MINIMIZATION OF THE ECONOMIC CONSEQUENCES OF AUJESZKY'S DISEASE OUTBREAKS IN THE EUREGION NL-NRW-NDS: A CONCEPTUAL FRAMEWORK

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Introduction

In this paper a conceptual framework is developed about the spread and control of Aujeszky's disease in pig farming in the region the Netherlands and the bordering German states Lower-Saxony and North Rhine-Westphalia. The main interest of this research is how (economic) measures on top of veterinary measures can mitigate the economic consequences of any outbreak of Aujeszky's disease. The aim of this paper is to describe the conceptual framework, which is the basis for quantification of the modelling of the economic consequences. The basic outline of this conceptual framework is presented in figure 1. This figure is explained in more detail in the rest of this paper.

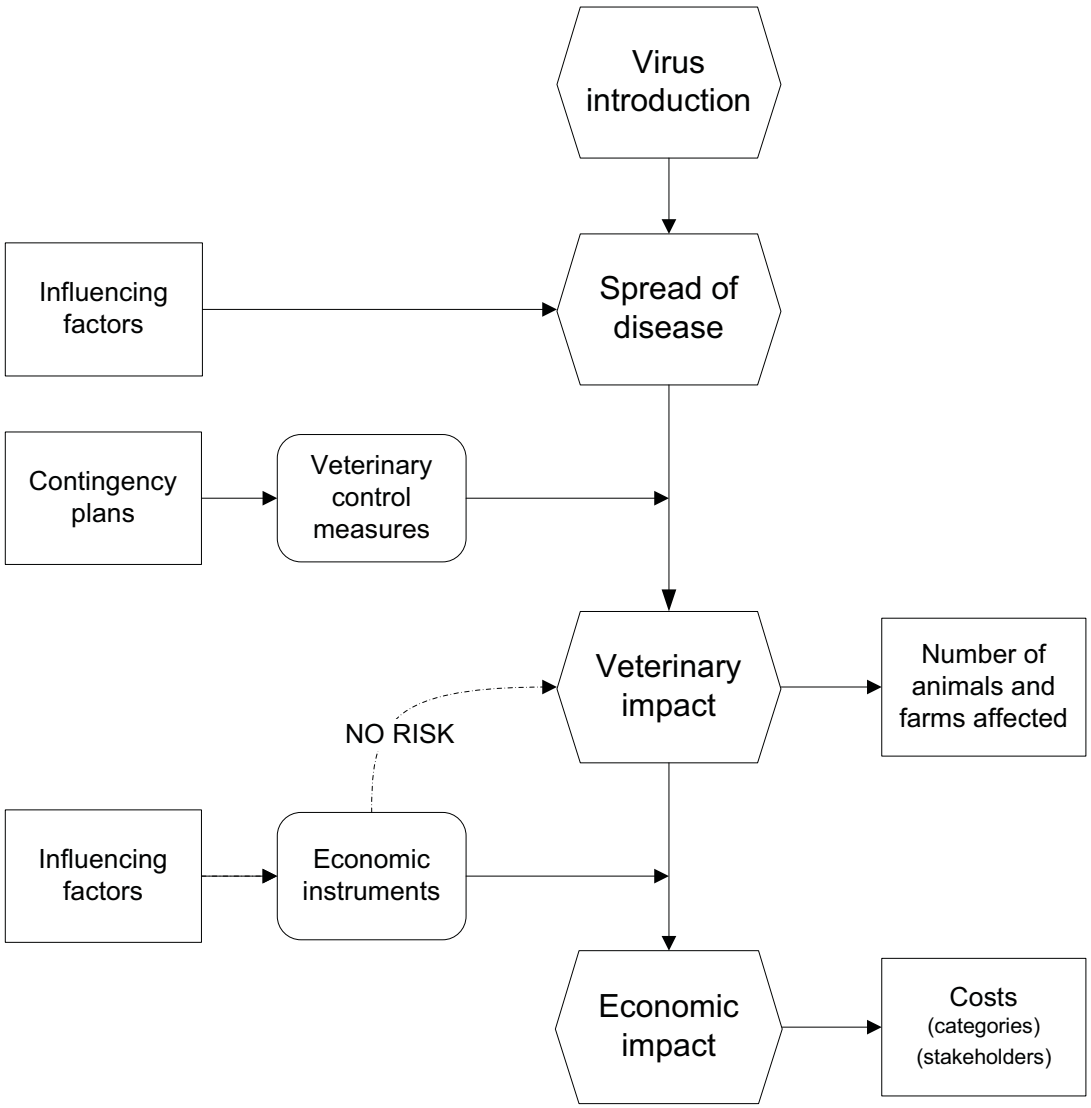

Figure 1: Conceptual framework

Virus introduction

The region the Netherlands, Lower-Saxony and North Rhine-Westphalia is currently free of the Aujeszky's disease virus (ADV). Hence, an outbreak of Aujeszky's Disease (AD) can only occur if the virus is re-introduced in the region. There are regulations and practices to prevent such a re-introduction, but once there is an introduction the virus can spread rapidly, because there is a completely susceptible population because no pig is vaccinated against Aujeszky's Disease.

