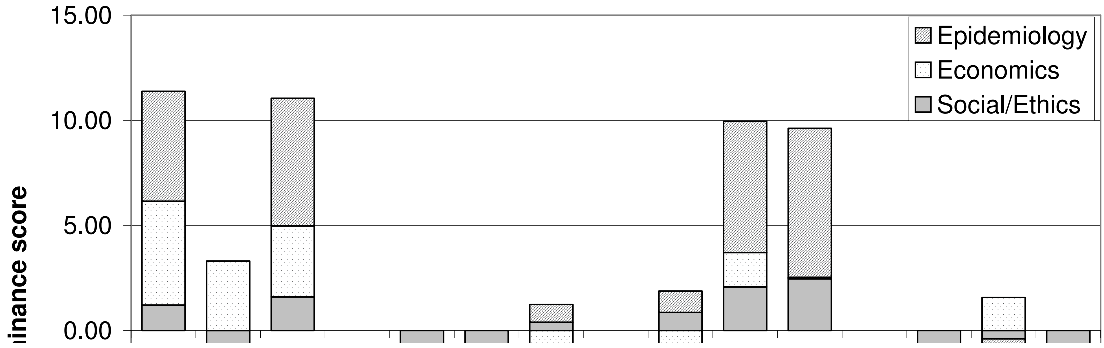

Figure D.2.2.4: Paired dominance scores of CSF control alternatives per main criterion.

D.2.3 MCA results Region F, CSF

- Scoring and weighting of epidemiological indicators

Table D.2.3.1 demonstrates the redirected, standardised and weighed scores of the epidemiological indicators per evaluated CSF control strategy based on the member state characteristics of Region F. The higher the value, the 'better' the score in relation to the other alternatives (max score = 100). The scores are derived from the epidemiological modelling results as described in Chapter 4.1.

Table D.2.3.1: Standardised and weighed scores of the epidemiological indicators per evaluated CSF control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Duration epidemic	5.28	5.28	0.00	0.00
Number infected farms	26.81	26.81	26.81	26.81
Size affected region	18.96	18.96	18.96	18.96
Number destroyed animals	8.58	0.00	8.58	0.00
Number destroyed herds	9.14	0.00	9.14	0.00
Number destroyed non-farm animals	3.15	0.00	3.15	0.00
Overall criterion value	71.92	51.05	66.64	45.77

Summation of the indicator scores per control strategy results in the overall score of the criterion "Epidemiology". These overall scores demonstrate that – according to the average CVO-judgement on the various epidemiological indicators - the EU strategy (overall score 71.9) is evaluated to exceed the other alternatives. The Vac-kill strategy is ranked as last (overall score 45.8). In terms of duration and number of infected farms, the Vac_kill strategy is just as effective as the Vac_live alternative. However, due to the fact that this strategy involves the slaughter of more animals (mainly vaccinated) than any other alternative, Vacc_kill is less preferred.

Figure D.2.3.1 gives a graphical overview of the contribution of each indicator within the overall criterion score. Again, the bigger the part the better the strategy scores on this indicator compared to the other 3 control alternatives. No score for an indicator means that – off all the evaluated control alternatives – the examined alternative scores worst for that specific indicator. For instance, Vac_kill only scores on 2 of the 6 epidemiological indicators, meaning that for the other four indicators this strategy scores worst in comparison to the other alternatives.

- Scoring and weighting of economic indicators

Table D.2.3.2 demonstrates the standardised and weighed scores of the economic indicators per evaluated CSF control strategy based on the member state characteristics of Region F. The economic scores are derived from the economic modelling results as described in 4.2.

Due to the lack of sufficient detailed information, it was not possible to score the specific indicator of '*consequential farm losses outside the affected region*'. The specific weight factor of this indicator equals 8.5. To account for the possible influence of this indicator, all alternatives within the analysis 'score' the average indicator value, which is equal to the indicator weight factor multiplied by ½ (viz. 8.5 x ½ = 4.25). As a consequence, overall criterion values may contain some variation, varying from 0 to a maximum of 4.25.

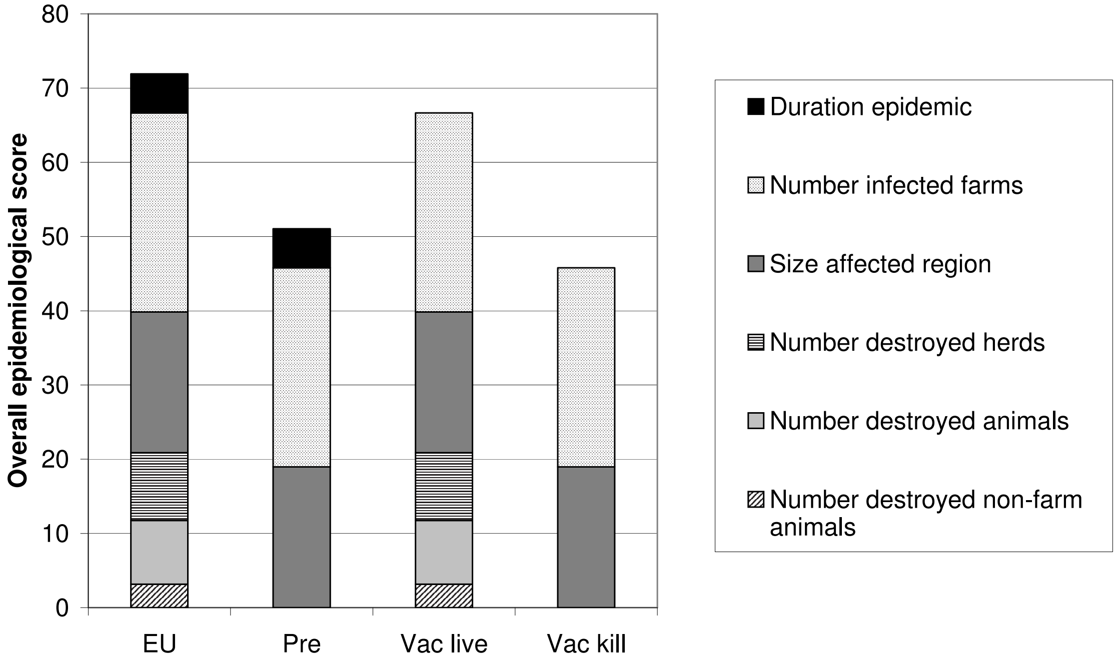

Figure D.2.3.1: Epidemiological indicator scores of each evaluated CSF control alternative.

Furthermore, the 2 indicators *'export restriction EU markets'* and *'export restrictions non-EU markets'* are aggregated into one general *'export restriction'* indicator, with a weighting factor equal to the sum of the two individual indicators

Table D.2.3.2: Standardised and weighed scores of the economic indicators per evaluated CSF control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Direct farm losses	11.28	0.00	11.28	0.00
Cons farm losses in affected region	12.82	9.88	0.00	12.06
Cons farm losses outside affected region	4.25	4.25	4.25	4.25
Losses other participants	2.99	11.93	2.99	8.52
Losses non agricultural sectors	1.53	6.21	1.53	4.58
Organisation costs	1.80	0.00	5.67	5.67
Export restrictions	24.16	24.16	24.16	24.16
Tax payer	3.00	0.00	4.22	1.79
Overall criterion value	61.82	56.44	54.10	61.03

Based on the overall economic criterion value, the EU control strategy (score = 61.8 ± 4.3) is preferred above the other control alternatives. However, compared to the second best strategy of Vac_kill, difference in overall dominance value is negligible. The Vac_live strategy (score = 54.1 ± 4.3) is ranked as last (see Table D.2.3.2 and Figure D.2.3.2).

Figure D.2.3.2 demonstrates the variation in scores per indicator and alternative. Due to the fact that – independent of the evaluated control strategy - there are no consequences due to export restrictions, all alternatives receive the maximum score for this indicator (i.e. 100% x indicator weight).

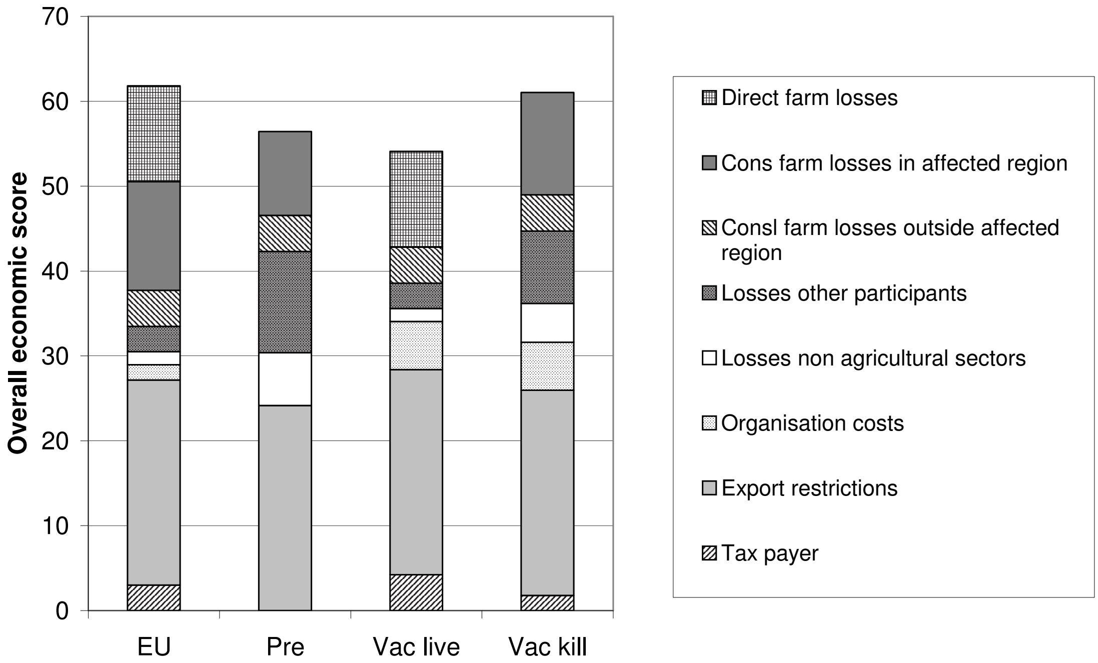

Figure D.2.3.2: Economic indicator scores of each evaluated CSF control alternative.

Scoring and weighting of social-ethical indicators

Table D.2.3.3 demonstrates the standardised and weighed scores of the social-ethical indicators per evaluated CSF control strategy based on the member state characteristics of Region F. The social-ethical scores are obtained by ranking the alternatives per criterion by its expected effectiveness. These effectiveness rankings are based on the insights obtained by the CVO questionnaires, personal interviews and model studies (Chapter 3 and 4.1 and 4.2).

Table D.2.3.3: Standardised and weighed scores of the social-ethical indicators per evaluated CSF control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Efficacy	9.68	9.68	0.00	0.00
Socio-economic factors	7.77	3.88	3.88	0.00
Macro-economic factors	10.89	10.89	10.89	10.89
Commercially interested parties	0.00	5.92	0.00	2.96
Animal health	2.73	0.00	5.45	0.00
Animal welfare	3.96	0.00	5.93	1.98
Tourism	0.00	2.88	0.00	1.44
Non-farm animals	1.21	0.00	1.82	0.61
Human health	3.21	0.00	6.42	6.42
Governmental policy	2.47	2.47	2.47	2.47
Natural life-cycle	3.21	0.00	3.21	1.61
Food source	6.32	3.16	6.32	0.00
Overall criterion value	51.44	38.87	46.40	28.37

Based on the overall social-ethical values (Table D.2.3.3) the EU strategy is evaluated as the best alternative to control a CSF epidemic.

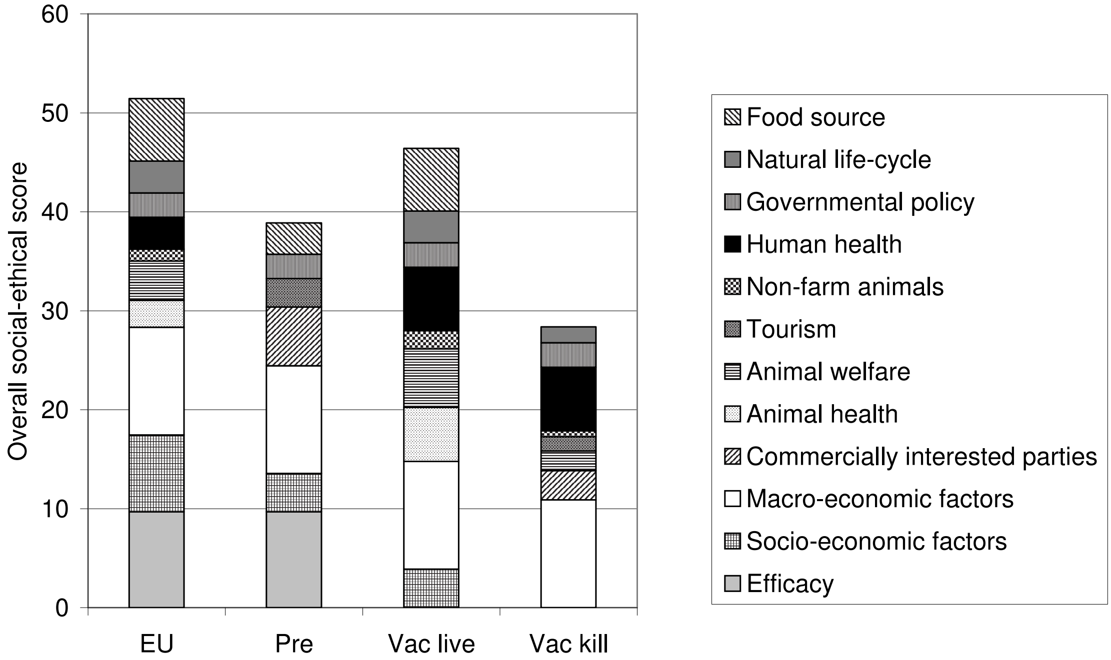

Figure D.2.3.3: Social-ethical indicator scores of each evaluated CSF control alternative.

Figure D.2.3.3 demonstrates the individual contribution of each indicator to the overall social-ethical value. Strategy EU contributes to 10 of the total of 12 indicators, strategy Pre contributes only to 7 of the 12 indicators.

Combined overall weighting of the three main criteria

Standardized scores of all indicators are compared in pairs of the evaluated alternatives, resulting in so-called dominance scores. A positive score implies dominance of a strategy in relation to another while a negative value implies submission. A dominance measure of 0 implies indifference between the compared strategies. By weighting the dominance scores per criterion, overall dominance scores of the three main criteria are obtained.

Table D.2.3.4 demonstrates the dominance scores of the three main criteria as a result of paired comparisons of the 4 control alternatives. For instance, the first column in the upper half of table, describes the results of the comparison between the EU strategy and the Pre strategy. As reflected by the positive scores, the EU strategy dominates the Pre strategy on all the main criteria (viz. + 5.88 on Epidemiology, + 2.89 on Economics and + 1.41 on Social-Ethics). The dominance scores based on the comparison of Pre with Vac_kill (sixth column) demonstrate that, regarding the epidemiological and social ethical criteria (scores of +1.49 and +1.18), the Pre strategy dominates the Vac-Live strategy. However, the opposite is true for the economic element (economic dominance score = -2.46).

According to the total dominance scores the EU strategy is favoured over all other strategies; i.e. all total paired dominance scores are positive.

Table D.2.3.4: Criteria dominance scores of the paired comparisons of the evaluated CSF control alternatives (e.g. EU/Pre = EU strategy compared to the Preventive culling strategy).

Criterion	EU/Pre	EU/V_live	EU/V_kill	Pre/EU	Pre/V_live	Pre/V_kill
Epidemiology	5.88	1.49	7.37	-5.88	-4.40	1.49
Economics	2.89	4.14	0.42	-2.89	1.26	-2.46
Social/Ethics	1.41	0.56	2.59	-1.41	-0.84	1.18
Total	10.18	6.20	10.38	-10.18	-3.98	0.20

Criterion	V_live/EU	V_live/Pre	V_live/V_kill	V_kill/EU	V_kill/Pre	V_kill/V_live
Epidemiology	-1.49	4.40	5.88	-7.37	-1.49	-5.88
Economics	-4.14	-1.26	-3.72	-0.42	2.46	3.72
Social/Ethics	-0.56	0.84	2.02	-2.59	-1.18	-2.02
Total	-6.20	3.98	4.19	-10.38	-0.20	-4.19

Figure D.2.3.4 illustrates the 'dominance course' of the evaluated alternatives. Concerning the three main criteria, a strategy dominates as long as the column representing the individual criterion score is situated above the zero-axes. The Pre and Vac-Kill strategies are overruled by the EU and Vac-Live alternatives; dominance scores are < - 4 (Table D.2.3.4 and Figure D.2.3.4).

