Economic incentives for disease prevention in danish pig and cattle herds

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Publication date:
2012

Document version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
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(FOI Udredning)
2012 / 17
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Prepared for the Danish Veterinary and Food Administration (DVFA) as part of the agreement on public sector services between the Institute of Food and Resource Economics and the Ministry of Food, Agriculture and Fisheries.

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Preface

Based on EU’s Animal Health Strategy 2007 – 2013 the Danish Veterinary and Food Administration (DVFA) have asked University of Copenhagen to analyze different incentive models for implementing disease preventive efforts in the animal production. Among other things, DVFA wants investigated which incentives will promote disease preventive measures at the herd level. This include both models that have positive effects on the production economy and other models that provide other benefits to the livestock keeper such as compensation for economic losses for movement stand still zones in case of outbreak of an contagious animal disease.

The report is written by Senior Researcher Mogens Lund, Professor Jens Leth Hougaard and PhD student Juliet Biira from the Institute of Food and Resource Economics and Professor Hans Houe, Department of Large Animal Sciences.

Mogens Lund
Institute of Food and Resource Economics
Copenhagen, December 2012
1. Danish summary and recommendations


På den baggrund er formålet med nærværende rapport at undersøge de økonomiske incitamenter til smittebeskyttelse på besætningsniveau med henblik på at sikre en fair og efficient deling af ansvaret og omkostningerne ved risikostyring og overvågning af husdyrsygdomme, som angivet i EU’s dyresundhedsstrategi.

Rapporten giver et overblik over biosecurity begrebet og beskriver de generelle mekanismer bag økonomiske incitamenter. Mere specifikt belyses følgende spørgsmål i rapporten:

1. Hvad er de eksisterende incitamenter og barrierer til smittebeskyttelse blandt især svine- og kvægproducenter?
2. Hvad er de eksisterende kompensationsregler og finansieringsskilder ved udbrud af smitsomme husdyrsygdomme og hvordan ser de ud i forhold til andre lande?
3. Hvad er mulighederne for at give husdyrproducenter bedre incitamenter til smittebeskyttelse?

Fokus er på alvorligt smitsomme sygdomme i kvæg- og svinebesætninger, dvs. sygdomme som har alvorlige konsekvenser for både sundhedstilstanden og produktionen samt det øvrige samfund (sygdomme som er kategoriseret som Liste 1 sygdomme af de danske veterinære myndigheder). Disse sygdomme, som bl.a. omfatter bl.a. mund- og klovsyge, Bluetongue og klassisk svinepest, har alle potentiale til at medføre omfattende økonomiske tab i tilfælde af et udbrud.

Rapportens analytiske del omfatter kapitel 3 til 6, hvor det undersøges, hvordan såvel de direkte som de indirekte økonomiske incitamenter kan ændres med henblik på at
give landmænd bedre økonomiske incitamenter til øget smittebeskyttelse i deres besætninger. De gennemførte analyser er overvejende baseret på kvalitative beskrivelser, vurderinger og evalueringer.

Kapitel 3 indeholder en forholdsvis detaljeret beskrivelse af principperne for smittespredning og specifikke sygdomsforebyggende aktiviteter i svine- og kvægbesætninger. Hovedpointerne er her at:

- indkøb og andre flytninger af dyr mellem besætninger bør minimeres
- dyr bør købes fra besætninger med højere sundhedsstatus
- dyr som flyttes fra en fremmed besætning til en anden bør i karantæne
- dobbelt hegn bør tages i anvendelse ved afgræsning af dyr
- skilte med “Adgang forbudt” bør sættes op
- alle instrumenter og udstyr bør så vidt muligt være tilgængelige på ejendommen, således at der ikke er behov for at flytte disse rundt mellem flere besætninger
- køretøjer til dyretransport og desse chauffører bør ikke komme i direkte kontakt med besætningen
- dyr bør så vidt muligt opdrættes i hold ved brug af alt-ind – alt-ud produktionsystemer
- sammenblanding af unge og gamle dyr bør undgås
- der bør være etableret skadedyrskærestemperatur
- det er ikke muligt præcist at sige, hvornår et bestemt antal smitteforebyggende foranstaltninger er tilstrækkelige til at sikre mod overførsel af husdyrsygdomme og hvornår det er “overkill”

I kapitel 4 er den økonomiske betydning af og sammenhængene mellem private og offentlige incitamenter til smittebeskyttelse i kvæg- og svineproduktionen analyseret. Hovedpointerne er her at:

- landmænds private incitamenter kan føre til for få investeringer i smittebeskyttelse
- for at fremme den sygdomsforebyggende adfærd blandt producenter er det nødvendigt at lave en risikoklassificering af bedrifter med husdyr
- denne risikoklassificering bør baseres på simple og gennemsigtige mål for risikofaktorer
• en selvisiko bør indgå i et system for omkostningsdeling for at reducere mulighederne for uhensigtsmæssig adfærd blandt husdyrproducenter
• landmænds økonomiske bidrag til en omkostningsdeling bør baseres på en kombination af ex-ante og ex-post betalinger i forhold til et sygdomsudbrud
• landmænd bør ikke modtage økonomisk kompensation for syge eller døde dyr, men kun modtage kompensation for de raske dyr, som skal nedslagtes, for at sikre de økonomiske incitamenter til en hurtig anmeldelse af et potentielt udbrud
• landmænd, som påvirkes negativt af beskyttelses- og overvågningszoner i tilfælde af et alvorligt sygdomsudbrud, bør økonomisk kompenseres, men kompensationen skal ikke overstige minimum af produktionsomkostningerne og markedsprisen
• en forsikringsordning med medfinansiering fra det offentliges side bør base-res på tvungen deltagelse af alle relevante husdyrproducenter
• som følge af den lave eller sjældne forekomst af visse sygdomme, kan den enkelte landmand undervurdere risikoen for at blive ramt af en alvorlig husdyrsygdom og derfor reducere hans forebyggende indsats

I kapitel 5 er de eksisterende danske erstatningsregler og finansieringsinstrumenter, som anvendes i tilfælde af udbrud af en alvorlig smitsom husdyrsygdom, undersøgt og sammenlignet med de tilsvarende ordninger i Holland og Tyskland. Hovedpointerne er her at:

• lovpligtige veterinære fonde er etableret i både Holland og Tyskland, men ikke i Danmark
• de hollandske kompensationsregler ikke giver erstatning for døde dyr som følge af en epidemiisk sygdom for at give landmænd incitament til tidlig anmeldelse af en sygdomsmistanke
• incitamenterne for producenterne og det offentlige skifter i det hollandske system, når det aftalte loft for økonomisk kompensation er nået. Når dette loft overskrides, har producenterne intet finansielt medansvar for dækning af de direkte omkostninger til bekæmpelse af et alvorligt sygdomsudbrud
• i Tyskland er der en fond for dyresygdomme i hver forbundsstat, hvilket gør det muligt at tage hensyn til regionale forskelle med hensyn til fx bedriftsstruktur og i de epidemiiske risici mellem regioner
• i Tyskland er der flere erfaringer med risikojusteret kompensation og med økonomisk medfinansiering fra landmændenes side end i Danmark
I kapitel 6 er nogle strategiske muligheder for forbedringer i de sygdomsforebyggende foranstaltninger på bedrifts- og besætningsniveau ved brug af økonomiske incitamenter diskuteret. Hovedpointerne er her at:

- et system til omkostningsdeling bør bygge på et hensigtsmæssigt smittebeskyttelsesindeks defineret på bedrifts- eller besætningsniveau
- smittebeskyttelsesindekset bør være afgrænset til dyresundheds- og tilhørende produktionsaspekter og ikke omfatte fx dyrevelfærd
- det er afgørende, at der er en entydig korrelation mellem landmændens forebyggende indsats og indeksværdien, og at de variable, som indgår i indekset, kan måles på en objektiv måde
- det bør overvejes at offentliggøre smittebeskyttelsesindekset for at opnå de største incitament-fremmende effekter
- den konkrete konstruktion af et sådant indeks og alle de heraf afledede konsekvenser bør forskningsmæssigt undersøges og politisk afklares inden det tages i brug
- de afgørende elementer, som har indflydelse på infektionsrisikoen og organiseringen af beskyttelses- og overvågningszoner i tilfælde af et alvorligt sygdomsudbrud, bør næremere analyseres


Svaret på det andet spørgsmål om, hvad de eksisterende kompensationsregler og finansieringskilder er ved udbrud af smitsomme husdyrsygdomme og hvordan ser de ud i forhold til andre lande er, at vi i Danmark ikke har en selvstændig veterinær fond i modsætning til en række andre af de lande, som vi normalt sammenligner os med.
Derfor anbefales det, at det overvejes at etablere en eller flere sådanne fonde for at skabe en yderligere mekanisme til at etablere en stærkere sammenhæng mellem landmænds tiltag til forbedring af smittebeskyttelsen og deres bidrag til finansiering af relevante initiativer i både freds- og fredstid, dvs. i perioder uden sygdoms mistanker og udbredt af alvorlige husdyrsværgdomme og i perioder med alvorlige udbredt. I den forbindelse vil det være naturligt at undersøge, hvilke rolle de nuværende produktionsafgiftsfonde i landbruget kan spille.

Det tredje hovedspørgsmål i rapporten vedrører mulighederne for at give husdyrproducenter bedre incitamenter til smittebeskyttelse. Her er svaret, at selvom der ikke eksisterer tilstrækkelige private incitamenter til at sikre en samfundsmæssig optimal smittebeskyttelse, er der alligevel flere muligheder for at give husdyrproducenter bedre økonomiske incitamenter til at undgå dyresygdomme. Sammenhængen mellem den store variation i niveauet for biosecurity hos husdyrproducenter, som beskrevet i afsnit 3.4, og de forskellige typer af effektiv forebyggelse, som beskrevet i afsnit 4.3, indeholder nøglen til at se disse muligheder. I afsnit 4.3 blev det vist, hvordan en effektiv forebyggelse både kan baseres på kontrol og sanktioner; læring og informationsdeling; og udvikling af nye innovative tiltag.

Derfor er det anbefalet, at den eksisterende lovgivning og de fastsatte regler bliver bedre kontrolleret og sikret overholdt. Det giver for eksempel forkerte signaler til landmænd, når der på den ene side er et juridisk krav om at lave en smittebeskyttelsesplan på større landbrug med kvæg og svin, men dette krav på den anden side ikke bliver håndhævet (se nærmere herom i afsnit 3.4).

Det anbefales endvidere, at “best practice” med hensyn til smittebeskyttelse blandt husdyrproducenter identificeres og dokumenteres, og at denne viden videreformidles til alle landmænd med husdyr. Benchmarking er allerede et udbredt værktøj i rådgivningstjenesten til at motivere beslutningstagere til at gennemføre forandringer i deres produktion.

Endelig anbefales det, at de praktiske udviklingsaktiviteter forstærkes med hensyn til smittebeskyttelse ved at give finansiel støtte, fx gennem produktionsafgiftsfondene og Grønt Udviklings- og Demonstrationsprogram GUDP, til gennemførelse af tværfaglige innovationsprojekter. Det bygger på en forventning om, at en større deltagelse af husdyrproducenter i udviklingen af nye tiltag inden for sygdomsforebyggelse både vil
give mere praktisk brugbare løsninger og give landmændene incitament til at tage større ansvar for smittebeskyttelsen af deres dyr.
2. Introduction

Questions concerning the responsibility for prevention and control of contagious animal diseases and how and who should finance the indemnities in case of an epidemic animal disease outbreak have been discussed for a long period of time between farmers and their associations on the one hand and different public authorities on the other. The reason is that both the agricultural sector and the society at large have high interests in avoiding contagious animal diseases which may jeopardize farmers’ income, public health, export of agricultural products, consumer confidence and employment opportunities.

For more than 100 years there has been a Danish national legislation which has provided laws and rules for control and eradication of animal diseases with high socio-economic costs. The regulation has included rules for culling of infected herds and how the affected farmers should be compensated for the loss of animals and related income.

The launch of EU’s new Animal Health Strategy 2007 – 2013 has revived the debate about how to share the responsibilities and costs with respect to the prevention and control of animal diseases between animal keepers, the public sector and other stakeholders. The overall principle in the strategy is that “prevention is better than cure”. This means a change in policy focus from control of disease outbreaks to risk management prevention and surveillance. In the report, we look at the economic incentives for a fair and efficient sharing of these responsibilities and costs.