Spread of disease

When there is at least one farm with Aujeszky's disease there is an outbreak. From this one infected farm the disease can spread to other farms. The most important mechanisms through which the virus can be transmitted are direct contacts between animals and for longer distances movements of live animals, vehicles and persons and airborne and local spread (Wittmann, 1991). The pig population is completely susceptible for the virus, because no pig is vaccinated against Aujeszky's disease.

Influencing factors

Several factors influence the spread of the disease. First there are factors that are related to the spread mechanisms: e.g. the number of contacts between pigs and between farms, the distances that trucks drive, hygienic measures (like cleansing and disinfection) for trucks and persons and the wind direction and speed and other climatic factors. That is why many preventive measures are related to the spread mechanisms: e.g. cleansing and disinfection of trucks, air filters in stables, minimization of contacts between farms and movements of pigs. Another indirect factor is the density of pig farms in the area around the infected farm. Also vaccination is a factor, because vaccinated pigs excrete less virus and during a shorter period. Vaccination does not limit virus spread in the first stage of the outbreak, because no pigs are vaccinated at that time.
Another factor is the number of farms that is already infected. Every infected farm is a possible source from where the virus can be spread, so the more infected farms, the more sources. Before the first detection, i.e. in the high risk period (HRP), virus spread is not limited by any control measures, so in the case of an outbreak the number of infected farms can increase easily. The number of farms infected in the HRP partly determines the magnitude of the outbreak during the post-HRP or disease control phase.

Veterinary control measures

The aim of the veterinary control is to minimize the veterinary impact and to eradicate the disease as soon as possible. An underlying assumption is that the costs of the outbreak are minimized when the disease is eradicated as soon as possible. This approach can be in conflict with other aims like minimizing socio-ethical impact and minimizing the economic impact for the affected stakeholders. The control strategies are therefore not only based on veterinary preferences, but also on others. The veterinary instruments can be deployed to protect the susceptible animals or herds from becoming infected and to mitigate the consequences for the already infected animals. There are two ways to prevent animals from becoming infected: reduce the virus transmission so that the chance to become infected is lower and increase the resistance of the animals so that more virus is needed to fall sick.

Contingency plans

The measures that are taken both in the Netherlands and in Lower-Saxony and North Rhine-Westphalia are laid down in contingency plans. Although the proposed measures are designed to control the outbreak of the disease, non-veterinary factors like legal settings, ethical beliefs, risks for human health and cost-effectiveness also play a role in the ultimate plans. The contingency plans are embedded in and follow from the legal settings of the respective countries and states. These legal settings are determined by the European Union legislation and the World Organization for Animal Health (OIE).
The Dutch contingency plan is formulated by the commodity boards for livestock, meat and eggs (PVE) in consultation with the ministry of agriculture (LNV). The commodity board is the prime responsible in the control of Aujeszky's disease. The plans in Lower-Saxony and North Rhine-Westphalia are different from the Dutch plans, e.g. culling of infected animals is a control measure that is deployed in Germany but not in the Netherlands.

Measures

The plans include the following (PVE, 2009):

- **standstill**: No transport of pigs and pig products between pig farms is allowed for a duration of a maximum of 72 hours within the entire Netherlands or Lower-Saxony or North Rhine-Westphalia. This should reduce the virus transmission and give time to investigate how widely the virus is spread.
- **vaccination**: All pigs on all farms within the movement restriction zone that are not to be (preventively) removed are to be vaccinated twice. Vaccination both decreases the likelihood of infection with Aujeszky's disease virus and/or reduces virus spread.
- **movement restriction zone**: No transport of pigs is allowed to and from farms located within a specified zone around infected farms until at least two weeks after the second vaccination has been administered. This restricts transportation for at least four weeks. After this period transports between pig farms free of Aujeszky's disease within the zone are allowed, but not to and from farms outside the zone. Also transport to slaughterhouses within or outside the movement restriction zone is allowed. These measures are in effect until two weeks after all the animals have been removed from the infected farms and these farms have been cleaned and disinfected. The virus is then eradicated from this area. The movement restrictions should reduce the virus transmission.
- **monitoring**: Farms within the movement restriction zone and farms that have had contact with the infected farms are monitored more intensively to detect infections early so that measures can be taken.
- **culling**: In Lower-Saxony and North Rhine-Westphalia culling of infected farms or animals is deployed as an instrument to control an outbreak of Aujeszky's disease.