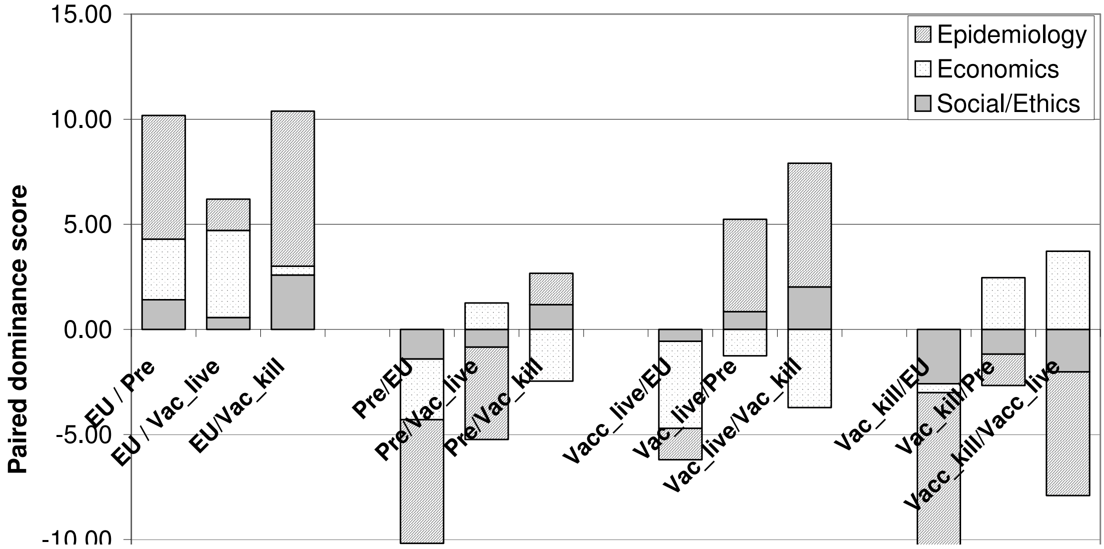

Figure D.2.3.4: Paired dominance scores of CSF control alternatives per main criterion.

D.2.4 MCA results Region D, CSF

- Scoring and weighting of epidemiological indicators

Table D.2.4.1 demonstrates the redirected, standardised and weighed scores of the epidemiological indicators per evaluated CSF control strategy based on the member state characteristics of Region D. The higher the value, the 'better' the score in relation to the other alternatives (max score = 100). The scores are derived from the epidemiological modelling results as described in Chapter 4.1.

Table D.2.4.1: Standardised and weighed scores of the epidemiological indicators per evaluated CSF control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Duration epidemic	0.00	5.87	0.73	0.73
Number infected farms	0.00	13.41	0.00	0.00
Size affected region	18.96	18.96	18.96	18.96
Number destroyed animals	5.72	0.00	8.58	0.00
Number destroyed herds	6.09	0.00	9.14	0.00
Number destroyed non-farm animals	2.10	0.00	3.15	0.00
Overall criterion value	32.87	38.23	40.56	19.69

Summation of the indicator scores per control strategy results in the overall score of the criterion "Epidemiology". These overall scores demonstrate that – according to the average CVO-judgement on the various epidemiological indicators - the Vac_Live strategy (overall score 40.6) is evaluated to exceed the other alternatives.

In terms of duration and number of infected farms, the Vac_kill strategy is just as effective as the Vac_live alternative. However, due to the fact that this strategy involves the slaughter of more animals (mainly vaccinated) than any other alternative, Vacc_kill is less preferred.

Figure D.2.4.1 gives a graphical overview of the contribution of each indicator within the overall criterion score. Again, the bigger the part the better the strategy scores on this indicator compared to the other 3 control alternatives. No score for an indicator means that – off all the evaluated control alternatives – the examined alternative scores worst for that specific indicator. For instance, Vac_kill only scores on 2 of the 6 epidemiological indicators, meaning that for the other four indicators this strategy scores worst in comparison to the other alternatives.

- Scoring and weighting of economic indicators

Table D.2.4.2 demonstrates the standardised and weighed scores of the economic indicators per evaluated CSF control strategy based on the member state characteristics of Region D. The economic scores are derived from the economic modelling results as described in 4.2.

Due to the lack of sufficient detailed information, it was not possible to score the specific indicator of '*consequential farm losses outside the affected region'*. The specific weight factor of this indicator equals 8.5. To account for the possible influence of this indicator, all alternatives within the analysis 'score' the average indicator value, which is equal to the indicator weight factor multiplied by ½ (viz. 8.5 x ½ = 4.25). As a consequence, overall criterion values may contain some variation, varying from 0 to a maximum of 4.25.

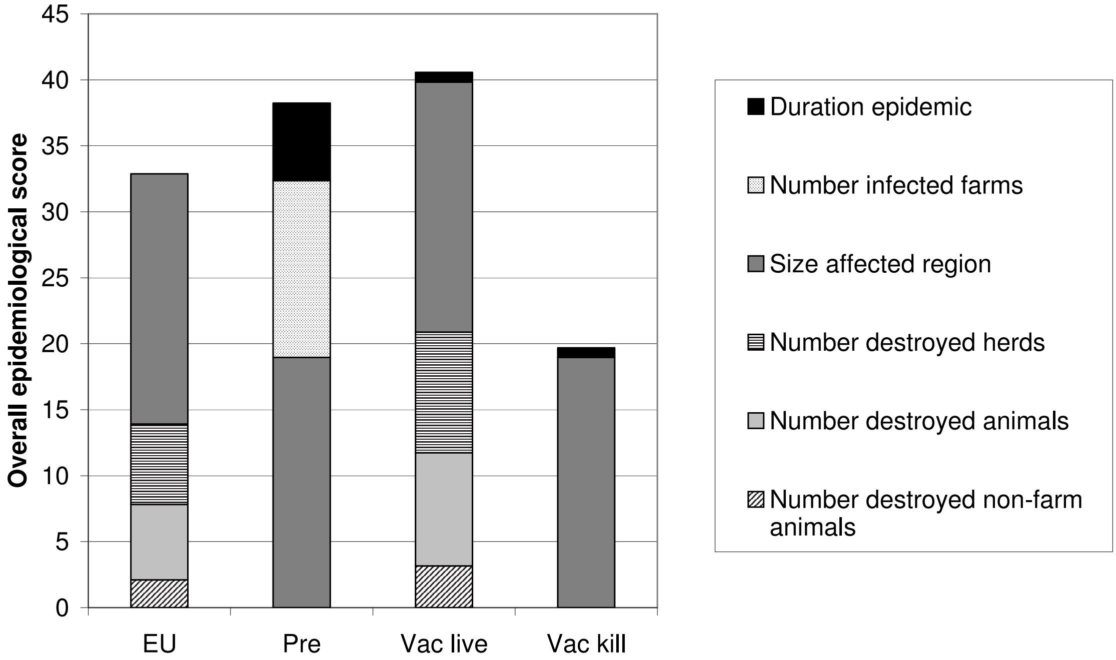

Figure D.2.4.1: Epidemiological indicator scores of each evaluated CSF control alternative.

Furthermore, the 2 indicators *'export restriction EU markets'* and *'export restrictions non-EU markets'* are aggregated into one general *'export restriction'* indicator, with a weighting factor equal to the sum of the two individual indicators

Table D.2.4.2: Standardised and weighed scores of the economic indicators per evaluated CSF control strategy.

Indicator	Control strategy			
	EU	**Pre**	**Vac live**	**Vac kill**
Direct farm losses	9.02	3.00	9.02	0.00
Cons farm losses in affected region	11.47	11.89	0.00	10.45
Cons farm losses outside affected region	4.25	4.25	4.25	4.25
Losses other participants	7.13	2.61	7.09	0.00
Losses non agricultural sectors	2.49	4.86	2.49	6.21
Organisation costs	4.92	0.00	4.98	4.98
Export restrictions EU markets	24.16	24.16	24.16	24.16
Tax payer	3.32	0.20	3.33	0.00
Overall criterion value	66.77	50.99	55.33	50.06

Based on the overall economic criterion value, the EU control strategy (score = 66.8 ± 4.3) is preferred above the other control alternatives. The Vac_kill strategy (score = 50.1 ± 4.3) is ranked as last (see Table D.2.4.2 and Figure D.2.4.2).

Figure D.2.4.2 demonstrates the variation in scores per indicator and alternative. Due to the fact that – independent of the evaluated control strategy - there are no consequences due to export restrictions, all alternatives receive the maximum score for this indicator (i.e. 100% x indicator weight).

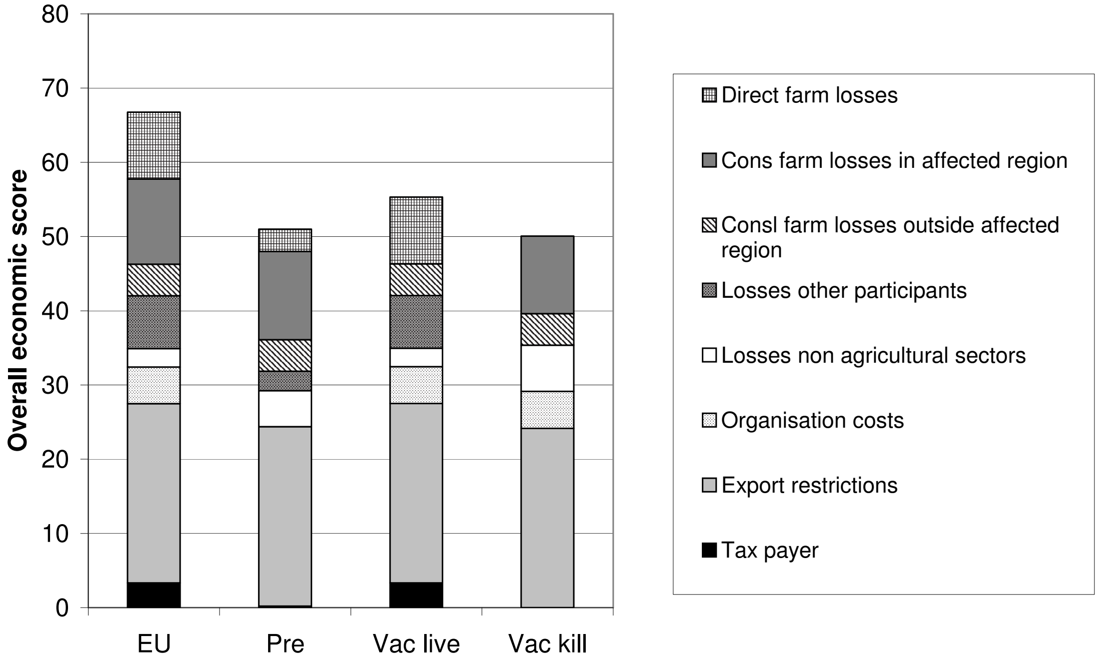

Figure D.2.4.2: Economic indicator scores of each evaluated CSF control alternative.

Scoring and weighting of social-ethical indicators

Table D.2.4.3 demonstrates the standardised and weighed scores of the social-ethical indicators per evaluated CSF control strategy based on the member state characteristics of Region D. The social-ethical scores are obtained by ranking the alternatives per criterion by its expected effectiveness. These effectiveness rankings are based on the insights obtained by the CVO questionnaires, personal interviews and model studies (Chapter 3 and 4.1 and 4.2).

Table D.2.4.3: Standardised and weighed scores of the social-ethical indicators per evaluated CSF control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Efficacy	0.00	9.68	0.00	0.00
Socio-economic factors	8.74	2.91	5.83	0.00
Macro-economic factors	10.89	10.89	10.89	10.89
Commercially interested parties	6.66	2.22	4.44	0.00
Animal health	2.73	0.00	5.45	0.00
Animal welfare	3.96	0.00	5.93	1.98
Tourism	0.00	1.44	0.00	2.88
Non-farm animals	1.21	0.00	1.82	0.61
Human health	3.21	0.00	6.42	6.42
Governmental policy	2.47	2.47	2.47	2.47
Natural life-cycle	3.21	0.00	3.21	1.61
Food source	6.32	3.16	6.32	0.00
Overall criterion value	49.39	32.77	52.78	26.85

Based on the overall social-ethical values (Table D.2.4.3) the Vac_Live strategy is evaluated as the best alternative to control a CSF epidemic. Figure D.2.4.3 demonstrates the individual contribution of each indicator to the overall social-ethical value. Strategies EU and Vac_live contribute both to 10 of the total of 12 indicators, strategies Pre and Vac_kill contribute only to 7 of the 12 indicators.

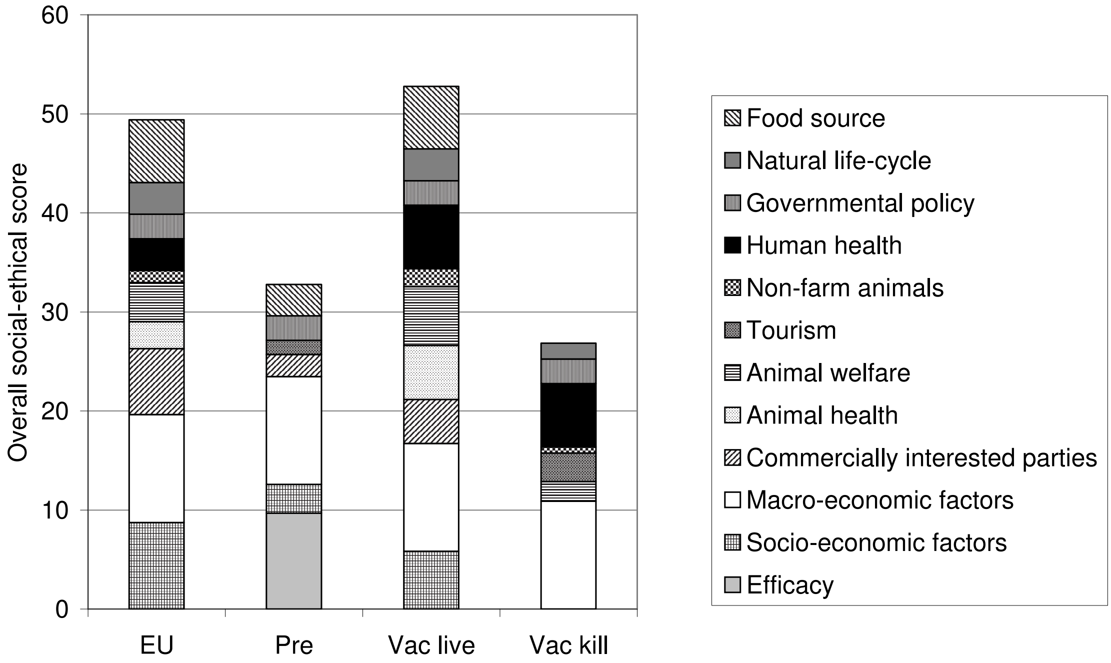

Figure D.2.4.3: Social-ethical indicator scores of each evaluated CSF control alternative.

Combined overall weighting of the three main criteria

Standardized scores of all indicators are compared in pairs of the evaluated alternatives, resulting in so-called dominance scores. A positive score implies dominance of a strategy in relation to another while a negative value implies submission. A dominance measure of 0 implies indifference between the compared strategies. By weighting the dominance scores per criterion, overall dominance scores of the three main criteria are obtained.

Table D.2.4.4 demonstrates the dominance scores of the three main criteria as a result of paired comparisons of the 4 control alternatives. For instance, the third column in the upper half of table, describes the results of the comparison between the EU strategy and the Vac_kill strategy. As reflected by the positive scores, the EU strategy dominates the Vac_kill strategy on all the main criteria (viz. + 5.14 on Epidemiology, + 4.57 on Economics and + 2.05 on Social-Ethics). The dominance scores based on the comparison of EU with Vac_live (second column) demonstrate that, regarding the epidemiological and social ethical criteria (scores of –3.00 and –0.31), the EU strategy is dominated by the Vac-Live strategy. However, the opposite is true for the economic element (economic dominance score = + 3.13).

Table D.2.4.4: Criteria dominance scores of the paired comparisons of the evaluated CSF control alternatives (e.g. EU/Pre = EU strategy compared to the Preventive culling strategy).

Criterion	EU/Pre	EU/V_live	EU/V_kill	Pre/EU	Pre/V_live	Pre/V_kill
Epidemiology	-2.09	-3.00	5.14	2.09	-0.91	7.23
Economics	4.31	3.13	4.57	-4.31	-1.19	0.26
Social/Ethics	1.51	-0.31	2.05	-1.51	-1.82	0.54
Total	3.74	-0.18	11.76	-3.74	-3.92	8.03

Criterion	V_live/EU	V_live/Pre	V_live/V_kill	V_kill/EU	V_kill/Pre	V_kill/V_live
Epidemiology	3.00	0.91	8.14	-5.14	-7.23	-8.14
Economics	-3.13	1.19	1.44	-4.57	-0.26	-1.44
Social/Ethics	0.31	1.82	2.36	-2.05	-0.54	-2.36
Total	0.18	3.92	11.94	-11.76	-8.03	-11.94

According to the total dominance scores the Vac_live strategy is favoured over all other strategies; i.e. all total paired dominance scores are positive. On the other hand Vac_kill is completely dominated by the other strategies as reflected by its negative total dominance scores (Table D.2.4.4 and Figure D.2.4.4).

Figure D.2.4.4 illustrates the 'dominance course' of the evaluated alternatives. Concerning the three main criteria, a strategy dominates as long as the column representing the individual criterion score is situated above the zero-axes.