2.1. Objectives

The report addresses the following questions:

1. What are the existing economic incentives and barriers for animal disease prevention, especially for pig and cattle farmers?
2. What are the current compensation and risk financing schemes for infectious disease outbreaks in Denmark and how does it compare to schemes in other countries?
3. What are the opportunities for providing livestock farmers with improved incentives to prevent animal diseases?
The focus of this report is on highly infectious cattle and pig diseases (categorized as List 1 diseases by the Danish Veterinary and Food Authorities). These diseases include, for example, Foot and Mouth Disease (FMD), Bluetongue, and Classical Swine Fever (CSF) and they have the potential to cause widespread economic losses. The protection of animal health is very complex as it covers many interrelated areas such as disease management, biosecurity, animal welfare, legislative and regulatory issues, trade of animals and animal products and even the risks of bioterrorism. Therefore, a large number of relevant issues related to the management of animal disease risks are not explicitly addressed in the report including subjects such as the use of medicine and antibiotics, animal welfare issues (although some indirectly effects of diseases on animal welfare may be addressed), zoonotic foodborne diseases such as salmonella and campylobacter and special animal health issues e.g. on hobby farms and niche productions.

Parallel with writing this report, the Danish Veterinary Contingency Planning is under scrutiny and the changes decided may affect farmers’ and other stakeholders’ incentives for disease prevention and control. This is especially true when it comes to farmers’ early recognition of a disease outbreak and the commercial and economic consequences associated with the establishment of movement and marketing restrictions in case of a serious disease outbreak.

2.2. Stakeholders in the animal health system

Animal health is a concern not only for animal keepers but for all citizens in the society. This concern stems not only from the public health and food safety aspects of animal health, but also from the economic costs that an animal disease outbreak can trigger and the animal welfare considerations, including the implication for disease control, (European Commission, 2007).

Partnerships with all interested parties concerned with animal health are the new approach adopted by EU and its member states. Thus, producers, consumers and other stakeholders are expected to play a role in the improvement of animal health and welfare. EU’s new Animal Health Strategy 2007 – 2013 should be built on trust, openness and willingness to take difficult decisions, but also the willingness to share the responsibilities and costs associated with high animal health standards.
One way of mapping the stakeholders at different levels involved in animal health is shown in Figure 2.1.

Overall, in order to improve farmers’ incentives for disease prevention and increase the sharing of responsibility and costs, farmers need to work together with other supply chain partners, e.g. slaughterhouses, feeding companies and vets; industry associations, e.g. the Danish Agricultural and Food Council, and public authorities, e.g. the Danish Veterinary and Food Administration. However, public authorities also include many international public and semi-public organizations such as the European Union, The World Trade Organization and The World Organization for Animal Health.

The Danish Agricultural & Food Council (DAFC) is an umbrella organization representing Danish farmers and the Danish food industry. Its major objectives are to influence political decisions to benefit farmers and the food industry and to provide good and efficient services to all its members. DAFC collaborates with the Danish veterinary authorities (see below) on making rules and regulations concerning animal health and welfare. To ensure compliance with this regulation, DAFC also participates in advisory activities, campaigns and in the education of farmers and other employees in the agricultural (and food) industry. While most agricultural advisers are employed by industry, this is not the general case for veterinarians. Typically, veterinarians, who provide health management services to individual livestock holders, are operating as private actors in the supply chain.

**Figure 2.1. Stakeholders in the animal health system**
The Danish Veterinary and Food Administration (DVFA) is a public authority responsible for food safety and health in the agricultural (and food) supply chain. In the field of animal health DVFA aims at adapting the legal framework for disease prevention and control to minimize the risks of introduction and spread of animal diseases in Denmark. Livestock registration, disease surveillance, disease notification, quarantines, health advisory agreements and biosecurity plans are some of the measures adopted. Furthermore, inspection and control are done at several levels including on farm inspections, border control of imported animals and animal products and the control of B2B trade and transportation of animals.

DVFA also has the responsibility for the contingency planning to ensure a rapid and effective response to any suspicious and actual outbreaks of an infectious animal disease. The Danish contingency planning consists of four parts: A preventive preparedness concerning disease prevention at different levels; surveillance to ensure early notification of diseases; an operational preparedness for a timely and efficient management of a disease outbreak; and the laboratorial preparedness to ensure a quick and reliable diagnostic and testing capability. The different contingency activities can be categorized to those performed in peace time, i.e. when there are no suspicions or outbreaks; those that are initiated during the period of a suspicion; and the activities during the time of an infectious disease outbreak, DVFA (2012).

The European Union (EU) is an example of an international public stakeholder participating in the risk management of animal health. In the EU, the European Commission, the EU Parliament, the European Centre for Disease Prevention and Control, the European Food Safety Authority and the European Medicines Agency are some of the organizational bodies involved in animal health issues.

The World Organization for Animal Health (OIE) is another intergovernmental organization responsible for improving animal health and welfare worldwide. OIE sets up – independently or together with e.g. Codex Alimentarius in FAO - international standards, recommendations and guidelines when it comes to legislation, organization, resources, capacities and the role of the public and private sector in the protection of all animals kept on a commercial as well as a non-commercial basis.

The World Trade Organization (WTO) is also involved in the protection against animal diseases through e.g. the international agreement on the application of sanitary and phytosanitary measures (the SPS Agreement).
2.3. **Organization of the report**

The organization of the remainder of the report is illustrated in Figure 2.2. The overall aim of all chapters 3-6 is to investigate how the existing direct as well as indirect economic incentives might be modified in order to provide livestock farmers with additional incentives for improved disease prevention in accordance with the policy objectives stated in EU’s Animal Health Strategy.

**Figure 2.2. Organization of the report**

Although all stakeholders as mentioned in section 2.2 are involved in the risk management of animal health, it is explicitly stated in the EU strategy that the main responsibility for animal health at farm level lies primarily with the farmers and collectively with the industry. This means that the farmers and the industry are in a better position to reduce animal health risks than for example the government according to the strategy, (European Commission, 2007).

Improved disease prevention by the individual farmer should manifest itself in the adoption of new biosecurity activities at the herd level. It is the reason why the biose-
curity principles, plans and specific activities in pig and cattle herds are analyzed rather detailed in the following chapter.

Furthermore, it is assumed that the level of biosecurity at the herd level can be affected by direct as well as indirect economic incentives. The direct economic incentives seen from both a private and public perspective are explained in chapter 4. This chapter also explains the existence of indirect economic incentives as a result of compensation and financing schemes applied in case of specific animal disease outbreaks. Thus, the design of compensation and cost-sharing rules provide indirect incentives to farmers to ensure and enhance their biosecurity. Therefore, different compensation and cost-sharing schemes are compared and discussed in chapter 5.

Chapters 3, 4 and 5 provide together with EU’s Animal Health Strategy the inputs to identify some strategic options for improvements in the on-farm biosecurity by use of economic incentives. The strategic options are identified and discussed in chapter 6. A realization of these options requires further research and development as well as political agreements between stakeholders in the animal health system. Therefore, these options can only be realized in the long run.

The content of these four chapters are mainly based on qualitative descriptions, assessments and evaluations. The main reason is that to our knowledge there are no comprehensive quantitative economic analyses of the costs and benefits of introducing new biosecurity measures at the farm level available. More quantitative knowledge seems to be available with respect to farmers’ behavioral responses to biosecurity. Some of this knowledge is cited in the report.

Chapter 7 contains an English summary with recommendations while the Danish summery, including the recommendations, is provided in chapter 1 of the report.
3. Biosecurity in pig and cattle herds

Biosecurity is here defined as all preventive principles, plans and specific activities (measures) that will reduce the risk of transmission of infectious diseases. The purpose of this chapter is to show that although some elements of biosecurity such as weather and geographic location are not easy to change, a considerable number of elements are directly related to the decisions and behaviour by the farmer. Furthermore, it is the purpose to give a brief background of transmission routes of infections which will provide an understanding for the long list of activities related to biosecurity. The long list of relevant biosecurity activities is a very direct reason that farmers needs considerable motivation to instigate these activities as they are time consuming, often expensive and sometimes in direct conflict with other interests of the farmer such as going to animal shows.

First, a description of possible sources of infections and routes of transmission is given. This basic understanding is followed by an outline of the possible specific activities that will reduce the risk of transmission. These activities can be seen at the international, national, sector and at the herd level. In parallel with the outline of biosecurity activities some general recommendations are given. To get an impression of which biosecurity activities have been prioritised, a brief description and examples of the current legislation are given. Finally the chapter ends with examples of surveys of farmers’ behaviour in relation to biosecurity. The latter in order to illustrate that there is considerable room for improvement.

It can be discussed whether vaccination is a preventive biosecurity measure or rather a part of a control program for an existing disease. In any case, as vaccination can help reducing the spread of infection it will briefly touched upon.

3.1. Transmission of infections

Transmission of infections can usually be seen as a continuum of excretions of agents (pathogens such as bacteria and virus) from infectious animals, followed by different modes of transmission of the agents to susceptible animals, which then becomes new infectious animals. Infectious animals are defined as animals shedding the disease agent.
The infectious animal (or host origin) can be divided into diseased animals or carriers. From a biosecurity point of view, it is an advantage that the infectious animals are diseased as they will be discovered and therefore tested for the particular pathogen (depending on how specific the clinical signs are). The so-called carrier animals, on the other hand, are clinically normal and may therefore go unnoticed in the population for long periods of time.

The infectious animal can be either transiently infected or to various degrees persistently infected, which has huge impact on the epidemiological importance. In particular, the combination of a carrier being persistently infected has immense impact on transmission.

The transmission of agents from one animal to another is typically divided into horizontal transmission vs. vertical transmission and direct vs. indirect transmission. The definitions may vary slightly in the literature, but here the definitions given by Toma et al. (1999) are used. Horizontal transmission is defined as “transmission of a pathogen from an individual hosting the agent to another individual, independent of the parental relationship of those animals”, whereas vertical transmission is defined as “transmission from a parent to a descendant, based on reproduction”. The distinction is thus in particular important for pathogens that are known to be able to transmit via e.g. placenta, embryos and semen.

Direct transmission is defined as “passage of a pathogen from one individual to another by close physical contact/proximity between individuals or by common use of an enclosed airspace”. This can occur e.g. when animals are touching, scratching, licking or biting each other. Transmission from aerosol over short distances when animals are coughing is also considered as direct transmission. Airborne transmission is used for spread over longer distances with small particles such as droplet nuclei or dust.

The indirect transmission is defined as “passage of a pathogen from one individual to another by the intermediary involvement or action of another individual, object or substance”. It is usually subdivided into vehicle borne or vector borne and provides a huge number of transmission possibilities. Thus, vehicle borne transmission can include food, bedding, equipment for handling animals, instruments, biological products (milk, blood, urine and semen), clothing, contaminated medical products and
others. The vector borne transmission involves invertebrates (flies, mosquitoes, ticks etc.) carrying pathogens between vertebrate hosts.

Although probably never quantified, the direct transmission route is the more likely to occur (if the circumstances for direct transmission is there) than the indirect transmission. Thus, the indirect transmission is dependent on the ability of the pathogen to survive in the environment.

There is a huge variation between pathogens for how long time and in which amount they are excreted and whether direct, indirect or airborne transmission is likely to occur. Many infected animals may after for example seroconversion not excrete the pathogen anymore and therefore not be infectious. Therefore, it is very important to distinguish between infected animals and infectious animals. In particular, for the indirect transmission there is huge variation in the ability of the pathogen to survive in the environment (from hours to years).

Overall, the variation in the probability of transmission of an infection is due to the dependence of determinants or risk factors related to the host, the agent or the environment (the so-called host-agent-environment-triad). Host related factors can include traits such as genetics, immunity, age, species and breed. For example, young animals will be very susceptible just after they have lost colostral immunity; and swine will excrete much higher amount of Foot and Mouth disease virus than cattle. Obviously, vaccination will affect the susceptibility of the host and hence also the excretion of virus. The infectious agents show variation in their ability to enter a new host, spread within the host and be excreted again. Furthermore, there is huge variation in its ability to survive in the environment, which, as already stated, has huge impact on indirect transmission. Finally, the environmental determinants include a huge number of variables related to the production system, management and climate, for example housing density, hygienic procedures, transportation and many others.

In addition to the variation of risk factors related to the host, the agent and the environment, these factors will also interact among each other. Therefore, the transmission of infections in one population setting can be quite different from another population setting. Thus, it is important to stress that all the following activities related to biosecurity can have quite different effects depending on how they are combined.
3.2. Specific activities related to biosecurity

The importance of the host origin or source is thus highly dependent on the relative importance of direct vs. indirect transmission. If only direct transmission is likely, it only has implications for animals in its proximity whereas indirect transmission can reach a much wider spectrum of animals. This has direct implications for the biosecurity activities. Dealing with infections where direct transmission is important, there is emphasis on activities such as animal tests and issuing certificates, avoiding transportation of animals (purchase, animal shows etc.) or using quarantine. When dealing with infections, where indirect transmission is likely, there is emphasis on several management procedures, such as avoiding sharing equipment, avoiding visitors to herds and implementing hygienic procedures.