Veterinary impact

The disease and the control measures together result in a number of affected animals and farms. Animals can be affected directly by the disease (e.g. fall sick or die) or directly by control measures (vaccination and culling). Animals can also be affected by movement restrictions as they have to stay longer at the same farm. There will be pigs present at farms that have a weight at which they usually are transported to another farm (piglets) or to a slaughterhouse (slaughter pigs), in that case problems with respect to floor space and body size of the pigs may arise. The state of farms with infected animals or close to farms with

infected animals can change. The animals on these farms can be vaccinated or the farms can be depopulated. Or the farm can be located in a movement restriction zone. The costs that follow from the control measures and the economic consequences that follow from changes in supply and demand because of the disease are described in section 5.
The situation of an outbreak can be divided in several periods, each with different specific economic impacts.

- **Period A1**: the normal situation, i.e. when there is no outbreak of Aujeszky's disease. The number of piglets and pigs that are present in an area is more or less constant, because the number of piglets supplied to finishing farms equals the number of new born piglets and the number of pigs transported to slaughterhouses equals the number of pigs bought from other farms.
- **Period A2**: the high risk period. In this period it is assumed that it still is a normal situation and therefore it has no economic impact at that time. However, from a veterinary point of view this period makes a difference, because virus spread is not limited by control measures.
- **Period B**: the period from the establishment of the movement restriction zone until the transportation ban is lifted for trade between AD free farms within the movement restriction zone, particularly in regions with an oversupply of piglets. In this period the number of piglets in a movement restriction zone increases, because new piglets are born, but there is a ban on the transport of piglets to other farms. The number of pigs will remain constant, because no pigs can be added to or removed from the herds due to the transportation ban. Piglets that are ready to be transported to another farm and pigs that are ready to be transported to a slaughterhouse will get overweight. This number is growing each week until the movement restrictions are relaxed and transportation to farms within the movement restriction zone and to slaughterhouses is allowed. All piglets and pigs are vaccinated twice in this period, piglets that are born after the sow has received the second vaccination are not vaccinated.
- **Period C**: the movement restrictions are relaxed, transportation is allowed between farms free of Aujeszky's disease within the movement restriction zone and to slaughterhouses. The piglets and pigs with overweight will be transported first. The period ends when the pigs and piglets with overweight are all slaughtered or transported to finisher farms.
- **Period D**: in this period there are no piglets and pigs anymore with overweight, but there are still vaccinated piglets and pigs. The number of vaccinated piglets decreases sooner than the number of pigs, because the piglets are transported to finisher farms. The latter keep receiving vaccinated piglets as long as there are any left in the movement restriction zone.
- **Period E**: the situation is normal again, there are no vaccinated pigs anymore and movement restrictions are lifted.

In figure 2 a simplified situation is shown of an outbreak in an area in which production of piglets is higher than demand. It takes very long before this outbreak is under control, so the underlying mechanisms can be described well.

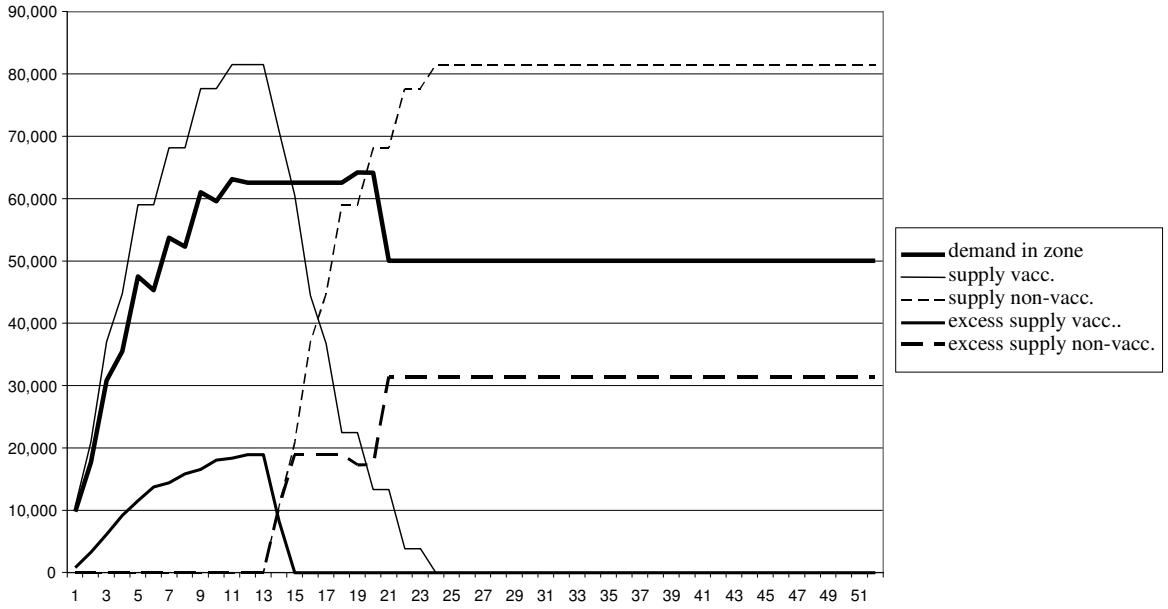

Figure 2: Example of production of piglets per week in a movement restriction zone (Saatkamp et.al, 2005).