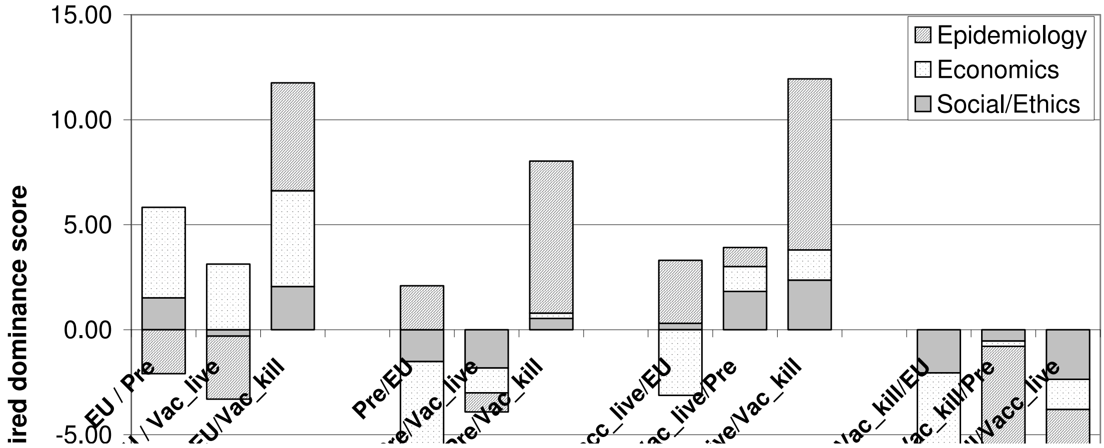

Figure D.2.4.4: Paired dominance scores of CSF control alternatives per main criterion.

D.2.5 MCA results Region E, CSF

- Scoring and weighting of epidemiological indicators

Table D.2.5.1 demonstrates the redirected, standardised and weighed scores of the epidemiological indicators per evaluated CSF control strategy based on the member state characteristics of Region E. The higher the value, the 'better' the score in relation to the other alternatives (max score = 100). The scores are derived from the epidemiological modelling results as described in Chapter 4.1.

Within this analysis only 3 alternatives are evaluated due to the restricted control efficiency of the EU strategy as explained in Chapter 4.1.

Table D.2.5.1: Standardised and weighed scores of the epidemiological indicators per evaluated CSF control strategy.

Indicator	Control strategy			
	EU	**Pre**	**Vac live**	**Vac kill**
Duration epidemic	n.a.	2.64	0.00	0.00
Number infected farms	n.a.	9.46	0.00	0.00
Size affected region	n.a.	1.43	0.00	0.00
Number destroyed animals	n.a.	1.60	11.39	0.00
Number destroyed herds	n.a.	1.71	12.13	0.00
Number destroyed non-farm animals	n.a.	0.59	4.19	0.00
Overall criterion value	n.a.	17.43	27.72	0.00

n.a.= not analysed due to restricted control efficiency of the strategy

Summation of the indicator scores per control strategy results in the overall score of the criterion "Epidemiology". These overall scores demonstrate that – according to the average CVO-judgement on the various epidemiological indicators - the Vac_Live strategy (overall score 27.7) is evaluated to exceed the other alternatives. The overall criterion value of the Vac_kill is 0, due to the fact that this alternative scores worst on all indicators. In terms of duration and number of infected farms, the Vac_kill strategy is just as effective as the Vac_live alternative. However, due to the fact that this strategy involves the slaughter of more animals (mainly vaccinated) than any other alternative, Vacc_kill is less preferred.

Figure D.2.5.1 gives a graphical overview of the contribution of each indicator within the overall criterion score. Again, the bigger the part the better the strategy scores on this indicator compared to the other 2 control alternatives. No score for an indicator means that – off all the evaluated control alternatives – the examined alternative scores worst for that specific indicator. As explained before Vac_kill scores worst on all the 6 epidemiological indicators, explaining the absence of any column in the Figure D.2.5.1.

- Scoring and weighting of economic indicators

Table D.2.5.2 demonstrates the standardised and weighed scores of the economic indicators per evaluated CSF control strategy based on the member state characteristics of Region E. The economic scores are derived from the economic modelling results as described in 4.2.

Due to the lack of sufficient detailed information, it was not possible to score the specific indicator of '*consequential farm losses outside the affected region*'. The specific weight factor of this indicator equals 8.5. To account for the possible influence of this indicator, all alternatives within the analysis 'score' the average indicator value, which is equal to the indicator weight factor multiplied by ½ (viz. 8.5 x ½ = 4.25). As a consequence, overall criterion values may contain some variation, varying from 0 to a maximum of 4.25.

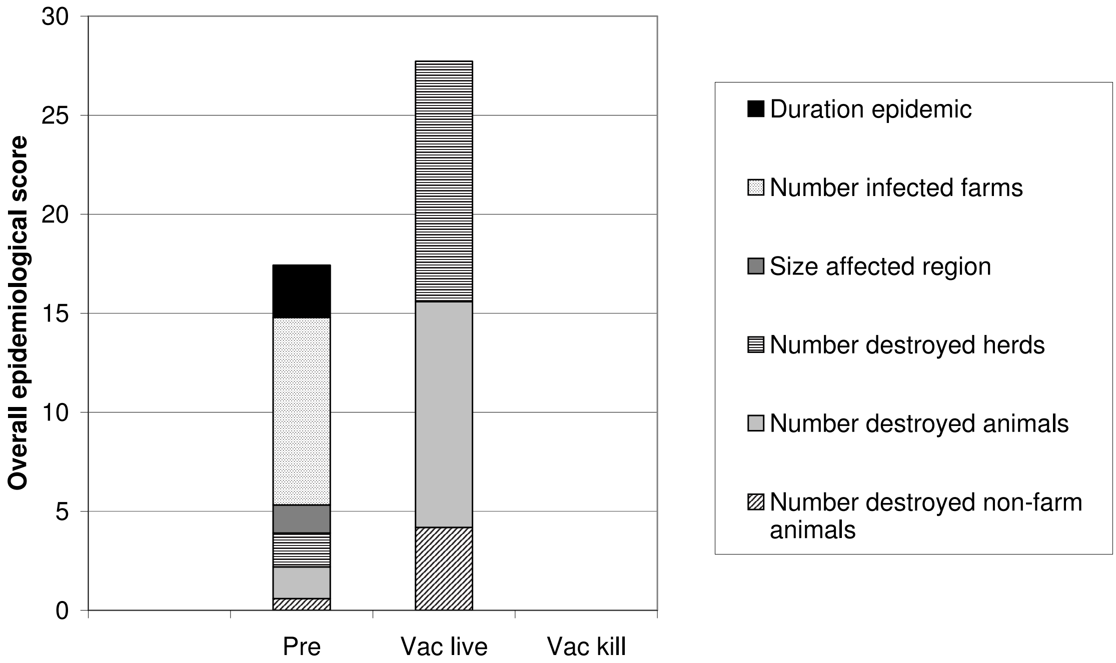

Figure D.2.5.1: Epidemiological indicator scores of each evaluated CSF control alternative.

Furthermore, the 2 indicators *'export restriction EU markets'* and *'export restrictions non-EU markets'* are aggregated into one general *'export restriction'* indicator, with a weighting factor equal to the sum of the two individual indicators.

Table D.2.5.2: Standardised and weighed scores of the economic indicators per evaluated CSF control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Direct farm losses	n.a.	2.90	14.07	0.00
Cons farm losses in affected region	n.a.	10.08	0.00	12.30
Cons farm losses outside affected region	n.a.	4.25	4.25	4.25
Losses other participants	n.a.	0.76	5.02	0.00
Losses non agricultural sectors	n.a.	1.21	5.70	0.00
Organisation costs	n.a.	0.00	8.61	8.89
Export restrictions	n.a.	16.51	0.00	15.91
Tax payer:	n.a.	0.00	5.73	1.76
Overall criterion value	n.a.	35.72	43.37	43.11

n.a.= not analysed due to restricted control efficiency of the strategy

Based on the overall economic criterion value, the Vac_live control strategy (score = 43.4 ± 4.3) is preferred above the other control alternatives. However, compared to the second best strategy of Vac_kill, difference in overall dominance value is negligible. Figure D.2.5.2 demonstrates the variation in scores per indicator and alternative.

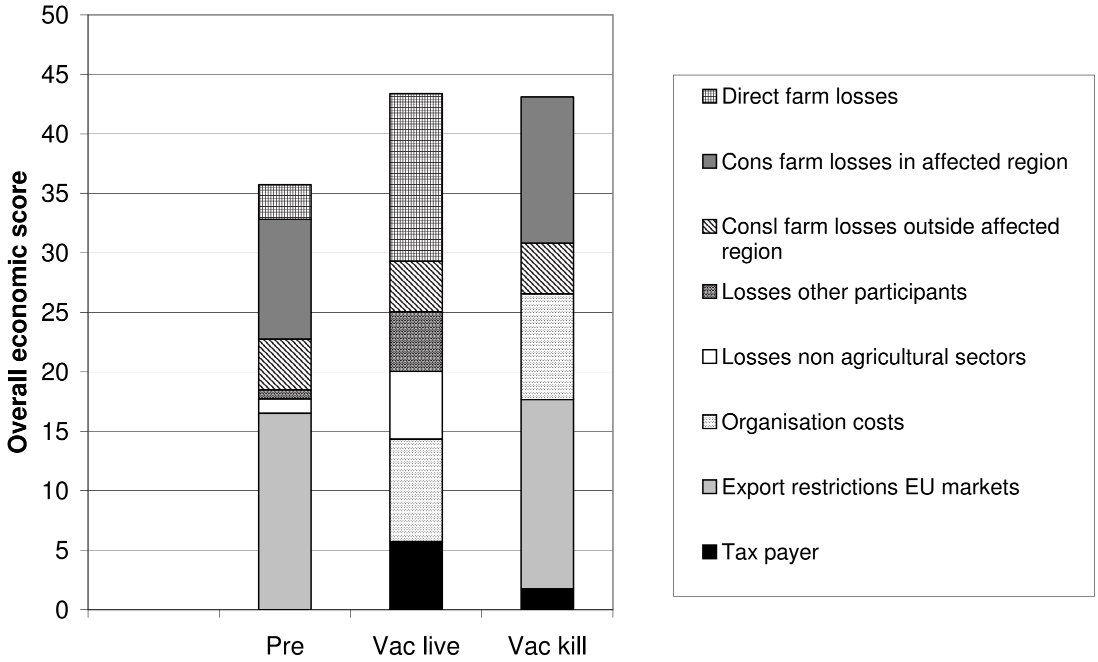

Figure D.2.5.2: Economic indicator scores of each evaluated CSF control alternative.

Scoring and weighting of social-ethical indicators

Table D.2.5.3 demonstrates the standardised and weighed scores of the social-ethical indicators per evaluated CSF control strategy based on the member state characteristics of Region E. The social-ethical scores are obtained by ranking the alternatives per criterion by its expected effectiveness. These effectiveness rankings are based on the insights obtained by the CVO questionnaires, personal interviews and model studies (Chapter 3 and 4.1 and 4.2).

Table D.2.5.3: Standardised and weighed scores of the social-ethical indicators per evaluated CSF control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Efficacy	n.a.	9.68	0.00	0.00
Socio-economic factors	n.a.	3.88	7.77	0.00
Macro-economic factors	n.a.	10.89	10.89	10.89
Commercially interested parties	n.a.	2.96	5.92	0.00
Animal health	n.a.	0.00	4.09	0.00
Animal welfare	n.a.	0.00	5.28	2.64
Tourism	n.a.	1.44	2.88	0.00
Non-farm animals	n.a.	0.00	1.62	0.81
Human health	n.a.	0.00	4.81	4.81
Governmental policy	n.a.	2.47	2.47	2.47
Natural life-cycle	n.a.	0.00	3.21	1.61
Food source	n.a.	3.16	6.32	0.00
Overall criterion value	n.a.	34.48	55.25	23.23

n.a.= not analysed due to restricted control efficiency of the strategy

Based on the overall social-ethical values (Table D.2.5.3) the Vac_Live strategy is evaluated as the best alternative to control a CSF epidemic.
Figure D.2.5.3 demonstrates the individual contribution of each indicator to the overall social-ethical value. Strategy Vac_live contributes to 11 of the total of 12 indicators, strategy Vac_kill contributes only to 6 of the 12 indicators.

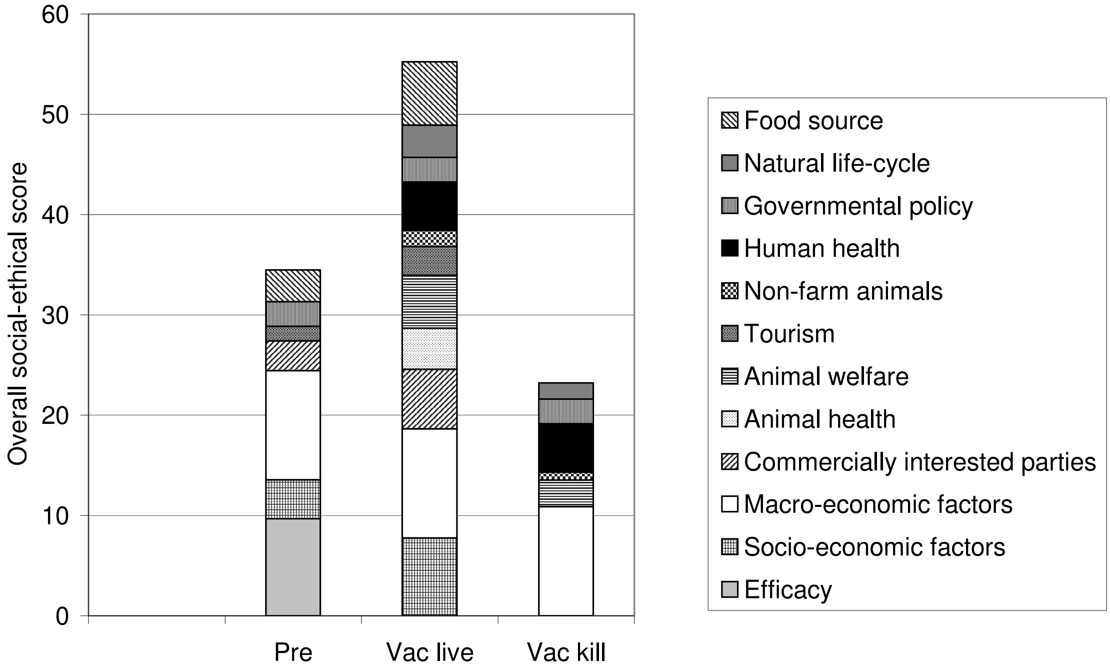

Figure D.2.5.3: Social-ethical indicator scores of each evaluated CSF control alternative.

Combined overall weighting of the three main criteria

Standardized scores of all indicators are compared in pairs of the evaluated alternatives, resulting in so-called dominance scores. A positive score implies dominance of a strategy in relation to another while a negative value implies submission. A dominance measure of 0 implies indifference between the compared strategies. By weighting the dominance scores per criterion, overall dominance scores of the three main criteria are obtained.

Table D.2.5.4 demonstrates the dominance scores of the three main criteria as a result of paired comparisons of the 3 control alternatives. For instance, the fifth column in the upper half of table describes the results of the comparison between the Pre strategy and the Vac_live strategy. As reflected by the negative scores, the Pre strategy is dominated by the Pre strategy on all the main criteria (viz. –2.71 on Epidemiology, -0.60 on Economics and –0.71 on Social-Ethics). The dominance scores based on the comparison of Pre with Vac_kill (sixth column) demonstrate that, regarding the epidemiological and social ethical criteria (scores of +4.59 and +0.39), the Pre strategy dominates the Vac-kill strategy. However, the opposite is true for the economic element (economic dominance score = -2.69).

Table D.2.5.4: Criteria dominance scores of the paired comparisons of the evaluated CSF control alternatives (e.g. EU/Pre = EU strategy compared to the Preventive culling strategy).

Criterion	EU/Pre	EU/V_live	EU/V_kill	Pre/EU	Pre/V_live	Pre/V_kill
Epidemiology	n.a.	n.a.	n.a.	n.a.	-2.71	4.59
Economics	n.a.	n.a.	n.a.	n.a.	-2.78	-2.69
Social/Ethics	n.a.	n.a.	n.a.	n.a.	-0.71	0.39
Total	n.a.	n.a.	n.a.	n.a.	-6.21	2.29

Criterion	V_live/EU	V_live/Pre	V_live/V_kill	V_kill/EU	V_kill/Pre	V_kill/V_live
Epidemiology	n.a.	2.71	7.31	n.a.	-4.59	-7.31
Economics	n.a.	2.78	0.10	n.a.	2.69	-0.10
Social/Ethics	n.a.	0.71	1.10	n.a.	-0.39	-1.10
Total	n.a.	6.21	8.50	n.a.	-2.29	-8.50

n.a.= not analysed due to restricted control efficiency of the strategy

According to the total dominance scores the Vac_live strategy is favoured over the other 2 strategies; i.e. all total paired dominance scores are positive. Figure D.2.5.4 illustrates the 'dominance course' of the evaluated alternatives. Concerning the three main criteria, a strategy dominates as long as the column representing the individual criterion score is situated above the zero-axes.