*Avoid purchase or other movement of animals between herds*

Movement of animals is among the most important means by which direct transmission of infections will take place. Many (or most diseases) have subclinical phases where animals will carry the infection without showing clinical signs. Therefore, avoiding purchase of animals, movement of animals to markets, animal shows or common pasture is a very effective way of reducing the risk of transmission both at short and long distances. However, to many farmers these are very rigorous constraints and therefore it is important to consider biosecurity measures in case the animals are moved (test strategies, quarantine and others).

*Testing animals and issuing certificates – Buy only animals from herds with known status*

For many infections, there are specific tests that can assure that animals are not infected. But to assure freedom it must be combined with isolation/quarantine to assure that the animal has not been in an incubation period. However, for many infections, the laboratory tests have low sensitivity (e.g. paratuberculosis) meaning that the animals cannot be tested free with a reasonably high probability.

An efficient way to avoid the need for individual certificates is to buy animals from herds known to be free from certain infections as it is known in the Danish SPF system for swine herds. Thus, animals should always be purchased from herds with a higher health status. Cattle herds do not have a similar declaration system involving several diseases, but have status categories for individual diseases.
Quarantine of animals
As there is a time lapse between the infection and appearance of clinical signs and from infection until antibodies are present, animals should be quarantined between the herd of origin and herd of destination. The needed period depend on the individual infection, but will often last some weeks. The need for testing and use of quarantine can thus mean quite substantial extra costs in relation to movement of animals.

Pasturing of animals
If pasturing is used, double fencing is often recommended to avoid over the fence contact between neighbouring herds. This is in particular important if the infection status of neighbouring herds is unknown.

Signs: “entrance forbidden”
Human beings can transmit infections in several ways depending on their activities at the farm.

An efficient means of total avoiding transmission by humans is therefore to put up signs with “entrance forbidden” to avoid visiting people who do not have a specific business on the farm. For those who have specific business on the farm (veterinarian, AI technician, claw trimmer and others), there should be visitor rules that they should be aware of and follow.

For swine herds there are particular rules for quarantines before visiting another herd. The length of the period depends of the infection status of herd of origin and herd of destination.

In particular, human beings having visited other countries should comply with quarantine rules before entering the herds.

Rules for visitors (Veterinarian, AI-technician, Hoof trimmer)
One of the larger elements is establishment an “entrance room”, where visitors change clothes and boots and wash their hands before entering or leaving the farm.

These rules can be more or less rigoristic. Some farms for example only have a foot bath with disinfectant to pass before entering the stable area.
Furthermore, as far as possible all instruments and equipment should be available on the farm, so that visitors do not have to carry it between farms. For example, all kinds of equipment for handling animals (nose tongs, claw trimmer box and the like) can preferably be available on the farm.

Other types of equipment like surgical instruments and medicine bottles need to be transported between farms. Here it is of course important to clean, disinfect and sterilize as far as possible. Furthermore, it is recommended only to bring the medicine bottles that are needed into the stables.

In some situations there are also rules for parking and cleaning of cars (for vehicles transporting animals).

Some farmers that share equipment and machinery should be aware of the transmission via feed stuffs, manure etc.

*Use of biological products, medicine, embryo transfer*

If any biological products are to be used on the farm, any risk of them being contaminated should be taken into account. For example, the re-use of needles into the medicine bottles between herds has been shown to transfer infection.

*Transportation - pick up for slaughter – trading of animals*

When animals are moved, not only infected animals being transported from one place to another pose an important risk, but also a number of other circumstances need to be addressed to prevent that infections are introduced to the animals being transported or by straw or manure being transported with the vehicle.

Thus, when picking up animals for slaughter there should be delivery facilities so that the vehicle and driver does not come in close contact with the animals staying at the farm. Such a facility is also important when trading animals.

In particular, when picking up animals for the rendering plant, there should be a special place away from the farm to put dead animals.

*Housing and management of animals*

In relation to prevent internal transmission at the farm, it is recommended to have all-in – all-out production where animals are reared in batches. Here all animals are re-
moved from the stable where after it is cleaned and disinfected before new animals are moved in again.

Also mixing of young animals with older animals should be avoided; or different age groups can be housed in separate buildings such as it is done in the multi-site production of pigs.

Rules concerning general farm hygiene at the farm are also important for reducing disease transmission in the herd, (Danish Agricultural & Food Council, 2012).

Depending on the individual characteristics of the infections, there can be several relevant management related biosecurity measures. For example, for some diseases colostrum from infected dams should be avoided.

*Control of rodents and birds – and wildlife*
In general, it is recommended to have poison for rats and mice. In some cases (e.g. Foot and Mouth suspicion) all kind of other species (cats and dogs) should be removed from the stable area. It may also be recommended that only one species is kept on the farm (e.g. not having pigs and cattle on the same farm).

Wild boars may pose a risk for pigs housed outdoors. In such situations, the wild boar is said to be a reservoir host.

*Biosecurity measures at borders – EU borders and national borders*
Many of the biosecurity measures at the borders are in principle mentioned above. But the important ones are emphasized here and further described under legislation. Transport of living animals across borders should obviously be kept at a minimum. Those importing living animals or breeding animals must be registered at the veterinary and food authorities. If animals are imported, quarantine is highly recommended. Both import and export of animals are important as transport vehicles are crossing the border. Therefore, washing of transport vehicles at the border is recommended.

It is obviously difficult to establish biosecurity measures for infections that are airborne over long distances. In these situations, it is important to have early warning systems for assessments of threats and increase the general alertness.
Vaccination

A huge variety of vaccines exists for both List 1 and List 2 diseases (see Table 4.3 in section 4.4). The obvious advantage is to provide animals with protective immunity, which can totally prevent disease or at least mean that the clinical signs will be less severe. A major disadvantage is that it may be very difficult to declare a herd or area free of infection when vaccines are used (unless for example advanced diagnostic tests are in place that can distinguish between antibodies induced by natural infections from vaccine induced antibodies). The use of vaccines can therefore exclude export market opportunities as freedom for infection cannot be documented. There are strict rules for which vaccines are allowed to use.

When use of vaccines is allowed, they can be used in individual herds that are believed to have less efficient biosecurity. They can also be used at regional level to provide a buffer zone between infected areas and infection free areas (which has been used for the Foot and Mouth Disease in south-eastern part of Europe).

3.3. Main measures in the legislation

Both at the EU level and at the national level, there are a huge number of regulations involving bio-security measures. They are just briefly summarized here as this report has emphasis of what can motivate farmers. Therefore, the following text is non-exhaustive.

EU regulation

EU has a number of rules for import of living animals from outside to inside the community. These rules include control of documents, clinical control, sampling for diagnostic investigations and many others. EU has a list of approved control places. Within EU, there are also a considerable number of biosecurity rules for control at primary production sites, health certificates, trading documents etc.

EU and Danish legislation demands that transport vehicles must be cleaned and disinfected before entering a herd.

EU has established the Animal Disease Notification System for the animal health status in member states. Furthermore, a database (TRACES) has been established to record certificates and documents in relation to the trade of animals.
**Danish regulation**
Washing of transport vehicles at the border is not part of legislation. But DANISH TRANSPORTSTANDARD for swine has regulations securing that vehicles from other countries are washed and disinfected at an approved washing place before entering Denmark. For cattle, there is a voluntary agreement of washing and disinfection of vehicles at the border.

Import to Denmark of animal products must only take place at approved border control places.

Movement of animals (cattle and pigs) should be recorded in the Central Herd Register (CHR). In relation to movements a certain 7/30 days rule imply that animals cannot be moved from a herd until 7 days after there has been a movement to the herd and further that an animal moved to a herd cannot be removed from the herd before 30 days later.

In order to improve the biosecurity in general at herd level, there are regulations for biosecurity for large cattle and swine herds. The exact herd size where these rules must be followed is specified in the legislation. These herds must establish a biosecurity plan together with the veterinarian taking care of health advice in the herd. The biosecurity plan must be approved by the veterinary authorities. The biosecurity plans include description of among other things peoples access to the herds, access for transport vehicles and pest control. Furthermore, there are rules for quarantine when moving animals to the herd and restrictions on the number of herds that there can be deliveries from.

For many infections prophylactic vaccination is directly forbidden in the legislation. But for some infections (for example Foot and Mouth Disease), emergency vaccination can be allowed by the Danish Veterinary and Food Administration.

**Biosecurity measures for infectious diseases under eradication**
For diseases where an eradication program has been decided, there are several biosecurity regulations, which may change considerable over time as the program is tightened.

As an illustration, a total of 11 BVDV government orders were issued from 1996 to 2008. During these years, many biosecurity measures were included in the legislation.
(Houe et al., 2008). The biosecurity measures had special focus on avoiding contact with persistently infected (PI) carrier animals. This control element was included at very different intensities in different government orders: not allowing PI animals on pasture, demanding them slaughtered or brought to an incinerating plant, demanding them isolated or demanding them killed or slaughtered on the farm. For individual animals, diagnostic tests were used to establish demands for certificates before any movement. Later, when there were good declarations for freedom at herd level, the demands for individual certificates were replaced by declaration of herd status. (Biosecurity measures such as indirect transmission by utensils and clothing that had less evidence of importance in the literature were too much lesser extent included in the legislation).

**Biosecurity measures if infectious exotic diseases are suspected**

An important part of the regulation consists of surveillance and reporting if occurrence of exotic diseases is suspected. Thus, this activity is a biosecurity measure that will prevent further spread after the infection is introduced.

As further explained in section 4.4, the legislation has a so-called “List 1” with diseases that upon suspicion must be reported directly to the veterinary authorities and a “List 2” with diseases where the practicing veterinarian upon suspicion takes samples for laboratory examination and contacts the veterinary authorities if the suspected infection is confirmed. Until response from the laboratory, the herd is given certain restrictions including no transport to and from the herd.

A number of infectious diseases have their own individual legislation (the Foot and Mouth Disease, swine fever, African swine fever, bovine virus diarrhoea virus, infectious bovine rhinotracheitis and many others) with very detailed regulation of the biosecurity measures. For example, herds suspected for Foot and Mouth Disease are not allowed to move milk, milk products, beef, beef products, feed stuffs and equipment etc. from the herd.

**National biosecurity measures after outbreak/index case**

After an index case (the first case that calls attention for the existence of an outbreak) of for example Foot and Mouth Disease, important biosecurity measures such as protection and surveillance zones are established.
The Danish Veterinary and Food Administration generally has a non-vaccination policy at an eventual disease outbreak, but emergency vaccination will be considered depending on the specific circumstances of an outbreak.

**Rules within the industry**

As already mentioned earlier, DANISH TRANSPORTSTANDARD for swine has regulations securing that vehicles from other countries are washed and disinfected at an approved washing place before entering Denmark; and for cattle, there is a voluntary agreement of washing and disinfection of vehicles at the border.

People entering from other countries to Denmark have a quarantine of 24 hours before entering a herd.

Especially the Danish pig sector has the unique SPF system (Specific Pathogen Free) that ensures that SPF pig farms are free from specific swine diseases. The SPF system is the “world’s most comprehensive health program for pigs”, (SPF Danmark, 2012). Approximately 3,700 pig herds or 70 per cent of Danish sows are housed in SPF holdings. In order for farmers to be SPF certified, they have to sign an agreement with SPF-SUS and follow certain animal health rules. These rules include protection against infections to ensure that diseases are not introduced to the farm, health inspection so that diseases are not spread through trade or transportation, declaration of herd health status and engaging in purchase and trade of health products approved by SPF-SUS. All trade and movement of pigs are done according to their health status. Although the salmonella level of each farm is declared in the health declaration, the SPF health declaration is mainly applicable to specific diseases such as Pleuropneumonia, ordinary pneumonia swine dysentery, atrophic rhinitis, PRRS, (SPF Danmark, 2012). As previously mentioned, cattle herds do not have a similar declaration system involving several diseases. But for individual diseases such as Salmonella Dublin, there are specific status categories. This has also been used during eradication programs for different viruses, e.g. infectious bovine rhinotracheitis (IBR) and bovine virus diarrhoea (BVD).

3.4. **Surveys of biosecurity in production herds**

A few surveys exist on the farmers’ choices and routines concerning biosecurity measures. Among the results from an interview among owners of 116 fattening swine herds (Boklund et al., 2004) were that:
• 78% purchased weaners from one sow herd, whereas 10% purchased from >
5 sow herds during one year
• Two swine herds purchased weaners from a market
• 22% did not use an effective barrier between the loading area and the stables
  when delivering pigs for slaughter
• The number of visitors was generally less than 10 per year

In a similar study, where owners of 121 sow herds were interviewed (Boklund et al.,
2003), the results among other things showed that:

• 52% sold weaners
• 71% used delivery facilities for picking up of weaners (but half of these did
  not have a barrier between the loading area and the stable)
• 19% of the pick-ups of weaners occurred directly from the stable
• 10% of the pick-ups, the truck driver had access to the stable
• 48% of the units required the vehicle to be cleaned and disinfected before
  the transport
• 16% of the units required the vehicle to be cleaned before the transport
• 57% of large sites used quarantine before introducing new animals to the
  herd
• 23% of small sites used quarantine before introducing new animals to the
  herd

A survey of biosecurity and management practices in 421 Belgian pig herds (Ribbens
et al., 2008) showed among other things that:

• 51% had changing room available
• 33% had disinfection bath available
• 3.3% allowed pigs to go outside
• 8% fed kitchen waste
• 72% performed insect control
• 32% had separated veterinary material available between different pens or
  compartments

These results are very important in order to identify areas where biosecurity can and
must be improved.
Another way to identify critical points of lack of biosecurity is to perform follow-up activities in recently infected herds. For example, follow-up investigations in 67 previously BVDV-free Danish herds identified obvious explanations for re-infection in 74 per cent of the cases (Bitsch et al., 2000). These investigations revealed severe flaws in important biosecurity measures. Thus, among the 67 herds:

- 28% had purchased pregnant animals that later delivered PI animals
- 36% of the herds, PI animals had been present on neighbouring pastures
- 7% of the herds had animals on common pasture
- 3% of the herds there had been PI animals in neighbouring farmhouses
- 26% of the remaining herds, no obvious explanations could be identified

These surveys show that there are several places where biosecurity can be improved. It is therefore relevant to e.g. interview farmers in order to understand the barriers for implementing different biosecurity measures. A study on Danish dairy farmers’ perception of biosecurity showed that it is a big challenge to motivate farmers to comply with biosecurity rules. Thus, back in 2008 farmers with large herds must according to the legislation have developed a farm-specific biosecurity plan. However, one year later none of the farmers in the study had complied with this rule (Kristensen and Jakobsen, 2011). The authors therefore conclude that it is important to provide farmers with incentives to improve biosecurity at the herd level.

Discussion/conclusions

There are a considerable number of transmission routes, which varies considerably among infectious diseases. Therefore, also a considerable number of activities of relevance to biosecurity can be listed. But the relative importance of each of these activities (or measures) is very difficult to quantify from the available literature as the effect of a biosecurity measure may depend on other measures and the population setting in general. It is therefore not possible to say exactly when a set of biosecurity measures is enough or when it is ‘overkill’. It can be discussed that maybe the best one can do, is to take the gross list of biosecurity measures and try to fulfil as many as possible and that the minimum list of requirements needs to be a judgement for the individual diseases.
4. Economic incentives for disease prevention

This chapter provides an introduction to an understanding of the economic incentives – or lack of economic incentives – for disease prevention in livestock production. Without such an understanding, it is impossible to discuss economic options to increase farmers’ incentives to improve their preventive efforts. Section 4.1 describes the role of private and public incentives whereas the general requirements to an insurance system for animal diseases are outlined in section 4.2. Section 4.3 describes the level of efficient prevention efforts from three different perspectives while section 4.4 explains the relationship between incentives and the categorization of animal diseases in the legislation.

4.1. The role of private and public incentives

As a starting point, it is important to recognize that professional livestock farmers under normal conditions, i.e. in peace time, have obvious economic incentives to prevent the introduction of diseases into their herds. These economic incentives are loss of profit or loss of asset value. Thus, if animals are diseased their productivity may decrease, e.g. lower milk yield per cow or less meat per unit of feed intake; and the product quality may deteriorate, i.e. lower sale price; and the vet costs for disease treatment may increase. Lower productivity, lower product quality and higher vet costs all contribute to reduced profit. In addition, if animals die because of diseases, asset values are lost and the farmer loose wealth. Therefore, livestock farmers have generally speaking clear private incentives to prevent animal diseases.

From section 2.2 it is also clear that the government – represented by e.g. DVFA - has a large number of incentives to keep as high disease-free status as possible in the livestock sector in order to protect the trade and export of animals and animal products, the employment in the food industry, the public health and protect many other benefits from having healthy animals. In economics, these benefits are in general called public goods. The most important characteristic of a public good is that the benefit to one person does not preclude that other persons may enjoy the same benefit. In principle, all citizens in a society might benefit from disease free animals. In other words, there is non-rivalry among people in benefiting.

The problem is that there is not necessarily any compatibility between farmers’ economic incentives and the government’s incentives to ensure animal health. For exam-
ple, many farmers may consider the risk of getting infected with Foot and Mouth Disease or other contagious diseases as so low that this risk should be ignored. Thus, the individual farmer has no real incentive to invest in the prevention of such diseases. The expected benefit of the investment is considered low, because of the very low probability of occurrence, while the cost is incurred for sure.

However, from a governmental perspective the risk of an outbreak of e.g. Foot and Mouth Disease might be considered as much higher. The reason is that the government has to consider the risk of an outbreak for the entire livestock sector which includes all animal producers. And if an epidemic outbreak occurs, there is a high risk that many of the benefits of a disease-free status, which we have called public goods, may either disappear or be significantly reduced. For example, trade of animals and animal products can be prohibited, export markets closed and consumer confidence decline. Therefore, from a public perspective farmers’ private incentives may lead to an under investment in disease prevention.

The explanation of the argument for the under provision of prevention efforts by private farmers is graphically illustrated in Figure 4.1 (see Lansink (2011) for a similar analysis of the provision of plant health). In the Figure, the efforts to prevent animal diseases are measured on the horizontal axis whereas the benefits as well as the costs of the prevention efforts are measured on the vertical axis. Thus, we are considering a cost-benefit analysis of efforts into animal disease prevention.

In the Figure, the MC curve shows the marginal costs of additional preventive efforts. Examples of marginal costs could be the cost of investing in additional hygiene measures, the cost of establishing a new quarantine section, or the cost associated with less trade of animals. The MC curve is depicted as an upward increasing with increasing slope indicating that the marginal costs increase as the amount of preventive efforts increase. Thus, the first efforts are assumed less costly to implement than later preventive efforts.

\( MB_{\text{private}} \) and \( MB_{\text{total}} \) in Figure 4.1 show the marginal private benefits and marginal total benefits, respectively, related to enhanced disease prevention. Examples of marginal private benefits are less sick animals and price premiums for animals with an extraordinary high health status (as in e.g. the Danish SPF system). Marginal total benefits on the other hand not only include marginal private benefits, but also margin-
al public benefits. As mentioned above are easier access to export markets and increased consumer confidence examples of public benefits.

**Figure 4.1. The under provision of disease prevention**

However, both the marginal private and marginal total benefits are assumed to decline as the level of efforts into disease prevention is increasing. It is a standard hypothesis in economics that as you get more and more of the same good, your utility of the marginal good will decline. It is the same with respect to disease prevention. If the farmer changes his behavior from none to five times hand washing every day, the increase in benefits may be rather high. However, if the farmer increases his hand washing from 20 to 25 times each day the enhanced benefits in the form of better prevention is probably rather small.

The Figure shows that a rational farmer has the incentive to produce a level of animal disease prevention corresponding to level $B_{private}$. From a rational farmer’s perspective this is considered as the optimal level as it depicts a cost-benefit ratio where the marginal private benefits equal marginal costs. Obviously, if the farmer increases his pre-
ventive efforts beyond that level the additional cost will exceed the extra benefit resulting in an economic loss.

However, exactly because of the before mentioned public good characteristics associated with animal health (and welfare) the marginal total benefits will be higher than the marginal private benefits as illustrated in Figure 4.1. Thus, from a societal point of view the optimal level of animal health is \((B_{\text{total}}, E_{\text{total}})\) as this is the aggregated prevention level where the marginal costs equal the total marginal benefits.

To sum up: Figure 4.1 shows that the private optimal level of disease prevention – which is \((B_{\text{private}}, E_{\text{private}})\) – is different from the total (social) optimum - which is \((B_{\text{total}}, E_{\text{total}})\) in the Figure. In the jargon of economics a market failure exists. A market failure exists when the market in itself cannot ensure that the private and social optimaums are coincident.

The size of public benefits is measured by the distance \(B_{\text{total}} - B_{\text{private}}\) whereas the public costs are measured by the distance \(E_{\text{total}} - E_{\text{private}}\) in Figure 4.1. There seems to be little disagreement that the government should be involved in the risk management of animal diseases as there are clearly public benefits associated with disease prevention in agriculture. However, disagreement arises when it comes to measure the size of these public benefits and therefore the costs that should be financed as public expenditures.

The problem is that in reality it is not possible to disentangle private goods from public goods in the provision of animal health. In fact most such goods are a mixture of private and public goods. For example, when a farmer improves his biosecurity, he not only reduces his own risk of introducing a new disease in his herd, but he also reduces the risk e.g. on other farms with animals. The reason is that most disease risks are not independent between producers. Correlated risks are also called systemic risks and the positive benefits that a farmer produces to other farmers (and maybe other stakeholders) by investing in extra disease prevention are called positive externalities. Externalities are another economic concept describing how private actions in production or consumption affect others that are not directly involved in these actions.

Also public goods might include elements of private benefits. Consumer confidence in food products is a well-known example of a public good. Most citizens are also consumers and may benefit from a high trust in the food sold. However, the individu-
al farmer benefits as well since it is easier to sell his products in a market with high consumer confidence; and perhaps he will receive a higher price on his products sold. Thus, it may be argued that farmers should partly pay for the investments in building a positive reputation of the produced food.

To conclude, it is not a simple task to provide farmers with new economic incentives for improved animal health management. Efficient farmers have optimized their production decisions according to the prevailing price and market conditions. Therefore, any new legal animal health requirements might for sure result in new production costs to livestock farmers while the benefits of additional efforts into disease prevention are shared among all stakeholders described in section 2.2.

4.2. General requirements for animal disease insurance schemes

To summarize the above discussion on the incentive issues, we present in Table 4.1 the following short checklist for designing good overall schemes for animal disease insurance adopted from Meuwissen et al. (2006).

<table>
<thead>
<tr>
<th>Behavioral aspects</th>
<th>Insurance contractual incentives</th>
<th>Insurance organizational incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk prevention</td>
<td>Risk classification with strong price discrimination&lt;br&gt;Deductibles, but only for consequential losses&lt;br&gt;Advance payments in combination with additional assessments&lt;br&gt;Additional assessments also apply to farmers who quit farming after an epidemic</td>
<td>Annual retention for insurance pool&lt;br&gt;Local organization&lt;br&gt;Sector organization&lt;br&gt;Mutual insurance company&lt;br&gt;No possibility to purchase insurance if epidemics occur in close proximity</td>
</tr>
<tr>
<td>Rapid disclosure</td>
<td>No compensation of sick and dead animals&lt;br&gt;Full compensation of healthy animals</td>
<td>Obligatory insurance for direct losses</td>
</tr>
<tr>
<td>Compliance with movement standstill</td>
<td>Insurance coverage for losses from movement standstills and emergency vaccination</td>
<td>Link between risk classification and governmental penalty system</td>
</tr>
<tr>
<td>No deliberate infection</td>
<td>Compensation at the lowest value of cost of production and market price</td>
<td></td>
</tr>
</tbody>
</table>

Source: Table 10.1. in Meuwissen et al. (2006)
In order to induce risk preventing behavior among the farmers it is necessary to make a risk classification of livestock farms and to let this classification be the basis for price discrimination. The risk classification should primarily be based on factors that the farmer can actually influence (such as factors related to hygiene, purchase of animals and other movements of animals as described in chapter 3), but it may also involve factors such as farm type and geographical location which can be considered as fixed in the short run. It is further recommended to let these factors be transparent and simple to monitor in order to minimize transaction costs of all involved parties. In practice, these transaction costs may often be substantial.

As in any type of insurance contract, deductibles play a role to reduce moral hazard issues. By introducing deductibles the farmers are in effect made co-insurers (in the same boat, so to speak, as the insurer) and therefore have incentive to reduce their risks. The literature recommends that deductibles are related to consequential losses only since deductibles on direct losses from culled animals may reduce farmers’ incentives for rapid disclosure.