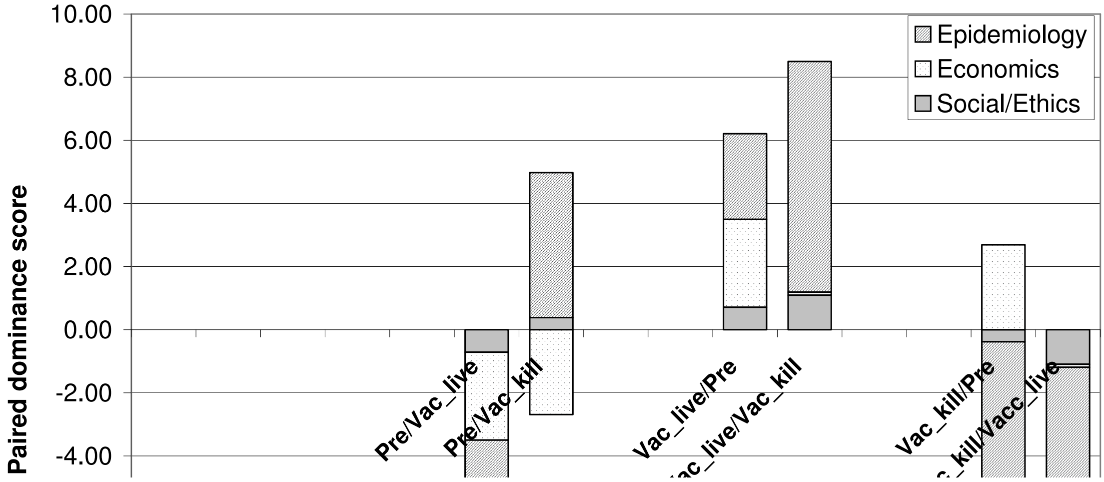

Figure D.2.5.4: Paired dominance scores of CSF control alternatives per main criterion.

D.2.6 MCA results Region C, CSF

- Scoring and weighting of epidemiological indicators

Table D.2.6.1 demonstrates the redirected, standardised and weighed scores of the epidemiological indicators per evaluated CSF control strategy based on the member state characteristics of Region C. The higher the value, the 'better' the score in relation to the other alternatives (max score = 100). The scores are derived from the epidemiological modelling results as described in Chapter 4.1.

Table D.2.6.1: Standardised and weighed scores of the epidemiological indicators per evaluated CSF control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Duration epidemic	n.a.	3.44	0.00	0.00
Number infected farms	n.a.	11.73	0.00	0.00
Size affected region	n.a.	0.45	0.00	0.00
Number destroyed animals	n.a.	2.25	11.39	0.00
Number destroyed herds	n.a.	2.39	12.13	0.00
Number destroyed non-farm animals	n.a.	0.83	4.19	0.00
Overall criterion value	n.a.	21.08	27.70	0.00

n.a. = not analysed due to restricted control efficiency of the strategy

Within this analysis only 3 alternatives are evaluated due to the restricted control efficiency of the EU strategy as explained in Chapter 4.1.

Summation of the indicator scores per control strategy results in the overall score of the criterion "Epidemiology". These overall scores demonstrate that – according to the average CVO-judgement on the various epidemiological indicators - the Vac_Live strategy (overall score 27.7) is evaluated to exceed the other alternatives. The overall criterion value of the Vac_kill is 0, due to the fact that this alternative scores worst on all indicators. In terms of duration and number of infected farms, the Vac_kill strategy is just as effective as the Vac_live alternative. However, due to the fact that this strategy involves the slaughter of more animals (mainly vaccinated) than any other alternative, Vacc_kill is less preferred

Figure D.2.6.1 gives a graphical overview of the contribution of each indicator within the overall criterion score. Again, the bigger the part the better the strategy scores on this indicator compared to the other 3 control alternatives. No score for an indicator means that – off all the evaluated control alternatives – the examined alternative scores worst for that specific indicator. As explained before Vac_kill scores worst on all the 6 epidemiological indicators, explaining the absence of any column in the Figure D.2.6.1.

- Scoring and weighting of economic indicators

Table D.2.6.2 demonstrates the standardised and weighed scores of the economic indicators per evaluated CSF control strategy based on the member state characteristics of Region C. The economic scores are derived from the economic modelling results as described in 4.2.

Due to the lack of sufficient detailed information, it was not possible to score the specific indicator of '*consequential farm losses outside the affected region*'. The specific weight factor of this indicator equals 8.5. To account for the possible influence of this indicator, all alternatives within the analysis 'score' the average indicator value, which is equal to the indicator weight factor multiplied by ½ (viz. 8.5 x ½ = 4.25). As a consequence, overall criterion values may contain some variation, varying from 0 to a maximum of 4.25.

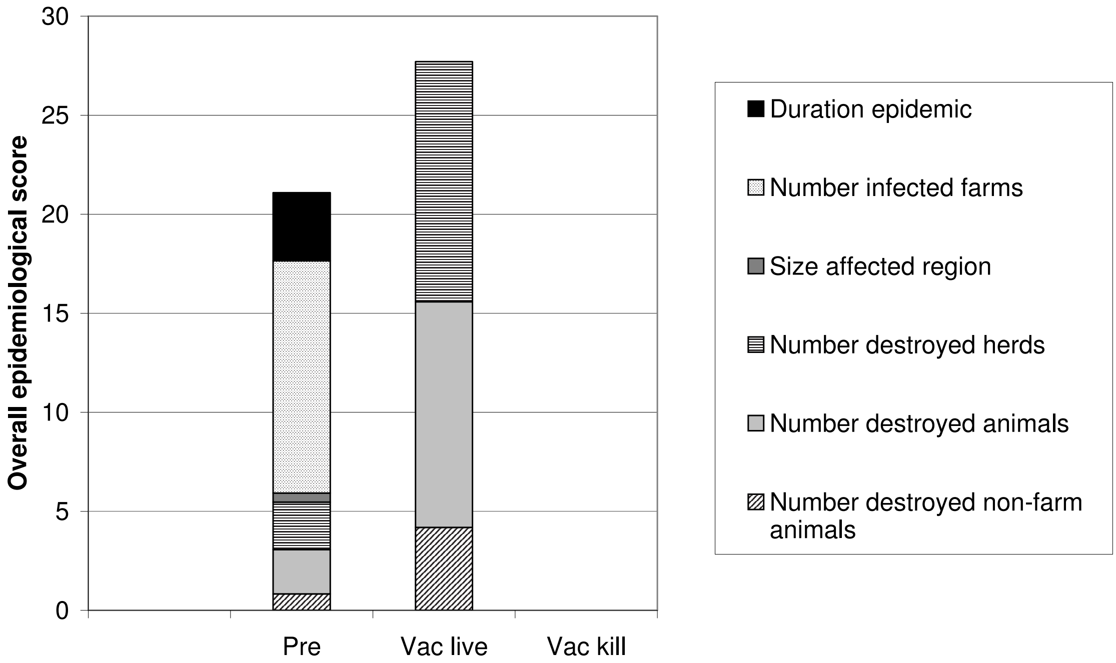

Figure D.2.6.1: Epidemiological indicator scores of each evaluated CSF control alternative.

Furthermore, the 2 indicators *'export restriction EU markets'* and *'export restrictions non-EU markets'* are aggregated into one general *'export restriction'* indicator, with a weighting factor equal to the sum of the two individual indicators

Table D.2.6.2: Standardised and weighed scores of the economic indicators per evaluated CSF control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Direct farm losses	n.a.	3.80	13.98	0.00
Cons farm losses in affected region	n.a.	10.28	0.00	12.74
Cons farm losses outside affected region	n.a.	4.25	4.25	4.25
Losses other participants	n.a.	10.08	0.00	11.93
Losses non agricultural sectors	n.a.	5.86	0.00	6.21
Organisation costs	n.a.	0.00	8.42	8.42
Export restrictions	n.a.	16.74	0.00	15.73
Tax payer	n.a.	0.00	5.61	1.36
Overall criterion value	n.a.	51.01	32.27	60.65

n.a. = not analysed due to restricted control efficiency of the strategy

Based on the overall economic criterion value, the Vac_kill control strategy (score = 60.7 ± 4.3) is preferred above the other control alternatives. The Vac_live strategy (score = 32.3 ± 4.3) is ranked as last (see Table D.2.6.2 and Figure D.2.6.2). Figure D.2.6.2 demonstrates the variation in scores per indicator and alternative.

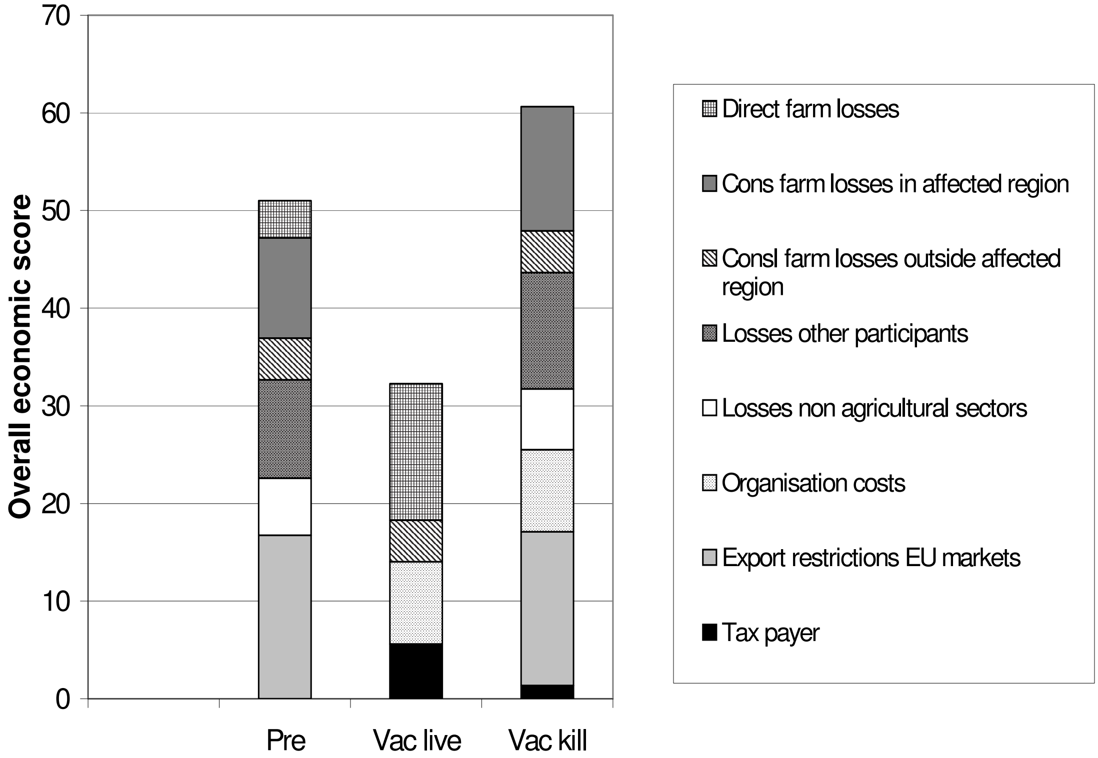

Figure D.2.6.2: Economic indicator scores of each evaluated CSF control alternative.

Scoring and weighting of social-ethical indicators

Table D.2.6.3 demonstrates the standardised and weighed scores of the social-ethical indicators per evaluated CSF control strategy based on the member state characteristics of Region C. The social-ethical scores are obtained by ranking the alternatives per criterion by its expected effectiveness. These effectiveness rankings are based on the insights obtained by the CVO questionnaires, personal interviews and model studies (Chapter 3 and 4.1 and 4.2).

Table D.2.6.3: Standardised and weighed scores of the social-ethical indicators per evaluated CSF control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Efficacy	n.a.	9.68	0.00	0.00
Socio-economic factors	n.a.	3.88	7.77	0.00
Macro-economic factors	n.a.	10.89	10.89	10.89
Commercially interested parties	n.a.	2.96	5.92	0.00
Animal health	n.a.	0.00	4.09	0.00
Animal welfare	n.a.	0.00	5.28	2.64
Tourism	n.a.	1.44	2.88	0.00
Non-farm animals	n.a.	0.00	1.62	0.81
Human health	n.a.	0.00	4.81	4.81
Governmental policy	n.a.	2.47	2.47	2.47
Natural life-cycle	n.a.	0.00	3.21	1.61
Food source	n.a.	3.16	6.32	0.00
Overall criterion value	n.a.	34.48	55.25	23.23

n.a. = not analysed due to restricted control efficiency of the strategy

Based on the overall social-ethical values (Table D.2.6.3) the Vac_Live strategy is evaluated as the best alternative to control a CSF epidemic.

Figure D.2.6.3 demonstrates the individual contribution of each indicator to the overall social-ethical value. Strategy Vac_live contributes to 11 of the total of 12 indicators, strategy Pre contributes only to 6 of the 12 indicators.

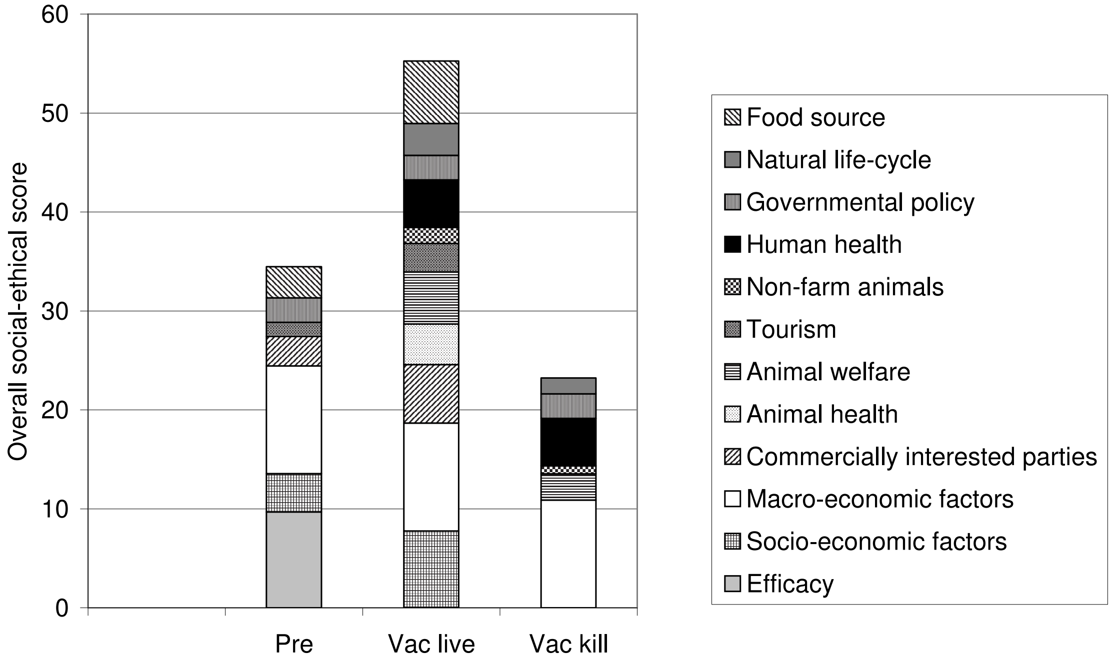

Figure D.2.6.3: Social-ethical indicator scores of each evaluated CSF control alternative.

Combined overall weighting of the three main criteria

Standardized scores of all indicators are compared in pairs of the evaluated alternatives, resulting in so-called dominance scores. A positive score implies dominance of a strategy in relation to another while a negative value implies submission. A dominance measure of 0 implies indifference between the compared strategies. By weighting the dominance scores per criterion, overall dominance scores of the three main criteria are obtained.

Table D.2.6.4 demonstrates the dominance scores of the three main criteria as a result of paired comparisons of the 4 control alternatives. For instance, the fifth column in the upper half of table describes the results of the comparison between the Pre strategy and the Vac_live strategy. As reflected by the negative scores, the Pre strategy is dominated by the Vac_live strategy on 2 of the 3 main criteria (viz. –1.68 on Epidemiology and –0.71 on Social-Ethics). From an economic point of view, however, the Pre strategy dominates the Vac-live strategy (economic dominance score = +4.67).

Table D.2.6.4: Criteria dominance scores of the paired comparisons of the evaluated CSF control alternatives (e.g. EU/Pre = EU strategy compared to the Preventive culling strategy).

Criterion	**EU/Pre**	**EU/V_live**	**EU/V_kill**	**Pre/EU**	**Pre/V_live**	**Pre/V_kill**
Epidemiology	n.a.	n.a.	n.a.	n.a.	-1.68	5.37
Economics	n.a.	n.a.	n.a.	n.a.	4.67	-2.40
Social/Ethics	n.a.	n.a.	n.a.	n.a.	-0.71	0.39
Total	n.a.	n.a.	n.a.	n.a.	2.27	3.35

Criterion	**V_live/EU**	**V_live/Pre**	**V_live/V_kill**	**V_kill/EU**	**V_kill/Pre**	**V_kill/V_live**
Epidemiology	n.a.	1.68	7.05	n.a.	-5.37	-7.05
Economics	n.a.	-4.67	-7.07	n.a.	2.40	7.07
Social/Ethics	n.a.	0.71	1.10	n.a.	-0.39	-1.10
Total	n.a.	-2.27	1.07	n.a.	-3.35	-1.07

n.a.= not analysed due to restricted control efficiency of the strategy

According to the total dominance scores the Pre strategy is favoured over the other 2 strategies; i.e. all total paired dominance scores are positive. However, differences in overall dominance scores are rather small.

Figure D.2.6.4 illustrates the 'dominance course' of the evaluated alternatives. Concerning the three main criteria, a strategy dominates as long as the column representing the individual criterion score is situated above the zero-axes.