Timing of premium payments made by farmers also matters. On the one hand, payment in advance of an outbreak increases awareness of the cost of the disease risk that farmers face. On the other hand, payment in advance also introduces moral hazard issues as they already have paid the insurance premium. Hence, it is typically recommended that a relevant insurance scheme should contain some sort of combination of parts paid in advance and later additional payments. However, it is not obvious whether payment discrimination should take place when farmers pay in advance or when they are reimbursed ex-post.

To provide incentives for rapid disclosure, it is recommended that farmers don’t receive compensation for sick and dead animals but receives full compensation for healthy animals. Clearly this should have the effect of early reporting by the farmer in order to minimize the loss from dead and infected animals.

To make sure that farmers do not have incentives to move their animals out of stand-still zones after a disease outbreak it is important that farmers are also compensated for losses within these zones. The compensation in infected zones should be sufficiently low in order to decrease incentives to move animals into infected zones. This can be achieved by making sure that compensation in infected zones does not exceed the minimum of the production costs and the market price of the animals. Moreover,
it is typically recommended that vaccination programs and suitable penalty systems are added to compensation in standstill zones in order to decrease incentives for moving animals into healthy zones.

Another issue is whether an insurance scheme with public involvement should be voluntary or mandatory for the livestock farmers. With a voluntary scheme there is a risk of the problem called adverse selection. The problem associated with adverse selection is that only high risk farmers will join the insurance scheme as farmers with low disease risks find it too costly to join the scheme. Thus, the premium payments may constantly increasing driving out more and more farmers with less than average risks. This indicates that the scheme should be based on mandatory participation of the livestock keepers.

4.3. **Efficient prevention**

There are many reasons why farmers do not necessarily obtain the efficient level of disease prevention. A prominent one being moral hazard issues as discussed above where wrong incentives will stand in the way of efficiency. But it is important to be aware that less sophisticated explanations can be found as well and that these also (at least indirectly) relate to the overall design of the insurance system.

In Figure 4.2 below, we try to illustrate this by mapping producer’s prevention costs against the level of obtained disease prevention. Three possible frontiers are in play: The (inner) compliance frontier represents the situation where farmers fully comply with biosecurity regulation and abstain from opportunistic behavior following from the presence of asymmetric information – that is, “Area I” in the Figure represents the inefficiency caused by moral hazard issues. To force producers to the efficient compliance frontier, possible tools are control (monitoring) in connection with various forms of enforcement (penalty systems). Obviously, control and enforcement are costly solutions – it would be better if the insurance system was designed such that the producers themselves chose to comply with biosecurity rules; that is, if the system by itself induces the right incentives. This is where the considerations concerning optimal design in section 4.2 above come into the picture. Careful design of the insurance system can potentially limit the inefficiencies from moral hazard and adverse selection.
The best practice frontier adds a further layer of potential inefficiency in the sense of technical inefficiency in the “production” of disease prevention. Even if the farmer is in full compliance with biosecurity regulation and do not engage in opportunistic behavior there may still remain inefficiencies due to lack of knowledge or obsolete technological possibilities. This emphasizes that biosecurity rules should be easy to understand and related procedures easy to execute. Ways to combat this form of inefficiencies include better information, learning and knowledge sharing among farmers.

Finally, the (outer) potential frontier represents what can be obtained if farmers are innovative and dares to think in new ways of organizing production processes. The inefficiency represented by “Area III” is therefore caused by risk-aversion among the farmers in the sense that “gambling” on new technological solutions always involves uncertainties about future costs and profits. Such uncertainties often stand in the way of innovation. It is important that the insurance system induces the farmers to be innovative in their production processes with respect to improved animal health and welfare.
We summarize this description in Table 4.2.

<table>
<thead>
<tr>
<th>Frontier</th>
<th>Inefficiency</th>
<th>Cause</th>
<th>Effect</th>
<th>Incentive scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential</td>
<td>Area III</td>
<td>Risk-aversion</td>
<td>Lack of innovation</td>
<td>Risk-/cost sharing</td>
</tr>
<tr>
<td>Best-practice</td>
<td>Area II</td>
<td>Behavioral inefficiencies</td>
<td>High variation in performance</td>
<td>Learning/knowledge sharing</td>
</tr>
<tr>
<td>Compliance</td>
<td>Area I</td>
<td>Asymmetric information</td>
<td>Opportunistic behavior</td>
<td>Control/punishment</td>
</tr>
</tbody>
</table>

4.4. Incentives and categorization of diseases

The categorization of livestock diseases serves as an important policy instrument. It classifies animal diseases according to different criteria such as contagiousness, impact on public health and potential economic losses to the society as a whole; defines the diseases which requires early disclosure in case of disease suspicion; and determines the diseases for which livestock farmers may be more or less publicly compensated in case of a disease outbreak. Thus, such a classification determines to a large extent the role and responsibility of public authorities in periods of a disease suspicion or outbreak.

However, it should also be acknowledged that a categorization of animal diseases in the legislation may provide farmers with both incentives and disincentives to make preventive actions in their herds in peace time. The causal chain is illustrated in Figure 4.3. The Figure shows how animal diseases included in the categorization partly determine the indemnification payments and how these indemnification payments in turn partly determine farmers’ incentives to prevent diseases in their herds. On the one hand, if farmers are compensated 100 per cent or more in case of an outbreak, they don’t have any economic incentive to take responsibility for the biosecurity among the animals. On the other hand, if the farmer is not compensated at all in any case of a disease outbreak, he doesn’t have any economic incentive to make an early disclosure of a suspected disease in his herd. On the contrary, the farmer may have an economic incentive to hide the suspicion for others and sell as much of his animals and animal products as possible at normal sale prices. It clearly shows the potential conflict between competing public and private incentives.
Early disclosure (and indemnification payments) is based on defining certain animal diseases as “notifiable diseases”. These are animal diseases that when suspected by farmers, authorities, vets or laboratories must be reported within a defined timeframe.

In Denmark, The Danish Animal Health Act of 2004 forms the legislative basis for the notification procedure and the notifiable animal diseases. The notifiable animal diseases are listed in Order No. 54 of 26/01/2011 where they are divided into List 1 diseases and List 2 diseases. The diseases included on List 1 and List 2 for multiple species diseases as well as for cattle and pigs are shown in Table 4.3.

| Table 4.3. Animal diseases on List 1 and List 2 in the Danish law |
|------------------|------------------|------------------|
| **List 1 diseases** | **List 2 diseases** |
| Multiple species diseases | Aujeszky’s disease |
| Bluetongue | Echinococcus multilocularis |
| Brucellosis | Hydatidosis |
| Japanese encephalitis | Leptospirose |
| Foot and Mouth disease | Salmonella |
| Rabies | Trichinellosis |
| Rift valley fever | Bovine virus diarrhea (BVD) |
| Bovin spongiform encephalopathy (BSE) | Enzootic bovine leucosis |
| Tuberculosis | Infectious bovine rhinotracheitis/pustular vulvovaginitis (IBR/IPV) |
| Vesicular stomatitis | Q-fever |
| West Nile Fever | Cysticercus cellulosae |
| | Transmissible gastroenteritis (TGE) |
| | Porcine respiratory and reproductive syndrome (PRRS) |

Source: Order No. 54 of 26/01/2011.

List 1 diseases comprise transmissible diseases with potential for very serious and rapid spread, having serious socio-economic public health effects and being essential in the international trade of animals and animal products. These include among others Foot and Mouth Disease (FMD), Bluetongue and Rift Valley Fever. List 2 diseases include transmissible diseases with mainly production economic consequences such
as Aujeszky’s disease, Salmonella, Enzootic Bovine Leucosis and Porcine Respiratory and Reproductive Syndrome (PRRS). List 1 diseases are usually more serious than List 2 diseases due to the wider economic consequences for the whole society.

Suspicion of a disease on List 1 shall immediately be notified to the Danish Veterinary and Food Administration, whereas notification of a disease on List 2 is only mandatory after confirmation of the disease, DVFA (2012). The Danish List 1 notifiable diseases include all former OIE List A diseases as well as several zoonotic diseases.

In accordance with the Animal Health Act, a farmer is obliged to immediately call a veterinarian if the farmer suspects a notifiable disease. The veterinarian shall immediately notify the Regional Veterinary and Food Administration (RVFA) if the veterinarian suspects a disease on List 1. A veterinary officer from the RVFA will inspect the farm within four hours and inform the DVFA about the suspicion. If the veterinary officer cannot rule out the suspicion of a List 1 disease the farm is placed under official surveillance and test material is collected and dispatched to the National Veterinary Institute, the Technical University of Denmark.

<table>
<thead>
<tr>
<th>Country</th>
<th>Disease</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>BSE</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>BT</td>
<td>0</td>
<td>1</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Netherlands</td>
<td>BSE</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>BT</td>
<td>456</td>
<td>5798</td>
<td>66</td>
<td>2</td>
<td>0</td>
<td>6322</td>
</tr>
<tr>
<td>Germany</td>
<td>BSE</td>
<td>16</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>BT</td>
<td>885</td>
<td>20669</td>
<td>2605</td>
<td>142</td>
<td>0</td>
<td>24301</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>BSE</td>
<td>132</td>
<td>65</td>
<td>41</td>
<td>12</td>
<td>11</td>
<td>261</td>
</tr>
<tr>
<td></td>
<td>BT</td>
<td>0</td>
<td>65</td>
<td>70</td>
<td>0</td>
<td>0</td>
<td>135</td>
</tr>
<tr>
<td>Sweden</td>
<td>BSE</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>BT</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>2</td>
<td>0</td>
<td>30</td>
</tr>
</tbody>
</table>

BSE: Bovine spongiform encephalopathy; BT: Bluetongue
Sources: European Union Animal Disease System Annual reports 2006-2010

As shown in Table 4.4, Denmark has relatively low numbers of animal disease outbreaks in comparison to other countries with similar production systems. The country is free of many major animal diseases such as Foot and Mouth Disease, Aujeszky’s
disease and Brucellosis. The last outbreak of Classical Swine Fever in Denmark was in 1933, last occurrence of Foot and Mouth Disease was in 1983, the last outbreak of Newcastle Disease was in 2005 and the only outbreak of highly Pathogenic Avian Influenza was in 2006, (DVFA, 2012).

The conclusion is that the design of the indemnification payment scheme which is used in case of a disease outbreak may contain positive and/or negative incentives to prevent epidemic diseases in the herd. As shown by the low number of disease outbreaks in Table 4.4 there is a high chance that the individual farmer underestimates the risk of getting serious animal diseases and therefore reduce his preventive efforts. It is a fundamental problem that emphasizes the need to provide farmers with more clear economic incentives for disease prevention in their herds.
5. Compensation and cost-sharing schemes

As argued in section 4.2, the design of the livestock compensation and cost-sharing schemes which are established to compensate farmers in case of a serious disease outbreak may also have significant effects on the farmers’ incentives to take actions to improve their animal disease prevention in peace time.

This section describes the current compensation and cost-sharing schemes for livestock farmers in Denmark, The Netherlands and Germany which include public involvement. The compensation and financing arrangements in the Netherlands and Germany are included to compare incentives (and disincentives) in these schemes against the incentives embedded in the Danish compensation system. Statutory livestock compensation and cost-sharing schemes vary greatly among the countries in EU. However, most of the schemes cover the loss of animal more or less in case of an outbreak whereas other interruption costs often are covered by private insurance schemes. These private schemes are not considered in what follows.

Before describing the specific compensation schemes in Denmark, The Netherlands and Germany, it is appropriate to define the costs that might be associated with an epidemic disease outbreak. An overview of the costs makes it easier to see which costs are compensated and which are not covered in case of a disease outbreak. These costs may be categorized in alternative ways as shown in e.g. FCEC (2006: 75) and Van Asseldonk et al. (2006: 155 ff.).

5.1. Categorization of disease outbreak costs

Here it is chosen to categorize the costs into direct and indirect costs at the farm, sector and national level as shown in Table 5.1. The costs categorization might not be exhaustive, but the idea is to show the most important outbreak costs. At the farm level the main direct costs are the value of the destroyed animals and the consequential costs, respectively. The indirect business costs are mainly resulting from market interruptions due to a disease outbreak.

The affected agricultural sector or sectors may experience costs from a lower sale of products both on export markets as well on domestic markets (shown as negative market and price effects in the table). The lower sale can be understood as a cost when the sale during an outbreak is compared to the normal sale in peace time. A re-
cent research project analyzing the economic consequences of an outbreak of Foot and Mouth Disease (FDM) in Denmark has shown that the costs of lost export may be more than 90 per cent of all the outbreak costs\(^1\). Many other studies confirm that the negative market and price effects associated with a disease outbreak may be more costly than the direct costs of lost animals and the consequential losses.

<table>
<thead>
<tr>
<th>Table 5.1. Examples of direct and indirect costs in case of an epidemic disease outbreak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business level</td>
</tr>
<tr>
<td>Costs of the animals destroyed in infected and contact herds, including the value of animals and slaughter, rendering, disinfection and cleaning costs</td>
</tr>
<tr>
<td>Costs of pre-emptive welfare slaughter of animals</td>
</tr>
<tr>
<td>Consequential losses can compromise one or more of the following costs categories: Business interruption costs because farm buildings are becoming more or less empty for a certain period etc. Costs related to established restrictions zones, e.g. extra feeding costs, costs of additional hygienic measures and extra transportation costs</td>
</tr>
<tr>
<td>Costs from emergency vaccination</td>
</tr>
<tr>
<td>Sector level</td>
</tr>
<tr>
<td>Costs of increased unemployment in the whole supply chain as well as other industry costs, e.g. excess slaughter capacity</td>
</tr>
<tr>
<td>National level</td>
</tr>
<tr>
<td>Costs associated with implementing in the veterinary operational preparedness, e.g. establish and monitor restriction zones</td>
</tr>
</tbody>
</table>

Loss of competiveness and reduced reputation are seen as two examples of indirect costs at the sector level. National costs are the costs of implementing the operational

\(^1\) See the project website: [www.vet.dtu.dk/English/Research/Projects/FMDSIM.aspx](http://www.vet.dtu.dk/English/Research/Projects/FMDSIM.aspx)
procedures of the veterinary contingency preparedness for a timely and efficient management of a disease outbreak as well as the costs associated with the public financed compensation payments to the affected farmers. According to Van Asseldonk et al. (2006: 117) refunds the veterinary budget of EU in most cases 50 per cent of the compulsory and pre-emptive slaughter, 70 per cent of the costs of welfare slaughter and 50 per cent of the costs of organization.

Indirect costs at the national level might for example be increased costs to protect public health. Table 5.1 clearly shows that the costs are increased for many different stakeholders in case of a disease outbreak. An English study, cited from FCEC (2006: 25ff.), shows that the total cost of the FMD crisis in the United Kingdom has been 13,594 million euros. Of this amount the 7,799 million euros or 57 per cent were economic losses to the tourism industry in the country.

It is important to recognize that Table 5.1 only shows the potential costs when a serious disease outbreak has occurred. Thus, either the costs to disease prevention and contingency planning in peace time or the costs to diagnostics etc. in the period of a suspicious of an infectious animal disease outbreak are included in the Table.

5.2. The Danish case

In Denmark, infectious animal diseases included in List 1 (see section 4.4) are so serious that the Government compensates the outbreak losses in accordance with the rules described in Order 239 of 12/04/1991 and Order 812 of 29/10/1999, whereas no public compensation is automatically provided for diseases on the List 2. However, in some cases diseases on List 2 are handled approximately in the same manner as List 1 diseases.

The costs paid by the Government in case of an outbreak, where combating is demanded by the veterinary authorities, are:

- indemnities for animals ordered slaughtered
- indemnities for feedstuff, eggs, milk etc. that are public ordered destroyed
- indemnities for 20 per cent of the affected farmers’ consequential economic losses

This section is mainly based on unpublished documents although some information about the Danish schemes might be found in Koontz et al. (2006).
• for diseases related to List 1 diseases, the Government also covers the following costs:
  - samples that are collected in case of a suspicion or after an outbreak of a disease
  - destruction and rendering of the animals
  - cleaning and disinfection of the infected farms
  - other costs ordered as part of the combat of the infectious disease
• for diseases related to List 2 diseases, the Government covers the following costs:
  - samples that are collected in case of a suspicion of an infectious disease

One of the largest costs in the event of an infectious outbreak is the cost to clean and disinfect the affected farms. Two elements are included in this cost. The first is the cleaning and disinfection cost used to enclose the further transmission of the infection. Secondly, the other element is the cost to bring the farm back to a level of biosecurity where it can again produce and trade at normal conditions. The cost to clean and disinfect in this second step is highly dependent on the maintenance level of the buildings, equipment etc. on the farm as well as the attitudes and behavior of the farmer.

The Danish compensation and financing schemes are shown in Figure 5.1.

The public indemnities and related costs are financed as a separate account on the Danish state budget. As it is a statutory account, it is possible for the Danish Veterinary and Food Administration to use the account without any upper limits in case of an outbreak emergency. For costs related to specific diseases and activities in combating an outbreak the Danish Government may be reimbursed from the EU. In 2012, the EU co-finances surveillance programs for TSE (BSE and Scrapie), Bluetongue and Avian Influenza.
Concerning indemnities to farmers for the remaining the 80 per cent of the consequential losses, which are not covered by the Government in case of a List 1 disease, these may be financed by the production levy funds that have been established in Danish agriculture. Today, there are in total 14 production levy funds, which is one for each agricultural sector that collect levies (and including one special per mille levy fund covering the whole agriculture that is not considered in the report). All farmers in each of the 13 sectors pay a levy according to the amount of agricultural products sold. Thus, the production levy paid is proportional to the amount sold from the farm.

Each production levy fund is governed by a board with public as well as commercial representatives that are appointed by the Minister of Food, Agriculture and Fisheries. The boards are independent and have the authority to make their own decisions within the constituted legal framework. In the area of animal disease prevention, eradication and control, it is possible for the board to support activities of public interest such as activities concerning zoonotic diseases, Avian Influenza and Newcastle disease. Fur-
thermore, the legislation makes it possible for the production levy funds to pay indemnifies to affected farmers in case of specific animal disease outbreaks.

Positive incentives
During peacetime, the Danish compensation and financing schemes provide some incentives for farmers to disclosure of suspicions of an infectious animal disease.

Furthermore, in the event of a List 1 disease outbreak the current schemes ensure a safety net for livestock producers. Farmers’ compensation for the direct and some indirect costs associated with such a disease outbreak ensure that their incomes are not grossly affected by the outbreak.

Negative incentives
There are a number of potential disincentives embedded in the existing compensation and financing schemes both during peacetime, during periods of suspicions and in periods of actual outbreaks.

In peacetime, the schemes do not really provide any incentives to farmers for early disclosure of a suspicion of an infectious disease. One reason is that the farmer cannot be sure that the suspicion is related to a List 1 disease. If it is not a List 1 disease, the farmer may receive no economic compensation. Another reason is all the restrictions that are made on the production and trading activities in case of a suspicion. Even if the suspicion is shown to be false, the farmer might still have high costs due to e.g. loss of trading partners.

Furthermore, in peacetime (as well as in periods of suspicions and outbreaks) there seems to be only weak incentives for ensuring “Good Agricultural Practice” in order to minimize the losses and costs associated with an outbreak. For example, the Government covers all the cleaning and disinfection costs if the herd is infected with a List 1 disease which is reducing (i.e. crowding-out) farmers’ incentives to ensure a good maintenance of farm buildings and equipment. In fact, for these diseases the farmer has no economic incentives for doing any prevention above the minimum requirements stated in the legislation.

After an infectious disease outbreak has occurred, the potential disincentives dependent on whether the livestock farmer is affected directly or indirectly. If the farmer is directly affected by having the List 1 disease in his herd, the farmer seems to have the
right incentives to disclose the disease. The disincentives are much more obvious for livestock farmers that are indirectly affected by being e.g. located in protection and surveillance zones. The Danish schemes don’t provide these farmers with any compensation although they might incur significant costs due to e.g. no allowance of trading and other movements of animals. In reality, some of these indirectly affected farmers might be better of economically by having the disease in their herds. This is a huge disincentive problem that is not properly handled by the current Danish schemes.

5.3. Case I: The Netherlands

In the Netherlands, there exists both a private - public collaboration dealing with epidemic animal diseases and private insurance products that cover other related livestock risks. The private-public collaboration has led to the establishment of the Animal Health Fund. The compensation and financing schemes with public involvement in the Netherlands are illustrated in Figure 5.2. The Animal Health Fund is closely related to the Ministry of Agriculture, Nature and Food Quality (in the following referred to as the Ministry or the Government) as shown in the Figure.

In case of a disease outbreak, the Ministry uses the Animal Health Fund to pre finances payments involved in indemnification and other related costs to farmers as prescribed in the legislation. The Fund covers costs such as culling, rendering, disinfection, and also vaccination and other prevention measures in case of specific disease emergencies. Afterwards the Ministry then invoices most of these expenses to a Product Board. The Product Board is also obligated to reimburse some other costs related to e.g. diagnostics of animal diseases and mandatory monitoring programs. The reimbursement by the Product Board is financed primarily by using own reserves and bank-guarantees and secondly by imposing levies on livestock farmers.

However, the Product Board only refunds the Ministry up to a certain pre-determined ceiling. Above this ceiling, the Government fully pays the rest. The ceiling for different animal sectors (as well as the maximum contribution for different diseases) is reached through negotiations between the Ministry and farmer representatives. The amount contributed by each subsector (to the Animal Health Fund) is dependent on the type of production and e.g. the need for refinancing the Fund due to previous out-

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3 This section is mainly based on section 4.2 in FCEC (2006: 40 ff.).
breaks. The levies are proportional to the level of production, e.g. the milk delivered and pigs and cattle slaughtered. Thus, levies paid by farmers are not differentiated according to individual farm and/or production risks. However, as only the direct costs of culling, rendering etc., but not the consequential economic losses, are covered by the scheme, the Dutch farmers might still have incentives to take preventive actions.

As shown in Figure 5.2, the Product Board covers the whole supply chain and it exists for a number of livestock industries. Three Product Boards are relevant with respect to the Animal Health Fund. In specific areas a Product Board is authorized to make statutory rules. Although the Product Board covers the costs by financing the Animal Health Fund (up to pre-specified limits), it is mainly the Ministry that makes the decisions about culling, rendering, disinfection and prevention in case of an outbreak. Thus, the Product Board makes the decisions about preventive actions, while the Ministry makes decisions concerning the control measures in case of a suspicion and/or outbreak.
The amount of compensation is based on the value of the animals before the outbreak or an equivalent value in the absence of realistic market prices. The final amount to be paid to the individual farmer is determined by the Ministry. In order to provide incentives for early disease reporting, the amount compensated is reduced to 50 per cent of the market value for animals with visible disease symptoms and no compensation for dead animals. These animal numbers are obtained at the first visit by the veterinarian after the farmer has reported an outbreak of a disease. The Animal Health Fund also pays for direct costs for non-commercial holders in order to provide them with incentives to report animal diseases early.

Farmers are obligated to meet certain hygiene standards at the farm which are checked by a veterinarian. If it is found that the outbreak was the fault of the farmer himself or certain conditions are not met, economic penalties can be imposed on the farmer.

*Positive incentives*
This system allocates financial responsibility to the production chain who decides on the prevention of disease epidemics. The ministry decides on control measures in case of a disease outbreak. It also provides incentives for early reporting to reduce the overall losses caused by the disease outbreak.

*Negative incentives*
A minor weakness of this scheme is that it does not provide strong incentives for farmers that plan to leave production after a disease outbreak because they do not pay levies after a disease outbreak. All they lose is from consequential losses and reduced compensation in case of a visibly diseased animal or dead animal.

After the ceiling of the amount to be compensated by the Product Board is reached, producers do not meet any of these direct costs but only the consequential losses.

5.4. **Case II: Germany**
In Germany there are different schemes with public involvement in compensating livestock farmers in case of specific livestock disease outbreaks. However, the most

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4 This section is mainly based on section 4.3 in FCEC (2006: 46ff.) and chapter 11 in Koontz et al. (2006).
important one is the Animal Disease Fund (Tierseuchenkasse in German). Generally, for every federal German State (Bundesland), there exists one such Animal Disease Fund. These are public entities controlled by a board whose members are chosen from the State Ministry, veterinary authorities and farmer organizations. The compensation and financing schemes are illustrated in Figure 5.3. The Governing Board administering the Fund (together with a Board of Directors) as shown in the figure. It decides on amendments to the statutes; budget and contributions from livestock keepers; appointing auditors; and approve payments not based on statutory legislation etc.