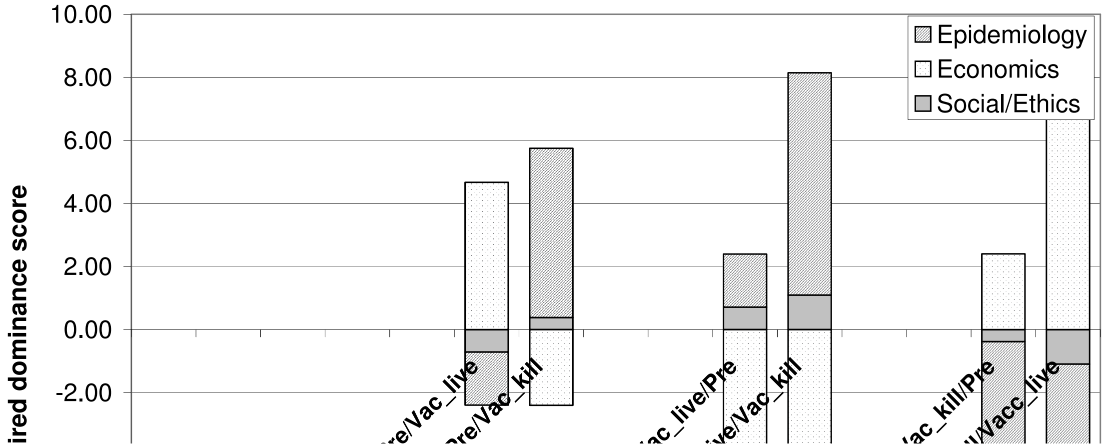

Figure D.2.6.4: Paired dominance scores of CSF control alternatives per main criterion.

Appendix D.3 – MCA results AI control alternatives

D.3.1 MCA results Region A, AI

- Scoring and weighting of epidemiological indicators

Table D.3.1.1 demonstrates the redirected, standardised and weighed scores of the epidemiological indicators per evaluated AI control strategy based on the member state characteristics of Region A. The higher the value, the 'better' the score in relation to the other alternatives (max score=100). The scores are derived from the epidemiological modelling results as described in Chapter 4.1.

Within this analysis only 3 alternatives are evaluated due to the restricted control efficiency of the EU strategy as explained in Chapter 4.1.

Table D.3.1.1: Standardised and weighed scores of the epidemiological indicators per evaluated AI control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Duration epidemic	n.a	0.00	0.46	0.46
Number infected farms	n.a.	11.14	0.00	0.00
Size affected region	n.a.	0.95	0.00	0.00
Number destroyed animals	n.a.	5.13	10.87	0.00
Number destroyed herds	n.a.	5.65	11.96	0.00
Number destroyed non-farm animals	n.a.	2.91	6.16	0.00
Overall criterion value	n.a.	25.77	29.46	0.46

n.a. = not analysed due to restricted control efficiency of the strategy

Summation of the indicator scores per control strategy results in the overall score of the criterion "Epidemiology". These overall scores demonstrate that – according the average CVO-judgement on the various epidemiological indicators - the Vac_Live strategy (overall score 29.5) is evaluated to exceed the other 2 alternatives. However, the differences in epidemiological scores are rather small compared to the Pre control alternative.

In terms of duration and number of infected farms, the Vac_kill strategy is just as effective as the Vac_live alternative. However, due to the fact that this strategy involves the slaughter of more animals (mainly vaccinated) than any other alternative, overall score of Vacc_kill is low (viz. 0.5).

Figure D.3.1.1 gives a graphical overview of the contribution of each indicator within the overall criterion score. Again, the bigger the part the better the strategy scores on this indicator compared to the other 2 control alternatives. No score for an indicator means that – off all the evaluated control alternatives – the examined alternative scores worst for that specific indicator. For instance, Vac_kill only scores on only 1 of the 6 epidemiological indicators, meaning that for the other four indicators this strategy scores worst in comparison to the other alternatives.

- Scoring and weighting of economic indicators

Table D.3.1.2 demonstrates the standardised and weighed scores of the economic indicators per evaluated AI control strategy based on the member state characteristics of Region A. The economic scores are derived from the economic modelling results as described in 4.2.

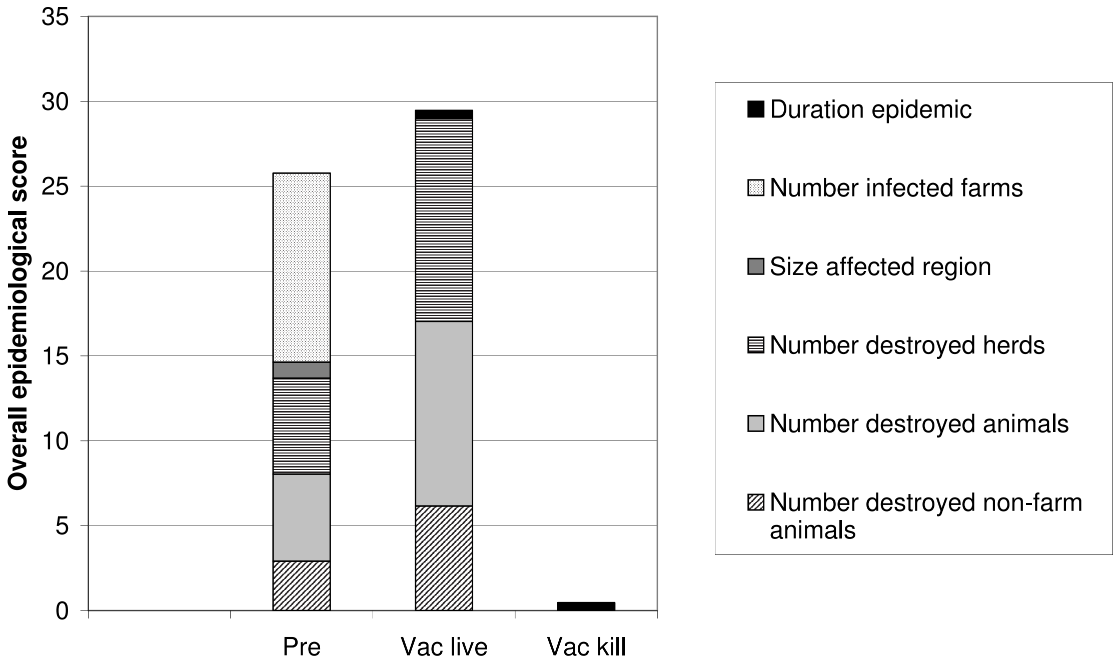

Figure D.3.1.1: Epidemiological indicator scores of each evaluated AI control alternative.

Due to the lack of sufficient detailed information, it was not possible to score the specific indicator of '*consequential farm losses outside the affected region*'. The specific weight factor of this indicator equals 10.16. To account for the possible influence of this indicator, all alternatives within the analysis 'score' the average indicator value, which is equal to the indicator weight factor multiplied by ½ (viz. 10.16 x ½ = 5.08). As a consequence, overall criterion values may contain some variation, varying from 0 to a maximum of 5.08.

Furthermore, the 2 indicators *'export restriction EU markets'* and *'export restrictions non-EU markets'* are aggregated into one general *'export restriction'* indicator, with a weighting factor equal to the sum of the two individual indicators.

Table D.3.1.2: Standardised and weighed scores of the economic indicators per evaluated AI control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Direct farm losses	n.a	7.45	14.73	0.00
Cons farm losses in affected region	n.a.	9.71	0.00	11.69
Cons farm losses outside affected region	n.a.	5.08	5.08	5.08
Losses other participants	n.a.	7.52	0.70	13.09
Losses non agricultural sectors	n.a.	4.25	6.61	0.00
Organisation costs	n.a.	0.00	3.55	3.55
Export restrictions	n.a.	18.77	0.00	0.00
Tax payer:	n.a.	1.73	5.03	0.00
Overall criterion value	n.a.	54.51	35.71	33.40

n.a. = not analysed due to restricted control efficiency of the strategy

Based on the overall economic criterion value, the Pre control strategy (score = 54.5 ± 5.1) is preferred above the other 2 control alternatives. The Vac-kill strategy (score = 33.4 ± 5.1) is ranked as last (see Table D.3.1.2 and Figure D.3.1.2). Figure D.3.1.2 demonstrates the variation in scores per indicator and alternative.

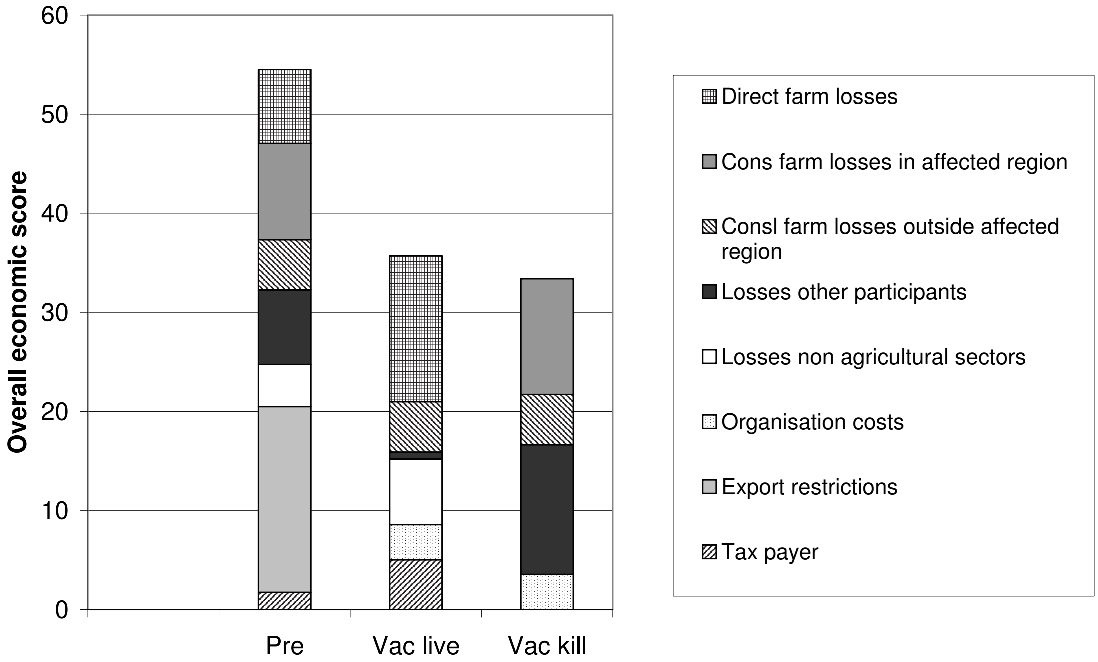

Figure D.3.1.2: Economic indicator scores of each evaluated AI control alternative.

Scoring and weighting of social-ethical indicators

Table D.3.1.3 demonstrates the standardised and weighed scores of the social-ethical indicators per evaluated AI control strategy based on the member state characteristics of Region A. The social-ethical scores are obtained by ranking the alternatives per criterion by its expected effectiveness. These effectiveness rankings are based on the insights obtained by the CVO questionnaires, personal interviews and model studies (Chapter 3 and 4.1 and 4.2)

Table D.3.1.3: Standardised and weighed scores of the social-ethical indicators per evaluated AI control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Efficacy	n.a	0.00	9.28	9.28
Socio-economic factors	n.a.	3.89	7.77	0.00
Macro-economic factors	n.a.	7.66	7.66	7.66
Commercially interested parties	n.a.	2.66	0.00	5.31
Animal health	n.a.	0.00	4.12	0.00
Animal welfare	n.a.	0.00	4.85	2.43
Tourism	n.a.	1.35	2.70	0.00
Non-farm animals	n.a.	0.00	4.54	2.27
Human health	n.a.	0.00	4.37	4.37
Governmental policy	n.a.	3.04	3.04	3.04
Natural life-cycle	n.a.	0.00	4.30	2.15
Food source	n.a.	3.19	6.37	0.00
Overall criterion value	n.a.	21.78	59.00	36.51

n.a. = not analysed due to restricted control efficiency of the strategy

Based on the overall social-ethical values (Table D.3.1.3) the Vac_Live strategy is evaluated as the best alternative to control an AI epidemic. Figure D.3.1.3 demonstrates the individual contribution of each indicator to the overall social-ethical value. Strategy Vac live contributes to 11 of the 12 indicators, strategy Pre contributes only to 6 of the 12 indicators.

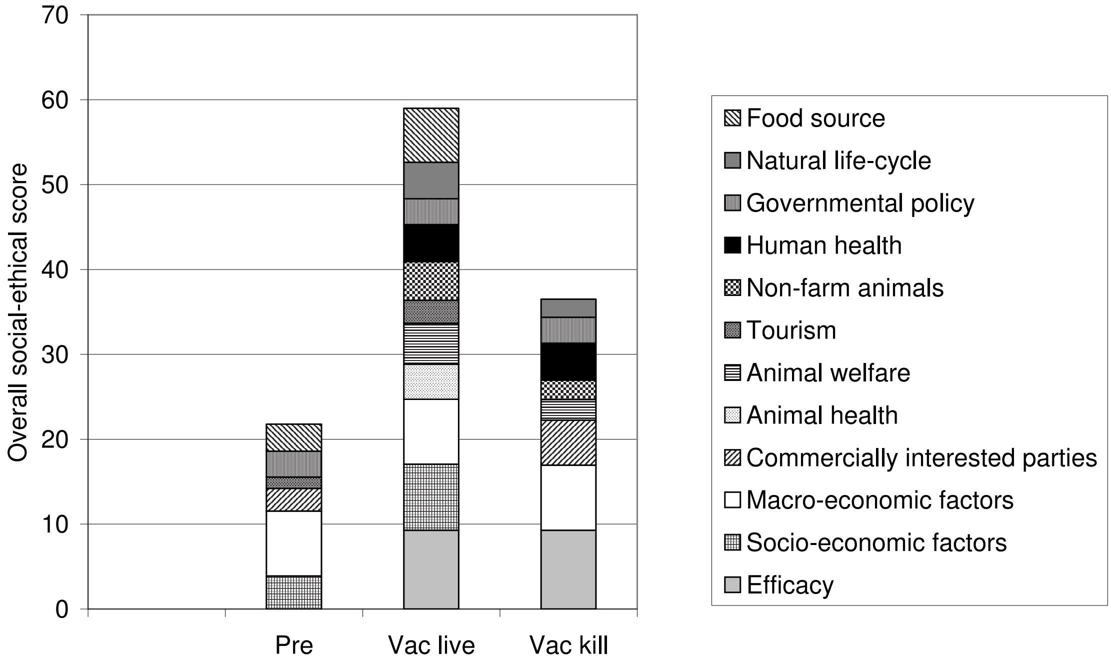

Figure D.3.1.3: Social-ethical indicator scores of each evaluated AI control alternative.

Combined overall weighting of the three main criteria

Standardized scores of all indicators are compared in pairs of the evaluated alternatives, resulting in so-called dominance scores. A positive score implies dominance of a strategy in relation to another while a negative value implies submission. A dominance measure of 0 implies indifference between the compared strategies. By weighting the dominance scores per criterion, overall dominance scores of the three main criteria are obtained.

Table D.3.1.4 demonstrates the dominance scores of the three main criteria as a result of paired comparisons of the 3 control alternatives. For instance, the third column in the lower half of the table, describes the results of the comparison between the Vac_live strategy and the Vac_kill strategy. As reflected by the positive scores, the Vac_live strategy dominates the Vacc_kill strategy on all the main criteria (viz. +6.65 on Epidemiology, +0.28 on Economics and +0.75 on Social-Ethics). The dominance scores based on the comparison of Vac_live with Pre (second column) demonstrate that, regarding the epidemiological and social ethical criteria (scores of +0.44 and +1.24), the Vac_live strategy dominates the Pre strategy. However, the opposite is true for the economic element (economic dominance score = -1.98).

Table D.3.1.4: Criteria dominance scores of the paired comparisons of the evaluated AI control alternatives (e.g. EU/Pre = EU strategy compared to the Preventive culling strategy)

Criterion	EU/Pre	EU/V_live	EU/V_kill	Pre/EU	Pre/V_live	Pre/V_kill
Epidemiology	n.a.	n.a.	n.a.	n.a.	-0.44	6.21
Economics	n.a.	n.a.	n.a.	n.a.	1.98	2.26
Social/Ethics	n.a.	n.a.	n.a.	n.a.	-1.24	-0.49
Total	n.a.	n.a.	n.a.	n.a.	0.30	7.98

Criterion	V_live/EU	V_live/Pre	V_live/V_kill	V_kill/EU	V_kill/Pre	V_kill/V_live
Epidemiology	n.a.	0.44	6.65	n.a.	-6.21	-6.65
Economics	n.a.	-1.98	0.28	n.a.	-2.26	-0.28
Social/Ethics	n.a.	1.24	0.75	n.a.	0.49	-0.75
Total	n.a.	-0.30	7.68	n.a.	-7.98	-7.68

n.a. = not analysed due to restricted control efficiency of the strategy

According to the total dominance scores the Pre strategy is favoured over the other 2 strategies; i.e. all total paired dominance scores are positive. The dominance difference with respect to the Vac_live strategy is, however, small (0.30). Vac_kill is completely dominated by the other strategies as reflected by its negative total dominance scores (Table D.3.1.4 and Figure D.3.1.4).

Figure D.3.1.4 illustrates the 'dominance course' of the evaluated alternatives. Concerning the three main criteria, a strategy dominates as long as the column representing the individual criterion score is situated above the zero-axes.