![Figure 5.3. German compensation and financing schemes with public involvement](image)


However, the legal basis for the Animal Diseases Funds is Animal Disease Act which prescribes e.g. the animals that should be compensated. The Act also serves to ensure animal keeper’s cooperation in disease control and in the mitigation of the economic losses resulting from the dead of suspected and infected animals. Each federal State passes an Implementation Act which prescribes the details of managing the Animal Disease Fund. Therefore, the specific governance of the Funds might differ between the different federal States.
The Animal Disease Funds are the major bodies responsible for animal disease prevention, improving animal health and controlling disease outbreak. Furthermore, they are responsible for establishing and financing of infectious disease outbreak control. These Animal Disease Funds work hand in hand with veterinary authorities and the local Government to implement eradication and prevention measures that are decided by the Government.

By law, each state has to reimburse farmers for animals compulsorily culled. The reimbursement is made by the Animal Disease Fund which is 50 per cent funded by the State Government and 50 per cent funded by levies paid by livestock farmers. The Animal Disease Act requires that contributions have to be collected for each of the animal species. However, it is possible to relate the contributions to herd sizes and infection risks as well as the characteristics of the animals.

In general, farmers are compensated the value of culled animals whereas the costs involved in the rendering and disposing of the animals are not including in the compensation payment, (Koontz, et al., 2006: 141). Livestock farmers have to pay a compulsory levy to the Animal Disease Fund and have to report the number of animals at the farm each year. Annual levies calculated for each animal have to be approved by the State Government. The levies can be differentiated according to animal age, herd size and hygienic practices implemented at the farm level and the absence or presence of infectious diseases.

The Animal Disease Funds cover diseases that are defined as notifiable diseases and compensate losses from public ordered culling or losses from animals which died after destruction has been ordered as well as died animals if the dead has been caused by the notifiable disease. Animals that have died before notification of the disease outbreak are only indemnified by 50 per cent which is an incentive for farmers to notify disease outbreaks early. In case of a disease outbreak, if funds from the Animal Disease Fund are not sufficient, the federal State is liable for deficits. However, farmers finance their share of these deficits by paying higher fees in the future.

Costs for losses on healthy farms in restriction zones and corresponding marketing bans are not covered, but parts of the Animal Disease Fund might be used for preventive animal health programs to reduce losses from animal diseases. A number of insurance companies offer coverage against e.g. consequential damage and economic losses resulting from isolation and surveillance zones.
**Positive incentives**

This scheme shares responsibility between the federal State which is responsible for making decisions about culling, movement restrictions etc. and the farmers who are the owners of the animals and have the responsibility to prevent and control diseases at the farm level.

This scheme provides incentives for early disease notification as dead animals are only indemnified by 50 per cent and if there is late reporting their indemnification can be reduced accordingly.

**Negative incentives**

A minor weakness is that farmers that do not expect to continue with livestock production after an outbreak do not have the right incentives to prevent disease except for the losses incurred in case of 50 per cent indemnification and consequential losses since they don’t pay future levies.

**5.5. Differences between the three schemes**

As revealed there are some major differences between the Danish compensation and cost-sharing schemes and the corresponding schemes in the Netherlands and Germany, respectively.

One significant difference is that statutory veterinary funds are established in both the Netherlands and Germany, but not in Denmark. In both countries these funds are partly financed by contributions from livestock owners and governed by boards which have their own decision-making authorities. This is not the case in Denmark where the direct compensation costs, i.e. the culling and rendering of suspicious and infected animals, are public financed as part of the Governmental budget. In all three countries a share of the public financed outbreak costs might be reimbursed from the Veterinary Fund in EU.

One significant difference between the Danish and Dutch compensation rules is that in the later system no compensation for dead animals due to an epidemic disease is paid in order to provide farmers with incentives for early disclosure reporting. In Denmark all dead animals from a listed disease are compensated when the disease has been reported to the veterinary authorities.
Another main difference between the Danish and Dutch schemes is that the incentives for the producers and for the Government are different in the Dutch scheme when the ceiling of compensation is reached. Above the ceiling the Dutch producers do not bear any financial responsibility of the direct costs to combat an outbreak.

A major difference between the Danish and German schemes is that there is an Animal Disease Fund for each state. This makes it possible to take account of regional differences with respect to e.g. the farm structure and the epidemic risks among regions.

Another interesting difference is that there are more experiences in Germany with risk adjusted compensation and farmer contribution payments than in Denmark. For example, about 15 years ago the compensation payments were adjusted according to the size of the farm. The German Animal Disease Act also makes it possible for the federal States to take account of individual infection risks etc. in collecting the contribution from the farmer. However, it is unclear to what extent this option is utilized by the federal States.
6. Strategic options for improved disease prevention

The previous chapters indicate that major aspects of the current system would gain from a restructuring in order to move towards a more effective animal disease prevention. Many stakeholders are involved in the protection of animals and their different incentives are in many cases badly (if at all) coordinated. Often the payments for disease outbreaks are based on policies which crowd-out private incentives and thus do not provide the necessary incentives to improve disease prevention among farmers. This implies that government responses to disease outbreaks are too often crisis-driven.

In order to be able to provide better recommendations for more strategic changes in the current system, we need to know more about several fundamental issues. This chapter therefore poses a series of vital questions where more research is called for. As such the chapter addresses the features of an improved animal health policy where focus is more directed towards prevention rather than cure and where compensation schemes and the financing of these schemes provide improved incentives to animal keepers and others to maximize their effort to keep animals healthy. Improved animal health starts with a clear understanding of the sharing of responsibilities and costs among farmers, the public and eventually other stakeholders.

6.1. Sharing the responsibilities and costs

When considering cost-sharing issues the first level concerns the overall sharing between the government and the livestock sector. As mentioned previously there are many arguments in favor of public intervention because of externalities and the non-exclusive nature of risk prevention. On top of that the government clearly benefits from risk prevention among livestock farmers since this ensures food supply and safety and therefore affects important health issues among the population. Furthermore, the responsibilities and thus the cost-sharing between the different livestock branches in agriculture, i.e. the pig, cattle and poultry sectors etc. should be clarified. Should the cost-sharing scheme include all farmers in the agricultural livestock sector or should there be established a cost-sharing scheme for each branch of animals?

Broadly speaking, the “golden rule” of the cost-sharing literature is that when sharing costs no agent should be forced to pay more than their “stand-alone cost”, that is, more than the cost of their outside option, see e.g. Young (1985). In the above case
this means that the government should not cover more than the expected loss to the population from an epidemic disease outbreak (i.e. the “social costs”) in a situation where there is regulation but no compensation to farmers from the government. Likewise, the livestock sector – or the subsectors! - should not be forced to pay more than their expected total profit loss from a disease outbreak (which here does not include the “social costs”). Obviously, these values will be very difficult to estimate in practice and the stand-alone cost principle therefore remains only an abstract notion which will require further simplification in order to be operational. Matters are further complicated by the fact that government regulation itself influences the costs of the industry. Since the government as a regulator sets up the “rules of the game” (zones with movement standstills, vaccination programs, penalty systems etc.), it is important that they share the cost of the consequences in order not to “over protect” the population at the expense of the livestock industry. All in all, it remains an open question how a suitable model can be developed in order to analyze optimal cost-sharing between the government and the livestock sector. Issues that deserve special attention are:

**Design of prevention incentive schemes:**

The expected costs from disease outbreaks should be kept at an efficient (low) level. Therefore risks should be controlled. How can farmers be incentivized to increase their risk preventive efforts? Note here that we do not want prevention at any cost – as a rule of thumb we should induce prevention until the marginal cost of prevention equals the marginal gain from reduced risk. In practice, it is clearly difficult (if not impossible) to determine the optimal level of prevention and due to the non-rival nature of reduced risk there seems to be a need for some kind of mechanism which induces risk preventing efforts among farmers. What should this mechanism look like?

**Design of movement restrictions:**

Is there an optimal way to set up movement restriction zones? Can we estimate costs and benefits and weigh these with the risks involved? How does the location of these zones influence the incentives of farmers and other stakeholders? What is the regulator’s incentive when setting up zones (protection and surveillance zones)?

Concerning the two latter questions: The regulator has incentive to set up zones that are too large in order to avoid various potential problems of political nature (to be on the safe side) – therefore it is important that the public also cover
part of the costs from standstill restrictions (i.e. welfare slaughter costs). The farmers on the other hand will have incentives to circumvent the restrictions by moving their animals around after restrictions have been announced – this will be an important element when designing incentive based schemes.

What are the costs and benefits of compartmentalization versus zoning? The idea of compartmentalization is that a country might define subpopulations with different health status. Such subpopulations may be defined by biosecurity measures related to disease prevention.

**Design of compensation schemes:**
How to set up optimal compensation rules? Although compensations may provide incentives for effective and rapid control measures, they may not provide incentives for prevention above minimum legislative requirements. Should the compensation rules be equal for all types of farms, e.g., cattle, pigs and poultry or should the rules be differentiated according to e.g., type of production and eventually other farm characteristics?

### 6.2. Prevention index

Naturally next step in the cost-sharing process concerns allocation internally in the agricultural and food industry between different branches, i.e. the cattle, pig and poultry sectors, and in the end between the individual farmers of a given industry branch. With respect to the latter, we shall here propose that the cost-sharing scheme is based on a suitably defined farm or herd level based prevention index.

One idea is to make livestock farmers’ contributions to the insurance system correlated with (proportional to) their prevention levels and efforts and as such be the foundation for price discrimination when setting up the overall insurance scheme. This provides the farmers with further (ex-ante) incentives for risk prevention.

As a possible tool, the prevention index should be an aggregate proxy of farmers’ risk preventing efforts. The main question is of course what should be contained by this measure? And how should the different risk factors included in the index be weighted in the final aggregation? Should it be absolute or relative to other farmers’ efforts? And for practical relevance - are the relevant data available – and if not, what is required?
Concerning the construction of the prevention index, the scope is the first thing to be decided: Which type of diseases should be covered (as mentioned there is currently different lists of diseases with varying degree of public awareness), and in close relation to that, should the index cover only animal health issues or should it cover health in the broader sense of animal welfare and general food safety? Practical issues seem to speak in favor of an index more narrowly related to animal health issues and diseases related only to “List 1” types such as shown in Table 4.3. In general, it is important that farmers can see a direct influence on the index value from their health preventing efforts. Broader issues related to animal welfare and food safety at large would ideally be interesting to include but practical application of the index is likely to limit the level of possible abstraction as many measurable effects on animal welfare and food safety may only present themselves in the long run. But it remains an important discussion and one which is closely related to practical aspects of implementation of the index.

Secondly, there are several ways of looking at production of animal health and this becomes relevant when searching for relevant factors to include in the prevention index. For example, if we consider the input side, relevant factors may include number of vet visits while considering the production process itself puts the organization of production into focus, such as the specific design of stables etc. On the output side, the number of animals without disease annotations may constitute an example of a potentially relevant factor.

The specific focus becomes important since if we for example focus on the production process and reward farmers for implementing a certain design of their production system (which may seem superior from a biosecurity point of view) we may potentially introduce a source of inefficiency in the system by “forcing” some farmers away from what would otherwise have been the optimal technological solution given their specific situation (see also the further comments on the negative side effects of the prevention index below).

It has also been argued elsewhere, e.g. see (European Commission, 2007), that a rating of farmers should include such things as disease status and various issues related to biosecurity compliance, all potentially relevant aspects. As mentioned, it is crucial that there is a clear correlation between farmers’ risks preventing efforts and the index value and that these can be registered by the farmers in the short run. However, the
index may partly depend on fixed factors such as geographical location and current production facilities in order to reflect the risks associated with these factors (which of course may be influenced by management decisions in the long run). It appears though that there are good arguments in favor of weighing factors that are directly influenced by the farmers risk preventing behavior higher than the fixed factors in the prevention index.

Another relevant aspect is whether the index should be absolute or relative. That is, should we measure the index value on an absolute scale defined for each factor and then aggregate or should the performance of the farms be measured relative other farms in the sample based on a multifactor “best performance” frontier (as it is known from e.g. productivity analysis). Again, there are no clear cut and straightforward arguments in favor of either. However, theoretical literature seems to suggest that a relative approach will be preferable, see e.g. Bogetoft (1994) and Bogetoft (1995). In particular, it can be shown that a relative index (designed on the basis of a multifactor “best performance” frontier) contains sufficient information for the construction of optimal incentive schemes. Below we shall briefly sketch the idea behind a relative evaluation. Consider the illustration in Figure 6.1.

**Figure 6.1. Absolute versus relative prevention index**
Say there are two relevant factors to be included in the prevention index: the number of vet visits, y, (where more visits is a proxy for better prevention) and the number of purchased animals, x, (where more animals is a proxy for worse prevention). A farm is represented by an observation (x,y). Loosely speaking, one farm, a, is said to dominate another farm, b, with respect to prevention effort if b has purchased more animals than a and has had fewer vet visits than a. On the basis of observations from the sample of all farms we can now estimate the undominated frontier, e.g. by convex envelopment of the data points. A given farm (b in the figure) can then be measured against the frontier using different types of projections onto the frontier – e.g. radial projection, shortest distance, hyperbolic distance etc., depending on the type of measure that fits best with the situation at hand. In the Figure, we have illustrated three different directional distances; one for each factor and one where distance is measured relative in the direction (-1,1) indicating that the benchmark farm should be farm a in the figure. A part from decisions concerning the appropriate measure there are also issues of estimation techniques for finding the frontier, underlying restrictions on weights (prices) etc. known from the literature on efficiency analysis, see e.g. Bogetoft and Otto (2011). Compared to an absolute index with fixed weights (wx, wy), the above relative approach is much more flexible and acknowledges that there may not be constant returns to scale in effort. For example, farm d in the figure in considered benchmark farm using the relative approach whereas an absolute ranking would render d lower ranked than a which is top ranked given the weights.

It is obvious from the above discussion that the specific construction of the index should be carefully researched before taken into use. Determining the various factors to be included and restrictions on weights of the index is a job that needs to be done in cooperation with the veterinary sciences. Moreover, it should probably be considered to publicly announce the result of the prevention index in order to obtain the best incentive effect. This is known from other areas of public monitoring and control with resulting “Smiley” evaluations, and typically has the effect that various stakeholders’ potential response further incentivizes the agents.

Having talked about introducing the index and its possible construction, it is also important to analyze any potential or indirect negative side effects from implementing a prevention index in practice. For instance, if frequent movement of animals increases risk, the index will punish trade and this will subsequently limit competition and gains from trade. Likewise, if we punish geographical density this may influence the geo-
graphical structure negatively in the long run – it should favor large farms distant from each other which will mean the end of small rural communities etc. All this must however be carefully researched before introducing the index in practice.

Above it was mentioned that the prevention index can be used to price discriminate when paying the premium of the insurance scheme. Another potential idea is that the prevention index may be used to reallocate costs between farmers ex-ante periodically in the short run: To improve incentives for preventive efforts, farmers need to see a clear connection between the immediate costs of effort (either direct costs or indirect transaction costs) and the benefits in terms of improved animal health and following reduced production costs in long run. It has already been mentioned that the non-exclusive nature of reduced infection risk and the obvious externalities involved are serious obstacles for this.

To overcome this problem, we may imagine an institution where farmers (each year) pay a certain insurance fee per animal common for everyone (as they already do now). However, unlike what is done now, if no disease outbreak occurred during the year, funds are returned to farmers but this time based on their prevention index. This means that some farmers will receive less than they paid on account (if their prevention index is low) while others will have a net gain (if their prevention index is high). As such there is a reallocation going on between farmers. In effect, farmers with low prevention efforts pay to farmers with high prevention efforts in order to compensate those for their positive externalities.

In case of disease outbreak, farmers can be reimbursed based on the prevention index according to a suitable insurance system where the government could offer credit in case of insufficient funds at the time of outbreak. Compared to the idea above where the prevention index is used to price discriminate between farmers at the time when premiums are paid into the system, farmers are here discriminated when money goes out of the system as either refunded or reimbursed.

6.3. Risk assessment and its relation to spacious factors

Part of the information contained by the prevention index could also relate to risk assessment in networks. We have already mentioned that movement of livestock increases infection risks. Geographical density of farms is another relevant risk factor. These factors are spacious in the sense that farms can be seen as in network relations
with their geographic location and trade patterns. The network here represents a kind of map that may prove useful not only for risk assessment but also for design of movement restriction zones in order to control and manage disease outbreaks. An interesting issue related to the prevention index is to what extent that risk is correlated with various centrality notions from graph theory that describes the importance of agents or links in a network, see e.g. Jackson (2008).

The literature on Social Network Analysis (SNA) provides the necessary tools to analyze and interpret the contacts between farmers which can be associated with animal location and other forms of contact (e.g. through trade, movement of livestock, human contact, veterinary contact and even through the air when neighboring another farm). Given that there are different influencing factors it becomes essential to apply different network centrality measures. Regression analysis can then be conducted to determine which of the influencing factors has the largest effect on increasing or decreasing the infection risk.

The challenge is twofold: First to develop a theoretical model, that is a network model reflecting vital elements that influences infection risk and relevant centrality notions, and second to either obtain estimates based on simulation studies or to obtain concrete empirical estimations. This requires close cooperation with the veterinary sciences.

Can we measure the marginal change in the overall risk of the network when adding or removing a farm with a certain centrality index?

In connection with design of restriction zones tools from network analysis can also be used to analyze what will happen to the surveillance zone when adding or removing a tie from the surveillance area. It can be determined whether there is a tendency for farmers to add more trading ties to their network and thereby increase their level of centrality. One way to investigate centrality is by using Exponentially Random Graph Models (ERGM). By using ERGM it is possible to measure any general local effect important in explaining the structure of the surveillance zone. To estimate the ERGM parameters, Markov Chain Monte Carlo Methods (Snijders, 2002) can be used.

Previous literature such as Bigras-Poulin et al. (2006) and Bajardi et al. (2012) apply network approaches (including centrality measures) on the trading of livestock to investigate disease spreading. We propose to go further in analyzing vital elements that
influence the infection risk and the overall organization of the protection and surveillance zones.
7. English summary and recommendations

The aim of the report is to investigate the economic incentives for preventing infectious animal diseases at the farm level in order to achieve a fair and efficient sharing of the responsibilities and costs associated with risk management and surveillance of animal diseases as described in EU’s Animal Health Strategy 2007 - 2013.

The report provides an overview of the biosecurity concept and describes the general mechanisms behind economic incentives. Specifically, the report addresses the following questions:

1. What are the existing economic incentives and barriers for animal disease prevention, especially for pig and cattle farmers?
2. What are the current compensation and risk financing schemes for infectious disease outbreaks in Denmark and how does it compare to schemes in other countries?
3. What are the opportunities for providing livestock farmers with improved incentives to prevent animal diseases?

The focus is on highly infectious cattle and pig diseases that have serious consequences for health and production as well as the whole society (e.g. diseases categorized as List 1 diseases by the Danish veterinary authorities). These diseases include for example the Foot and Mouth Disease (FMD), Bluetongue and Classical Swine Fever (CSF). They all have the potential to cause widespread economic losses in case of an outbreak.

The analytical part of the report consists of chapters 3 to 6 where it is analyzed how the existing direct as well as indirect economic incentives might be modified in order to provide livestock farmers with better economic incentives for improved disease prevention. The analyses carried out are mainly based on qualitative descriptions, assessments and evaluations.

Chapter 3 contains a rather detailed description of the biosecurity principles, plans and specific activities in pig and cattle herds. The main points are that:

- purchase and other movements of animals between herds ought to be minimized
animals ought to be purchased from herds with higher health status
animals moved between origin and destination herds ought to be quarantined
double fencing ought to be adopted if pasturing is utilized
signs with “entrance forbidden” ought to be set up
as far as possible all instruments and equipment ought to be available on the farm so they not need to be moved between farms
pick-up vehicles and the drivers ought not to be in close contact with animals on the farm
animals ought to be reared in batches by use of all-in – all-out production systems
mixing of young and older animals ought to be avoided
rodent control ought to be established
it is not possible give exact probabilities when a set of biosecurity measures are sufficient to prevent transmission of infection or when it is “overkill”

In Chapter 4 are the economic role of and interactions between private and public incentives in disease prevention in cattle and pig production analyzed. The main points are that:

• farmers’ private incentives may lead to an underinvestment in disease prevention
• to induce risk preventing behavior among producers it is necessary to make a risk classification of livestock farms
• the risk classification ought to be based on simple and transparent factors
• deductibles ought to be introduced in a cost-sharing scheme to reduce farmers’ undesirable behavior
• farmers’ payments to the cost-sharing scheme ought to be a combination of ex-ante and ex-post payments in relation to a disease outbreak
• farmers ought not to receive any compensation for sick and dead animals but receive full compensation for healthy animals that need to be culled to ensure economic incentives for rapid disclosure of an outbreak
• affected farmers in established restriction zones ought to be compensated in case of an outbreak, but the compensation should not exceed the minimum of the production costs and the market price
• an insurance scheme with public co-financing ought to be based on mandatory participation of all relevant livestock keepers
because of low or seldom occurrence of certain diseases, the individual farmer may underestimate the risk of getting serious livestock diseases and therefore reduces his preventive efforts.

In chapter 5 the current Danish compensation and cost-sharing schemes used in case of an outbreak of a contagious animal disease is investigated and compared to the corresponding schemes in The Netherlands and Germany, respectively. The main points are that:

- statutory veterinary funds are established in both the Netherlands and Germany, but not in Denmark
- the Dutch compensation scheme does not provide any compensation for dead animals due to an epidemic disease in order to provide farmers with incentives for early disclosure reporting
- the incentives for the producers and for the government change in the Dutch scheme when the ceiling of compensation is reached. Above the ceiling the Dutch producers do not bear any financial responsibility of the direct costs to combat an outbreak
- in Germany there is an Animal Disease Fund for each federal State which makes it possible to take account of regional differences with respect to e.g. the farm structure and the epidemic risks among regions
- there are more experiences in Germany with risk adjusted compensation and farmer contribution payments than in Denmark

In chapter 6 are some strategic options for improvements in the on-farm biosecurity by use of economic incentives discussed. The main points are that:

- the cost-sharing scheme ought be based on a suitably defined farm or herd level based prevention index
- the prevention index ought to be related to animal health and production issues and not for example animal welfare
- it is crucial that there is a clear correlation between farmers’ risks preventing efforts and the index value and that the included variable are objectively measured
- it ought to be considered to publicly announce the result of the prevention index in order to obtain the best incentive effects
- the specific construction of the index and all its effects ought to be carefully researched and politically clarified before it is take into use
- vital elements that influence the infection risk and the organization of the protection and surveillance zones in case of a disease outbreak ought to be analyzed

Thus, the answer to the first question concerning the existing economic incentives addressed in the report is that no economic incentives exist among farmers to ensure a social optimal level of animal disease prevention. Therefore, our recommendation is that the possibilities for the development of a prevention index should be researched and all potential positive and eventually negative effects carefully clarified. Development of such an index should be considered as an important first step towards a more fair and efficient sharing of all the social costs between livestock famers (and eventually other stakeholders in the supply chain) on the one hand and the public sector on the other hand. Practical experiences from e.g. the SPF system and scientific knowledge obtained from e.g. the development of animal welfare indexes should be utilized.

The answer to the second question concerning compensation and financing schemes is that we don’t have any independent veterinary fund in Denmark while this is the case in other countries that we usually compare ourselves to. Thus, the recommendation is that such an independent veterinary fund (or several veterinary funds) should be considered established to provide another mechanism for building a stronger relationship between farmers’ preventive efforts and their contributions to financing relevant initiatives both in peace time, e.g. in periods with no suspicion and no outbreaks, and in periods with a serious disease outbreak. Here it seems natural to investigate the role that the existing production levy funds might have in the establishment of such a veterinary fund(s).

The answer to third question addressed in the report concerning the opportunities to provide farmers with better economic incentives for disease prevention is that although no private incentives exist to reach the social optimal level of animal disease prevention, there are several opportunities to provide livestock farmers with improved economic incentives to prevent animal diseases. The linkage between the huge variation in the adopted biosecurity measures among livestock keepers as described in section 3.4 and the different types of efficient prevention as described in section 4.3 provides the key to see these opportunities. In section 4.3 it was shown that an efficient
prevention can be based on both control and sanctions; learning and information sharing; and development of new innovative measures.

Thus, it is recommended that the existing legislation and statutory rules are better controlled and enforced. For example, it provides the wrong signals to farmers when there are legal requirements to develop biosecurity plans on big pig and cattle farms, but there are no consequences associated with not developing such a plan (see section 3.4).

Furthermore, it is recommended that best practice with respect to animal disease prevention is identified and documented and the knowledge obtained disseminated to all livestock farmers. Benchmarking is a well-known approach used in the advisory service to motivate decision-makers to make changes in their production.

Finally, it is recommended that the practical development activities are enhanced with respect to animal disease prevention by proving financial support, e.g. through the production levy funds and the Danish Agricultural Development and Demonstration Program (GUDP), to carry out interdisciplinary innovation projects. The expectation is that enhanced participation of practical livestock farmers in the development of new preventive measures might both lead to more practical solutions and improved incentives among farmers to accept greater responsibility for the risk management of animal diseases.
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