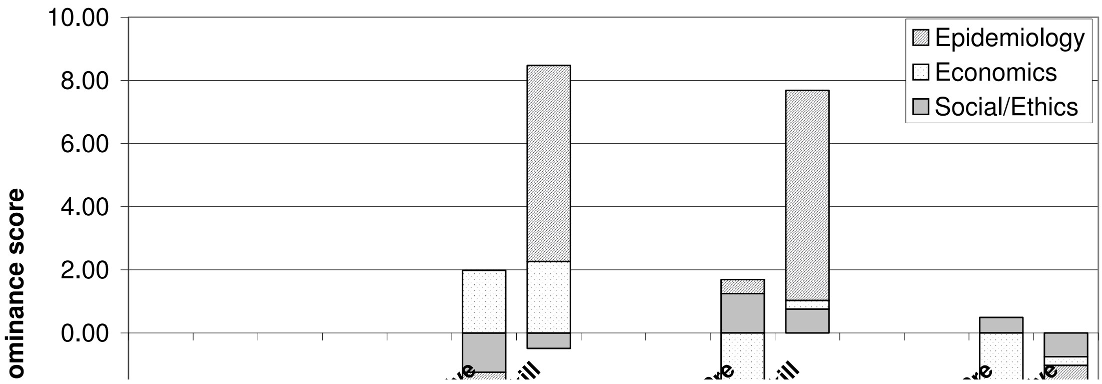

Figure D.3.1.4: Paired dominance scores of AI control alternatives per main criterion.

D.3.2 MCA results Region F, AI

- Scoring and weighting of epidemiological indicators

Table D.3.2.1 demonstrates the redirected, standardised and weighed scores of the epidemiological indicators per evaluated AI control strategy based on the member state characteristics of Region F. The higher the value, the 'better' the score in relation to the other alternatives (max score=100). The scores are derived from the epidemiological modelling results as described in Chapter 4.1.

Table D.3.2.1: Standardised and weighed scores of the epidemiological indicators per evaluated AI control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Duration epidemic	3.36	5.77	0.00	0.00
Number infected farms	0.00	9.23	3.08	3.08
Size affected region	0.89	4.04	0.00	0.00
Number destroyed animals	7.23	1.45	8.19	0.00
Number destroyed herds	7.95	1.59	9.01	0.00
Number destroyed non-farm animals	4.10	0.82	4.64	0.00
Overall criterion value	23.54	22.89	24.93	3.08

Summation of the indicator scores per control strategy results in the overall score of the criterion "Epidemiology". These overall scores demonstrate that – according to the average CVO-judgement on the various epidemiological indicators - the Vac_Live strategy (overall score 24.9) is evaluated to exceed the other alternatives. However, the differences in epidemiological scores are small compared to the EU and Pre control alternatives. In terms of duration and number of infected farms, the Vac_kill strategy is just as effective as the Vac_live alternative. However, due to the fact that this strategy involves the slaughter of more animals (mainly vaccinated) than any other alternative, overall score of Vacc_kill is low (viz. 3.1).

Figure D.3.2.1 gives a graphical overview of the contribution of each indicator within the overall criterion score. Again, the bigger the part the better the strategy scores on this indicator compared to the other 3 control alternatives. No score for an indicator means that – off all the evaluated control alternatives – the examined alternative scores worst for that specific indicator. For instance, Vac_kill only scores on 1 of the 6 epidemiological indicators, meaning that for the other five indicators this strategy scores worst in comparison to the other alternatives.

- Scoring and weighting of economic indicators

Table D.3.2.2 demonstrates the standardised and weighed scores of the economic indicators per evaluated AI control strategy based on the member state characteristics of Region F. The economic scores are derived from the economic modelling results as described in 4.2.

Due to the lack of sufficient detailed information, it was not possible to score the specific indicator of '*consequential farm losses outside the affected region*'. The specific weight factor of this indicator equals 10.16. To account for the possible influence of this indicator, all alternatives within the analysis 'score' the average indicator value, which is equal to the indicator weight factor multiplied by ½ (viz. 10.16 x ½ = 5.08). As a consequence, overall criterion values may contain some variation, varying from 0 to a maximum of 5.08.

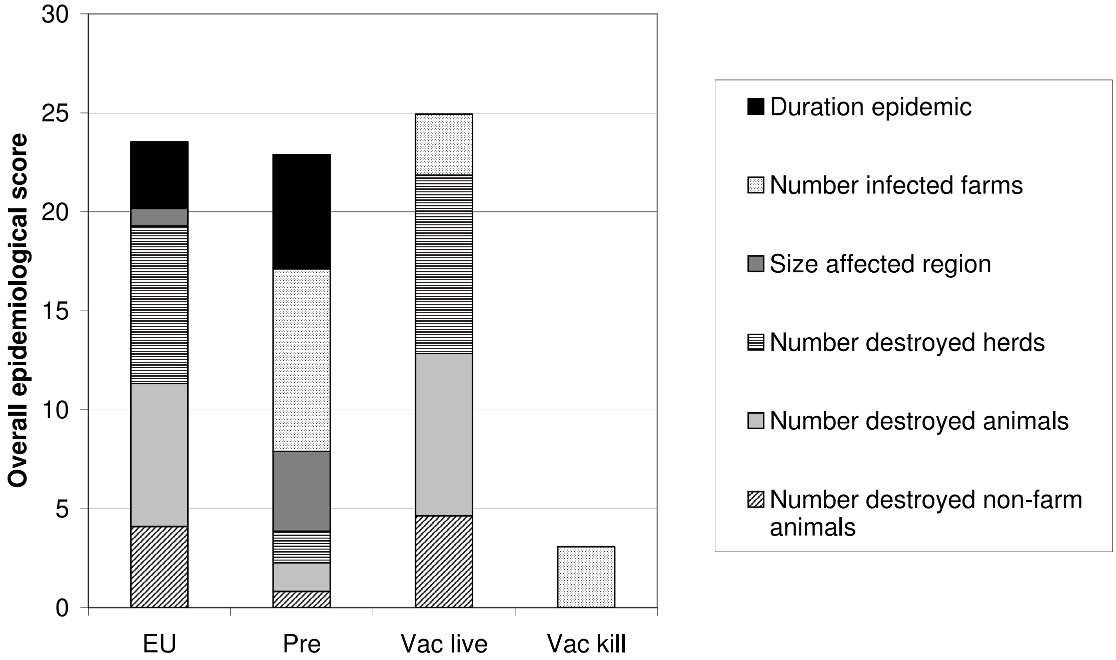

Figure D.3.2.1: Epidemiological indicator scores of each evaluated AI control alternative.

Furthermore, the 2 indicators *'export restriction EU markets'* and *'export restrictions non-EU markets'* are aggregated into one general *'export restriction'* indicator, with a weighting factor equal to the sum of the two individual indicators.

Table D.3.2.2: Standardised and weighed scores of the economic indicators per evaluated AI control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Direct farm losses	10.34	2.59	10.99	0.00
Cons farm losses in affected region	9.74	11.00	0.00	7.80
Cons farm losses outside affected region	5.08	5.08	5.08	5.08
Losses other participants	7.64	0.00	7.64	8.14
Losses non agricultural sectors	3.91	0.00	3.91	4.18
Organisation costs	0.00	0.00	0.98	0.98
Export restrictions	18.77	18.77	18.77	18.77
Tax payer:	0.22	0.00	0.86	0.55
Overall criterion value	55.69	37.43	48.22	45.50

Figure D.3.2.2 demonstrates the variation in scores per indicator and alternative. Due to the fact that – independent of the evaluated control strategy - there are no consequences due to export restrictions, all alternatives receive the maximum score for this indicator (i.e. 100% x indicator weight).

Based on the overall economic criterion value, the EU control strategy (score = 55.7 ± 5.1) is preferred above the other control alternatives. The Pre strategy (score = 37.4 ± 5.1) is ranked as last (see Table D.3.2.2 and Figure D.3.2.2).

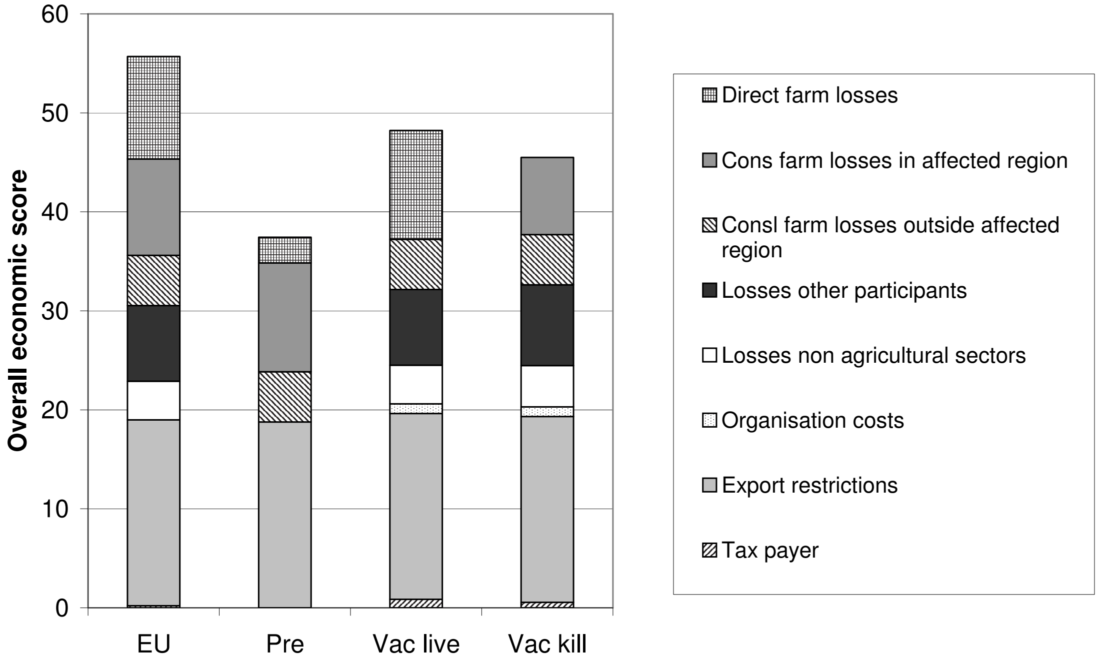

Figure D.3.2.2: Economic indicator scores of each evaluated AI control alternative.

Scoring and weighting of social-ethical indicators

Table D.3.2.3 demonstrates the standardised and weighed scores of the social-ethical indicators per evaluated AI control strategy based on the member state characteristics of Region F. The social-ethical scores are obtained by ranking the alternatives per criterion by its expected effectiveness. These effectiveness rankings are based on the insights obtained by the CVO questionnaires, personal interviews and model studies (Chapter 3 and 4.1 and 4.2).

Based on the overall social-ethical values (Table D.3.2.3) the Vac_Live strategy is evaluated as the best alternative to control an AI epidemic. However, compared to the second best strategy of EU default, difference in overall criterion value is small.

Table D.3.2.3: Standardised and weighed scores of the social-ethical indicators per evaluated AI control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Efficacy	6.19	12.37	0.00	0.00
Socio-economic factors	8.74	2.91	5.83	0.00
Macro-economic factors	7.66	7.66	7.66	7.66
Commercially interested parties	2.66	0.00	2.66	5.31
Animal health	2.75	0.00	5.49	0.00
Animal welfare	3.64	0.00	5.46	1.82
Tourism	0.00	0.00	2.02	2.02
Non-farm animals	3.40	0.00	5.11	1.70
Human health	2.91	0.00	5.82	5.82
Governmental policy	3.04	3.04	3.04	3.04
Natural life-cycle	4.30	0.00	4.30	2.15
Food source	6.37	3.19	6.37	0.00
Overall criterion value	51.66	29.18	53.76	29.54

Figure D.3.2.3 demonstrates the individual contribution of each indicator to the overall social-ethical value. Strategy Vac live contributes to 11 of the 12 indicators, strategy Pre contributes only to 5 of the 12 indicators.

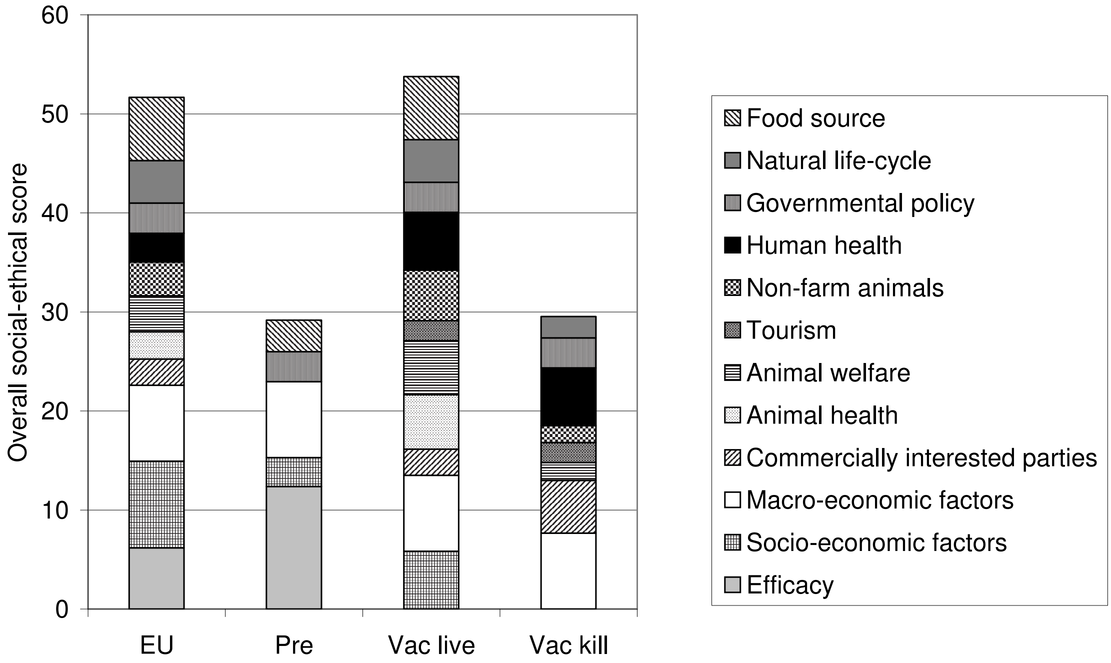

Figure D.3.2.3: Social-ethical indicator scores of each evaluated AI control alternative.

Combined overall weighting of the three main criteria

Standardized scores of all indicators are compared in pairs of the evaluated alternatives, resulting in so-called dominance scores. A positive score implies dominance of a strategy in relation to another while a negative value implies submission. A dominance measure of 0 implies indifference between the compared strategies. By weighting the dominance scores per criterion, overall dominance scores of the three main criteria are obtained.

Table D.3.2.4 demonstrates the dominance scores of the three main criteria as a result of paired comparisons of the 4 control alternatives. For instance, the third column in the upper half of the table, describes the results of the comparison between the EU strategy and the Vac_kill strategy. As reflected by the positive scores, the EU strategy dominates the Vacc_kill strategy on all the main criteria (viz. +8.04 on Epidemiology, +2.66 on Economics and +1.98 on Social-Ethics). The dominance scores based on the comparison of EU with Pre (first column) demonstrate that, regarding the economic and social ethical criteria (scores of +4.68 and +2.02), the EU strategy dominates the Pre strategy. However, the opposite is true for the epidemiological element (epidemiological dominance score = -0.43).

Table D.3.2.4: Criteria dominance scores of the paired comparisons of the evaluated AI control alternatives (e.g. EU/Pre = EU strategy compared to the Preventive culling strategy).

Criterion	EU/Pre	EU/V_live	EU/V_kill	Pre/EU	Pre/V_live	Pre/V_kill
Epidemiology	-0.43	-0.65	8.04	0.43	-0.22	8.47
Economics	4.68	1.81	2.66	-4.68	-2.87	-2.02
Social/Ethics	2.02	-0.19	1.98	-2.02	-2.21	-0.03
Total	6.27	0.97	12.69	-6.27	-5.29	6.42

Criterion	V_live/EU	V_live/Pre	V_live/V_kill	V_kill/EU	V_kill/Pre	V_kill/V_live
Epidemiology	0.65	0.22	8.69	-8.04	-8.47	-8.69
Economics	-1.81	2.87	0.85	-2.66	2.02	-0.85
Social/Ethics	0.19	2.21	2.17	-1.98	0.03	-2.17
Total	-0.97	5.29	11.71	-12.69	-6.42	-11.71

According to the total dominance scores the EU strategy is favoured over the other 3 control strategies; i.e. all total paired dominance scores are positive. The dominance difference with respect to the Vac_live strategy is, however, small (0.97). Vac_kill is completely dominated by the other strategies as reflected by its negative total dominance scores (Table D.3.2.4 and Figure D.3.2.4).

Figure D.3.2.4 illustrates the 'dominance course' of the evaluated alternatives. Concerning the three main criteria, a strategy dominates as long as the column representing the individual criterion score is situated above the zero-axes.

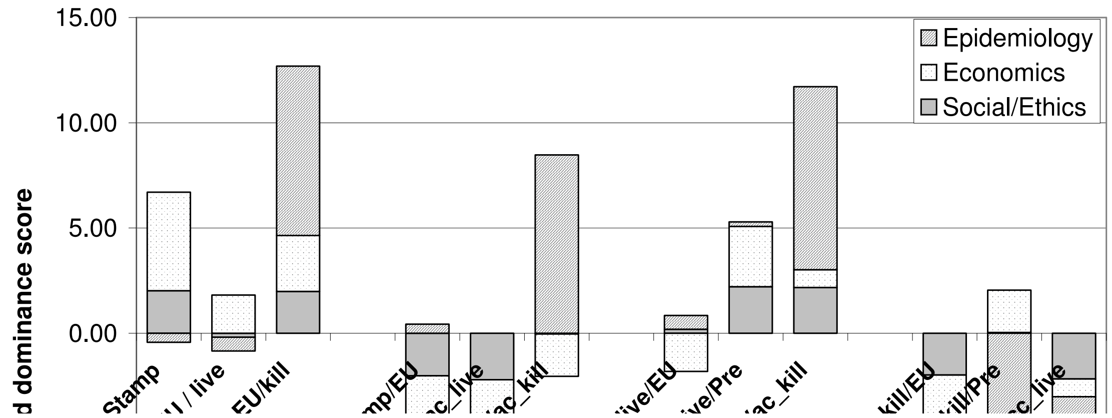

Figure D.3.2.4: Paired dominance scores of AI control alternatives per main criterion.

D.3.3 MCA results Region B, AI

- Scoring and weighting of epidemiological indicators

Table D.3.3.1 demonstrates the redirected, standardised and weighed scores of the epidemiological indicators per evaluated AI control strategy based on the member state characteristics of Region B. The higher the value, the 'better' the score in relation to the other alternatives (max score=100). The scores are derived from the epidemiological modelling results as described in Chapter 4.1.

Table D.3.3.1: Standardised and weighed scores of the epidemiological indicators per evaluated AI control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Duration epidemic	0.39	4.73	0.00	0.00
Number infected farms	0.00	4.92	1.97	1.97
Size affected region	0.00	0.63	0.06	0.06
Number destroyed animals	7.13	0.95	7.60	0.00
Number destroyed herds	7.84	1.05	8.36	0.00
Number destroyed non-farm animals	4.04	0.54	4.31	0.00
Overall criterion value	19.40	12.82	22.31	2.03

Summation of the indicator scores per control strategy results in the overall score of the criterion "Epidemiology". These overall scores demonstrate that – according to the average CVO-judgement on the various epidemiological indicators - the Vac_Live strategy (overall score 22.3) is evaluated to exceed the other alternatives. However, the differences in epidemiological scores are small compared to the EU control alternative. In terms of duration and number of infected farms, the Vac_kill strategy is just as effective as the Vac_live alternative. However, due to the fact that this strategy involves the slaughter of more animals (mainly vaccinated) than any other alternative, overall score of Vacc_kill is low (viz. 2.0).

Figure D.3.3.1 gives a graphical overview of the contribution of each indicator within the overall criterion score. Again, the bigger the part the better the strategy scores on this indicator compared to the other 3 control alternatives. No score for an indicator means that – off all the evaluated control alternatives – the examined alternative scores worst for that specific indicator. For instance, Vac_kill only scores on 2 of the 6 epidemiological indicators, meaning that for the other four indicators this strategy scores worst in comparison to the other alternatives.

- Scoring and weighting of economic indicators

Table D.3.3.2 demonstrates the standardised and weighed scores of the economic indicators per evaluated AI control strategy based on the member state characteristics of Region B. The economic scores are derived from the economic modelling results as described in 4.2.

Due to the lack of sufficient detailed information, it was not possible to score the specific indicator of '*consequential farm losses outside the affected region*'. The specific weight factor of this indicator equals 10.16. To account for the possible influence of this indicator, all alternatives within the analysis 'score' the average indicator value, which is equal to the indicator weight factor multiplied by ½ (viz. 10.16 x ½ = 5.08). As a consequence, overall criterion values may contain some variation, varying from 0 to a maximum of 5.08

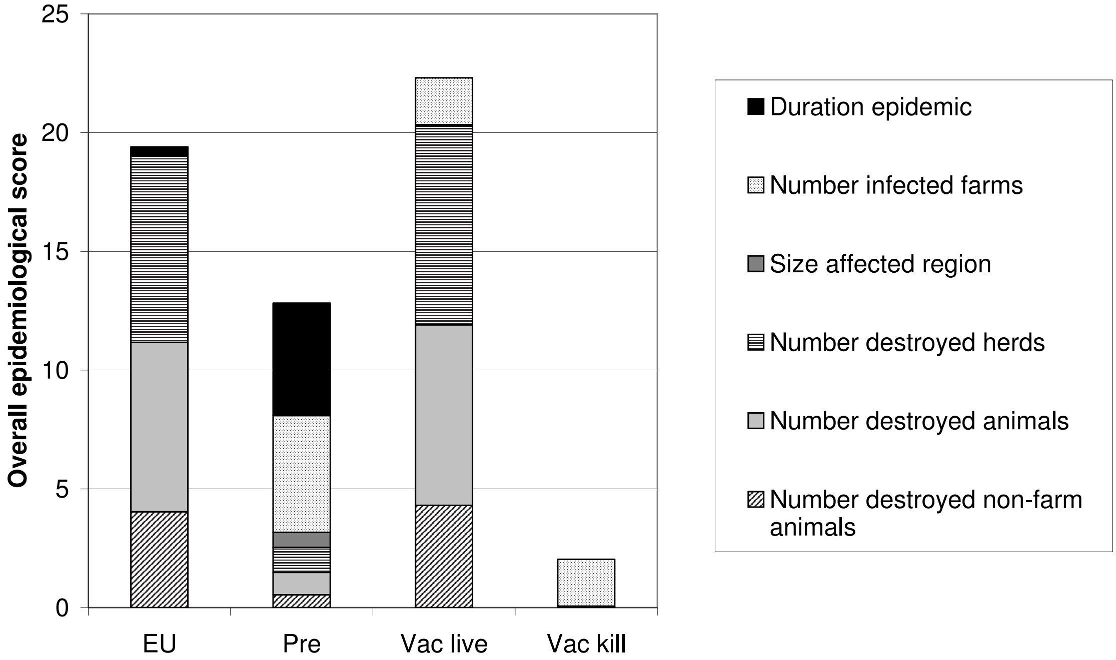

Figure D.3.3.1: Epidemiological indicator scores of each evaluated AI control alternative.

Furthermore, the 2 indicators *'export restriction EU markets'* and *'export restrictions non-EU markets'* are aggregated into one general *'export restriction'* indicator, with a weighting factor equal to the sum of the two individual indicators.

Table D.3.3.2: Standardised and weighed scores of the economic indicators per evaluated AI control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Direct farm losses	9.64	0.69	10.10	0.00
Cons farm losses in affected region	5.54	6.55	0.00	4.72
Cons farm losses outside affected region	5.08	5.08	5.08	5.08
Losses other participants	9.47	4.35	9.74	0.00
Losses non agricultural sectors	4.86	2.23	5.00	0.00
Organisation costs	1.30	0.00	1.03	1.03
Export restrictions	18.77	18.77	18.77	18.77
Tax payer:	2.47	0.00	2.48	0.20
Overall criterion value	57.13	37.66	52.20	29.80

Figure D.3.3.2 demonstrates the variation in scores per indicator and alternative. Due to the fact that – independent of the evaluated control strategy - there are no consequences due to export restrictions, all alternatives receive the maximum score for this indicator (i.e. 100% x indicator weight).

Based on the overall economic criterion value, the EU control strategy (score = 57.1 ± 5.1) is preferred above the other control alternatives. The Vac_kill strategy (score = 29.8 ± 5.1) is ranked as last (see Table D.3.3.2 and Figure D.3.3.2).

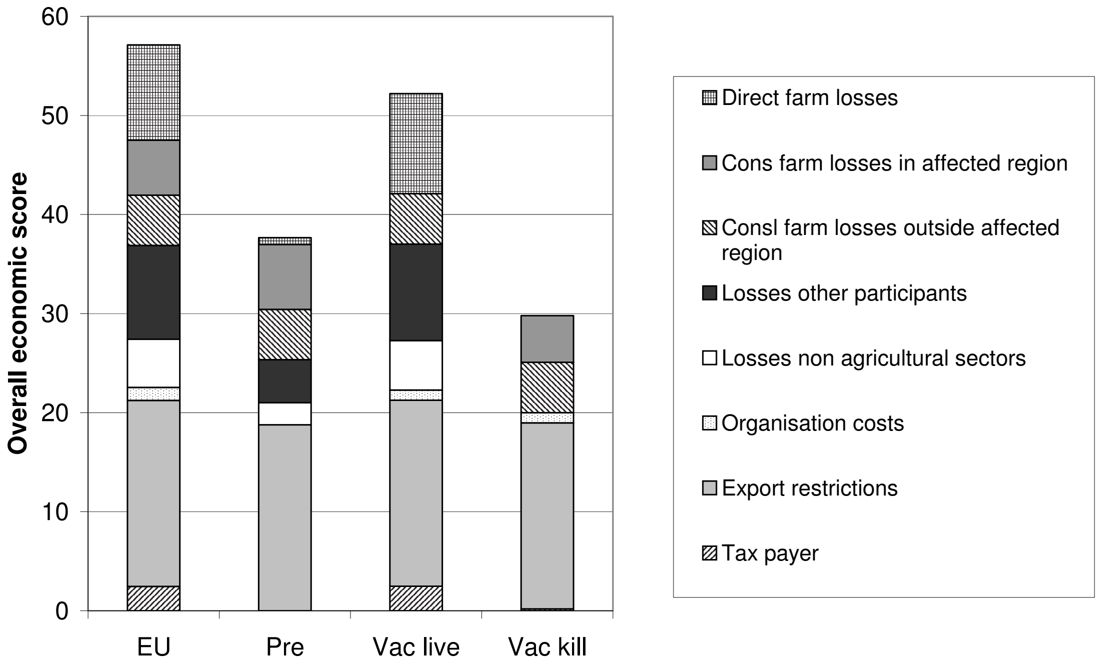

Figure D.3.3.2: Economic indicator scores of each evaluated AI control alternative.

Scoring and weighting of social-ethical indicators

Table D.3.3.3 demonstrates the standardised and weighed scores of the social-ethical indicators per evaluated AI control strategy based on the member state characteristics of Region B. The social-ethical scores are obtained by ranking the alternatives per criterion by its expected effectiveness. These effectiveness rankings are based on the insights obtained by the CVO questionnaires, personal interviews and model studies (Chapter 3 and 4.1 and 4.2).

Table D.3.3.3: Standardised and weighed scores of the social-ethical indicators per evaluated AI control strategy.

Indicator	Control strategy			
	EU	Pre	Vac live	Vac kill
Efficacy	0.00	12.37	6.19	6.19
Socio-economic factors	8.74	2.91	5.83	0.00
Macro-economic factors	7.66	7.66	7.66	7.66
Commercially interested parties	3.99	1.99	5.98	0.00
Animal health	2.75	0.00	5.49	0.00
Animal welfare	3.64	0.00	5.46	1.82
Tourism	2.02	1.01	3.03	0.00
Non-farm animals	3.40	0.00	5.11	1.70
Human health	2.91	0.00	5.82	5.82
Governmental policy	3.04	3.04	3.04	3.04
Natural life-cycle	4.30	0.00	4.30	2.15
Food source	6.37	3.19	6.37	0.00
Overall criterion value	48.83	32.18	64.28	28.38

Based on the overall social-ethical values (Table D.3.3.3) the Vac_Live strategy is evaluated as the best alternative to control an AI epidemic. Figure D.3.3.3 demonstrates the individual contribution of each indicator to the overall social-ethical value. Strategy Vac live contributes to all of the 12 indicators, strategies Pre and Vac_kill contribute only to 7 of the 12 indicators.

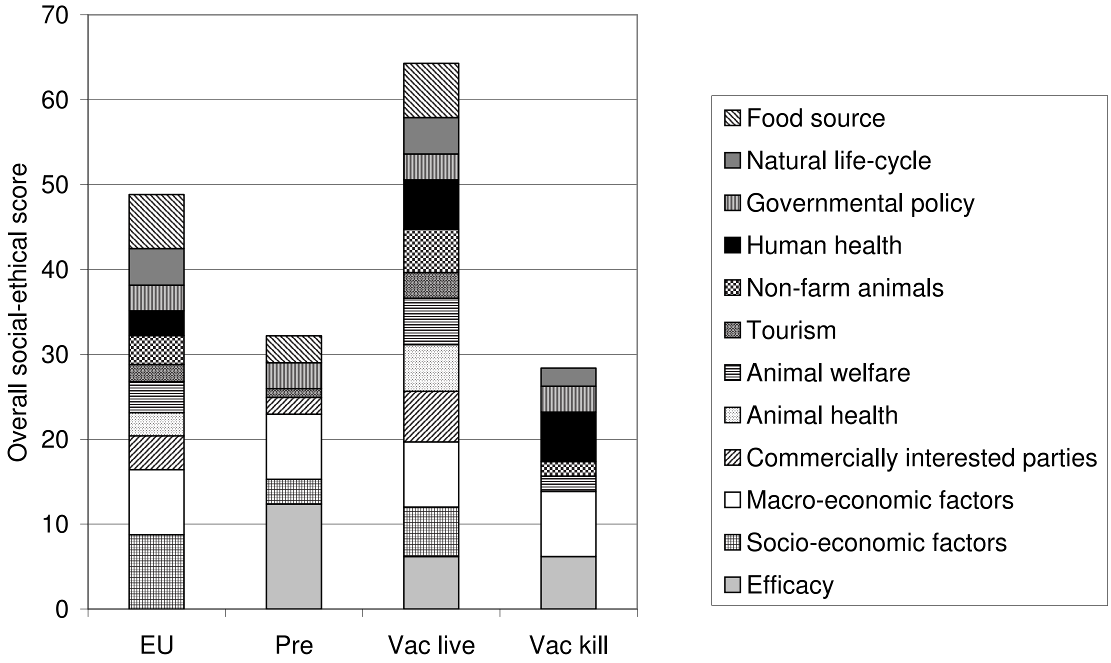

Figure D.3.3.3: Social-ethical indicator scores of each evaluated AI control alternative.

Combined overall weighting of the three main criteria

Standardized scores of all indicators are compared in pairs of the evaluated alternatives, resulting in so-called dominance scores. A positive score implies dominance of a strategy in relation to another while a negative value implies submission. A dominance measure of 0 implies indifference between the compared strategies. By weighting the dominance scores per criterion, overall dominance scores of the three main criteria are obtained.

Table D.3.3.4 demonstrates the dominance scores of the three main criteria as a result of paired comparisons of the 4 control alternatives. For instance, the first column in the upper half of the table, describes the results of the comparison between the EU strategy and the Pre strategy. As reflected by the positive scores, the EU strategy dominates the Pre strategy on all the main criteria (viz. +2.20 on Epidemiology, +3.03 on Economics and +1.15 on Social-Ethics). The dominance scores based on the comparison of EU with Vac_live (second column) demonstrate that, regarding the epidemiological and social ethical criteria (scores of –1.28 and –1.07), the EU strategy is dominated by the Vac_live strategy. However, the opposite is true for the economic element (economic dominance score = +0.74).

Table D.3.3.4: Criteria dominance scores of the paired comparisons of the evaluated AI control alternatives (e.g. EU/Pre = EU strategy compared to the Preventive culling strategy)

Criterion	EU/Pre	EU/V_live	EU/V_kill	Pre/EU	Pre/V_live	Pre/V_kill
Epidemiology	2.20	-1.28	6.83	-2.20	-3.48	4.62
Economics	3.03	0.74	4.20	-3.03	-2.30	1.16
Social/Ethics	1.15	-1.07	1.41	-1.15	-2.22	0.26
Total	6.39	-1.61	12.44	-6.39	-8.00	6.05

Criterion	V_live/EU	V_live/Pre	V_live/V_kill	V_kill/EU	V_kill/Pre	V_kill/V_live
Epidemiology	1.28	3.48	8.10	-6.83	-4.62	-8.10
Economics	-0.74	2.30	3.46	-4.20	-1.16	-3.46
Social/Ethics	1.07	2.22	2.48	-1.41	-0.26	-2.48
Total	1.61	8.00	14.05	-12.44	-6.05	-14.05

According to the total dominance scores the Vac_live strategy is favoured over the other 3 control strategies; i.e. all total paired dominance scores are positive. Vac_kill is completely dominated by the other strategies as reflected by its negative total dominance scores (Table D.3.3.4 and Figure D.3.3.4).

Figure D.3.3.4 illustrates the 'dominance course' of the evaluated alternatives. Concerning the three main criteria, a strategy dominates as long as the column representing the individual criterion score is situated above the zero-axes.

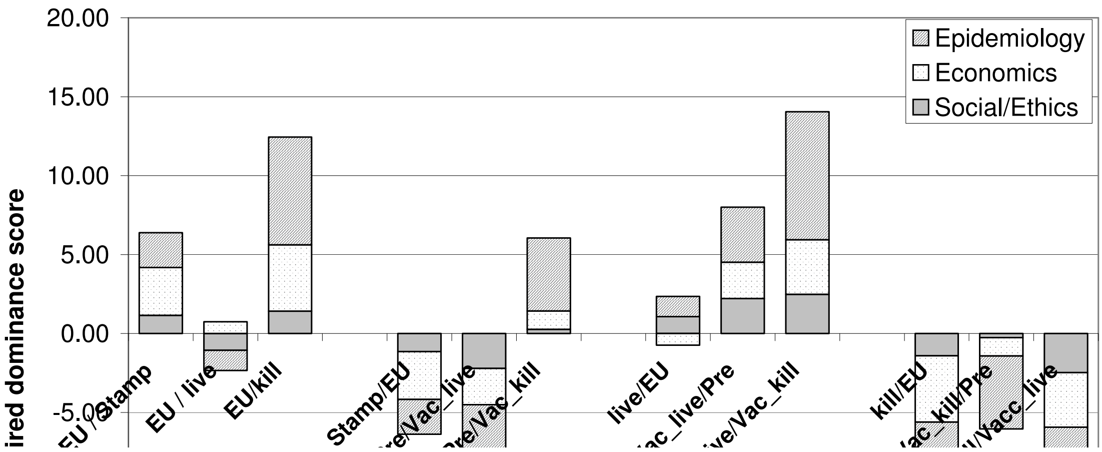

Figure D.3.3.4: Paired dominance scores of AI control alternatives per main criterion.

D.3.4 MCA results Region D, AI

- Scoring and weighting of epidemiological indicators

Table D.3.4.1 demonstrates the redirected, standardised and weighed scores of the epidemiological indicators per evaluated AI control strategy based on the member state characteristics of Region D. The higher the value, the 'better' the score in relation to the other alternatives (max score=100). The scores are derived from the epidemiological modelling results as described in Chapter 4.1.

Table D.3.4.1: Standardised and weighed scores of the epidemiological indicators per evaluated AI control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Duration epidemic	3.05	6.10	0.00	0.00
Number infected farms	0.00	5.68	3.79	3.79
Size affected region	0.00	1.26	0.39	0.39
Number destroyed animals	7.19	0.90	8.09	0.00
Number destroyed herds	7.91	0.99	8.90	0.00
Number destroyed non-farm animals	4.08	0.51	4.58	0.00
Overall criterion value	22.23	15.44	25.75	4.17

Summation of the indicator scores per control strategy results in the overall score of the criterion "Epidemiology". These overall scores demonstrate that – from an epidemiological point of view - the Vac_Live strategy (overall score 25.8) is evaluated to exceed the other alternatives. However, the differences in epidemiological scores are small compared to the EU control alternative.

In terms of duration and number of infected farms, the Vac_kill strategy is just as effective as the Vac_live alternative. However, due to the fact that this strategy involves the slaughter of more animals (mainly vaccinated) than any other alternative, overall score of Vacc_kill is low (viz. 4.2).

Figure D.3.4.1 gives a graphical overview of the contribution of each indicator within the overall criterion score. Again, the bigger the part the better the strategy scores on this indicator compared to the other 3 control alternatives. No score for an indicator means that – off all the evaluated control alternatives – the examined alternative scores worst for that specific indicator. For instance, Vac_kill only scores on 2 of the 6 epidemiological indicators, meaning that for the other four indicators this strategy scores worst in comparison to the other alternatives.

- Scoring and weighting of economic indicators

Table D.3.4.2 demonstrates the standardised and weighed scores of the economic indicators per evaluated AI control strategy based on the member state characteristics of Region D. The economic scores are derived from the economic modelling results as described in 4.2.

Due to the lack of sufficient detailed information, it was not possible to score the specific indicator of '*consequential farm losses outside the affected region*'. The specific weight factor of this indicator equals 10.16. To account for the possible influence of this indicator, all alternatives within the analysis 'score' the average indicator value, which is equal to the indicator weight factor multiplied by ½ (viz. 10.16 x ½ = 5.08). As a consequence, overall criterion values may contain some variation, varying from 0 to a maximum of 5.08

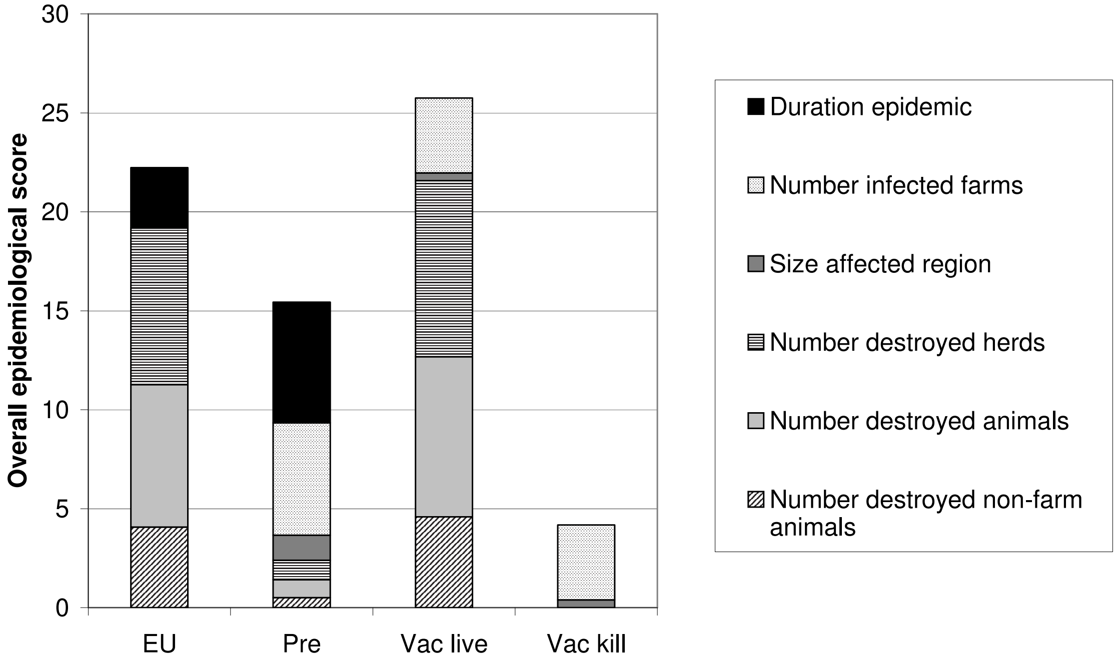

Figure D.3.4.1: Epidemiological indicator scores of each evaluated AI control alternative.

Furthermore, the 2 indicators *'export restriction EU markets'* and *'export restrictions non-EU markets'* are aggregated into one general *'export restriction'* indicator, with a weighting factor equal to the sum of the two individual indicators.

Table D.3.4.2: Standardised and weighed scores of the economic indicators per evaluated AI control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Direct farm losses	10.21	5.23	11.02	0.00
Cons farm losses in affected region	6.83	7.59	0.00	5.45
Cons farm losses outside affected region	5.08	5.08	5.08	5.08
Losses other participants	4.35	10.81	3.79	13.09
Losses non agricultural sectors	2.23	5.73	1.94	6.72
Organisation costs	4.77	0.00	2.87	2.87
Export restrictions	18.77	18.77	18.77	18.77
Tax payer:	4.27	1.89	4.45	0.00
Overall criterion value	56.51	55.09	47.92	51.97

Figure D.3.4.2 demonstrates the variation in scores per indicator and alternative. Due to the fact that – independent of the evaluated control strategy - there are no consequences due to export restrictions, all alternatives receive the maximum score for this indicator (i.e. 100% x indicator weight).

Based on the overall economic criterion value, the EU control strategy (score = 56.5 ± 5.1) is preferred above the other control alternatives. However, the differences in Economic scores are rather small as expressed by the very small range in overall criterion values (viz. [47.9 , 56.5] The Vac_live strategy (score = 47.92 ± 5.1) is ranked as last (see Table D.3.4.2 and Figure D.3.4.2).

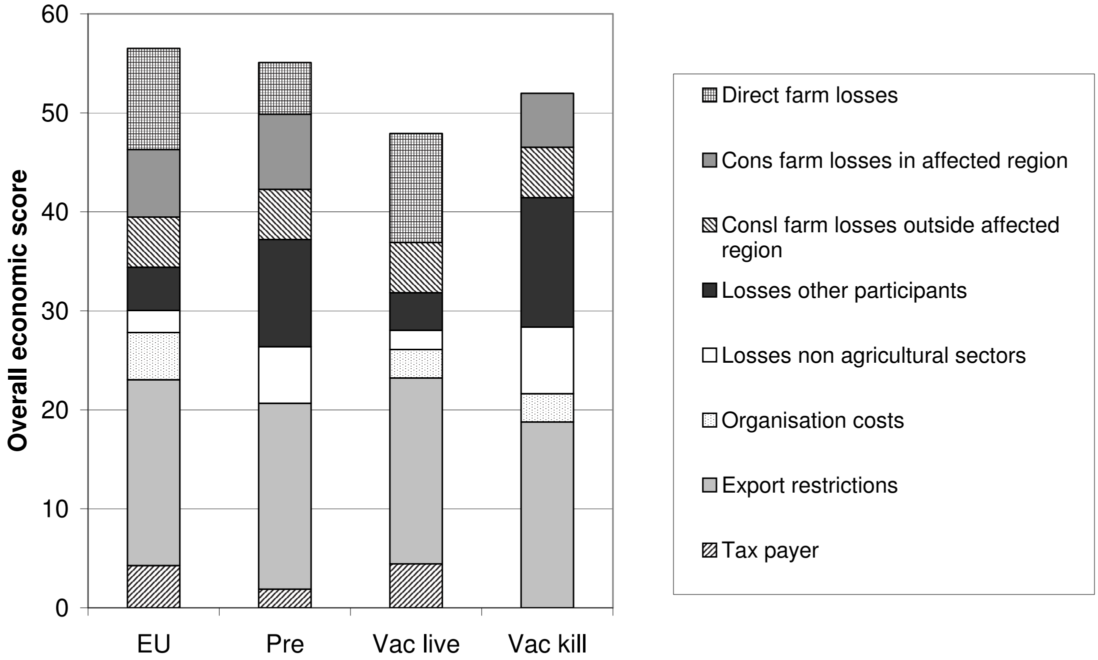

Figure D.3.4.2: Economic indicator scores of each evaluated AI control alternative.

Scoring and weighting of social-ethical indicators

Table D.3.4.3 demonstrates the standardised and weighed scores of the social-ethical indicators per evaluated AI control strategy based on the member state characteristics of Region D. The social-ethical scores are obtained by ranking the alternatives per criterion by its expected effectiveness. These effectiveness rankings are based on the insights obtained by the CVO questionnaires, personal interviews and model studies (Chapter 3 and 4.1 and 4.2).

Table D.3.4.3: Standardised and weighed scores of the social-ethical indicators per evaluated AI control strategy.

Indicator	**Control strategy**			
	EU	**Pre**	**Vac live**	**Vac kill**
Efficacy	6.19	12.37	0.00	0.00
Socio-economic factors	8.74	2.91	5.83	0.00
Macro-economic factors	7.66	7.66	7.66	7.66
Commercially interested parties	1.99	3.99	0.00	5.98
Animal health	2.75	0.00	5.49	0.00
Animal welfare	3.64	0.00	5.46	1.82
Tourism	1.01	2.02	0.00	3.03
Non-farm animals	3.40	0.00	5.11	1.70
Human health	2.91	0.00	5.82	5.82
Governmental policy	3.04	3.04	3.04	3.04
Natural life-cycle	4.30	0.00	4.30	2.15
Food source	6.37	3.19	6.37	0.00
Overall criterion value	52.01	35.19	49.08	31.21

Based on the overall social-ethical values (Table D.3.4.3) the EU strategy is evaluated as the best alternative to control an AI epidemic. Figure D.3.4.3 demonstrates the individual contribution of each indicator to the overall social-ethical value. Strategy Pre contributes to all of the 12 indicators, strategy Pre contributes only to 7 of the 12 indicators.

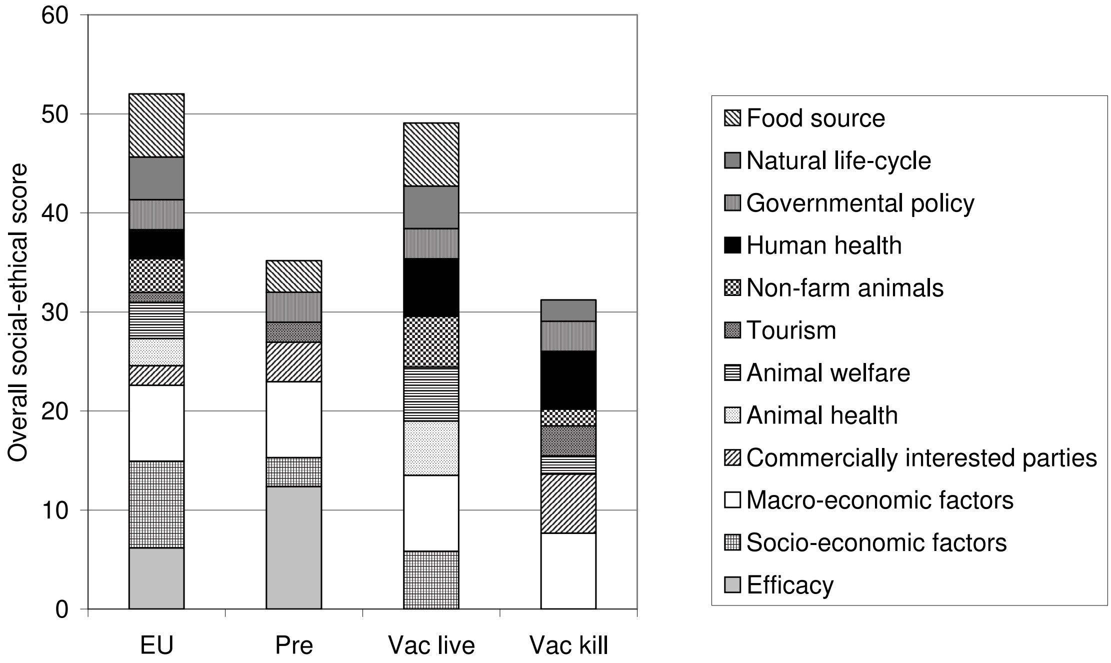

Figure D.3.4.3: Overall social-ethical indicator scores of each evaluated AI control alternative.

Combined overall weighting of the three main criteria

Standardized scores of all indicators are compared in pairs of the evaluated alternatives, resulting in so-called dominance scores. A positive score implies dominance of a strategy in relation to another while a negative value implies submission. A dominance measure of 0 implies indifference between the compared strategies. By weighting the dominance scores per criterion, overall dominance scores of the three main criteria are obtained.

Table D.3.4.4 demonstrates the dominance scores of the three main criteria as a result of paired comparisons of the 4 control alternatives. For instance, the first column in the upper half of the table, describes the results of the comparison between the EU strategy and the Pre strategy. As reflected by the positive scores, the EU strategy dominates the Pre strategy on all the main criteria (viz. +4.02 on Epidemiology, +1.21 on Economics and +1.90 on Social-Ethics). The dominance scores based on the comparison of Pre with Vac_live (fifth column) demonstrate that, regarding the epidemiological and social ethical criteria (scores of –6.82 and –1.57), the Pre strategy is dominated by the Vac_live strategy. However, the opposite is true for the economic element (economic dominance score = +3.22).

Table 3.4.4: Criteria dominance scores of the paired comparisons of the evaluated AI control alternatives (e.g. EU/Pre = EU strategy compared to the Preventive culling strategy).

Criterion	EU/Pre	EU/V_live	EU/V_kill	Pre/EU	Pre/V_live	Pre/V_kill
Epidemiology	4.02	-2.80	12.52	-4.02	-6.82	8.50
Economics	1.21	4.43	2.81	-1.21	3.22	1.60
Social/Ethics	1.90	0.33	2.34	-1.90	-1.57	0.45
Total	7.13	1.96	17.68	-7.13	-5.17	10.55

Criterion	V_live/EU	V_live/Pre	V_live/V_kill	V_kill/EU	V_kill/Pre	V_kill/V_live
Epidemiology	2.80	6.82	15.33	-12.52	-8.50	-15.33
Economics	-4.43	-3.22	-1.62	-2.81	-1.60	1.62
Social/Ethics	-0.33	1.57	2.01	-2.34	-0.45	-2.01
Total	-1.96	5.17	15.72	-17.68	-10.55	-15.72

According to the total dominance scores the EU strategy is favoured over the other 3 control strategies; i.e. all total paired dominance scores are positive. Vac_kill is completely dominated by the other strategies as reflected by its negative total dominance scores (Table D.3.4.4 and Figure D.3.4.4).

Figure D.3.4.4 illustrates the ‘dominance course’ of the evaluated alternatives. Concerning the three main criteria, a strategy dominates as long as the column representing the individual criterion score is situated above the zero-axes.

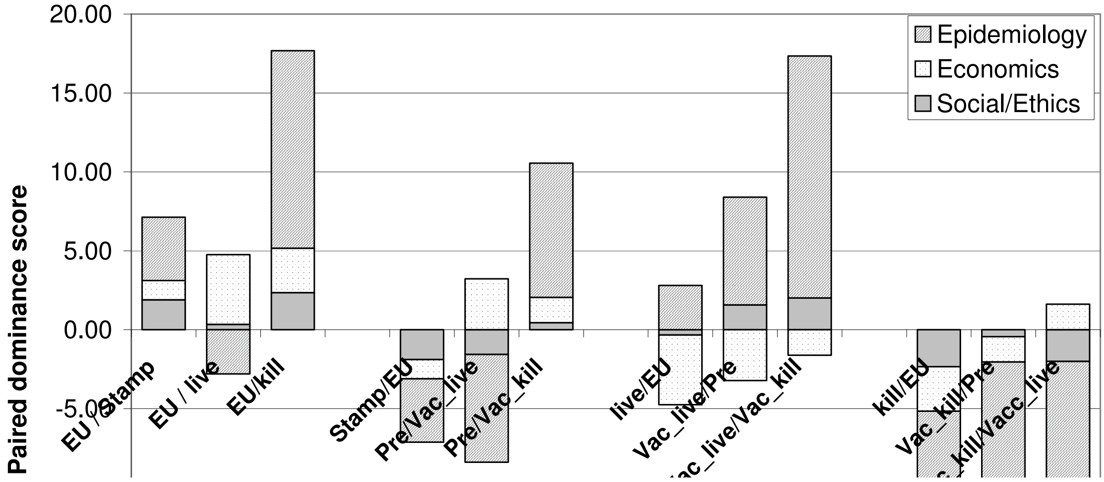

Figure D.3.4.4: Paired dominance scores of AI control alternatives per main criterion.