In the first part of the outbreak the production of vaccinated piglets increases, because the movement restriction zone is extended because of new infections and all of the piglets present at that time will be vaccinated, but also demand (i.e. number of available places) increases. The number of produced piglets is larger than demand in the zone. This causes problems, because the piglets are not allowed to be transported to outside the zone, but there are no places for them in the zone either. Temporary places can overcome this problem, but not the problem that a surplus of vaccinated piglets will cause lower prices for piglets in the zone. When the movement restrictions are lifted when the surplus is largest (e.g. week 12) these effects can be more severe than when there is no surplus of vaccinated piglets anymore (after week 15). The first non vaccinated piglets are available again after about twelve weeks, the number of vaccinated piglets decreases at the same time and so does the surplus of vaccinated piglets.
The figure shows a simplified description of the problem. The effect of movement restrictions between farms within the zone for at least four weeks is not shown. Also it is assumed that slaughter pigs can be transported freely to slaughterhouses during the outbreak, which is only allowed after the restrictions are relaxed. These restrictions can cause problems with weight and size of the piglets and slaughter pigs, which makes the problem larger than shown in the figure.
An outbreak of Aujeszky's disease causes three major problems: a surplus or shortage of piglets, production of vaccinated piglets and slaughter pigs and production of piglets and slaughter pigs with overweight.

Economic impact

Cost categories

There are costs involved in the disease and the control of the disease. The costs for the primary pig producing sector can be divided in several **specific cost categories**.

1 **direct costs**, which can be divided in a) production losses, which are the costs for the farmer as a result of sick and dead animals and consequential lower production and b) direct costs of control, which are costs that are paid for the control measures. The direct costs include costs for e.g. the administration of vaccination, the culling of and compensation for animals and monitoring.
2 **consequential costs**, which can be divided in a) direct consequential costs, which directly result from the control measures (e.g. the costs of idle production factors and extra feed) and b) indirect consequential costs, which follow from price changes because of changes in supply of and demand for live pigs as a result of the disease and the control of the disease. These costs can be beneficial for some farmers and adverse for others.
3 **aftermath costs**: these costs result from the disease or its control, but occur when the disease is already controlled. These costs can be a result of price changes or changes in buying or sales opportunities.

These categories can be summed up to **total financial-economic impact**.

The costs can also be specified in another way:

- **impact for specific stakeholders**: the financial-economic impact for a specific group of stakeholders, e.g. farrowing farms or farms in a movement restriction zone. This can be for one or more or all of the above listed cost categories. An outbreak of Aujeszky's disease can have a **disproportional large impact** for some stakeholders. In the worst case the farm can go bankrupt. Therefore it is important to take this into account.

Minimizing the economic consequences can be directed at each of the cost categories apart or together. It can also be directed at mitigation of the impact for a specific group of stakeholders or to reduce disproportional impact for any stakeholder. More about the measures that can be taken in section 6.

Changes in supply and demand and price effects

Supply and demand of piglets is influenced by several factors:

- **disease characteristics**: Aujeszky's disease results e.g. in less live born piglets and in more piglets that die within several weeks after birth. Supply of piglets from infected farms is therefore lower than usual, even apart from other factors that influence supply from these farms.
- **movement restriction zone**: Farms located in a movement restriction zone are not allowed to buy or sell any pigs for at least four weeks. Because no pigs are allowed to leave the zone and new pigs are born, the number of pigs in the zone will increase.

  If the total net demand for piglets in this zone is positive in a normal situation, then the farms outside the zone that usually supply piglets to farms in this zone cannot deliver to these farms and have to find alternative sales opportunities. The larger the net demand from the movement restriction zone, the more difficult it is for the suppliers of piglets from outside the zone to find buyers. This might result in lower prices for piglets outside the zone and in higher prices inside the zone.

  On the contrary, if the farms within the zone are net suppliers the opposite is true. The farms that usually buy piglets from the zone cannot buy and have to find other suppliers. The larger the usual net supply from the movement restriction zone, the more difficult it is for the buyers from outside the zone to find piglets. This might result in higher prices for piglets outside the zone and in lower prices inside the

zone. The situation in which the farms in the movement restriction zone are net suppliers to the rest of the market has a high likelihood in the Netherlands. This situation is shown in figure 3.

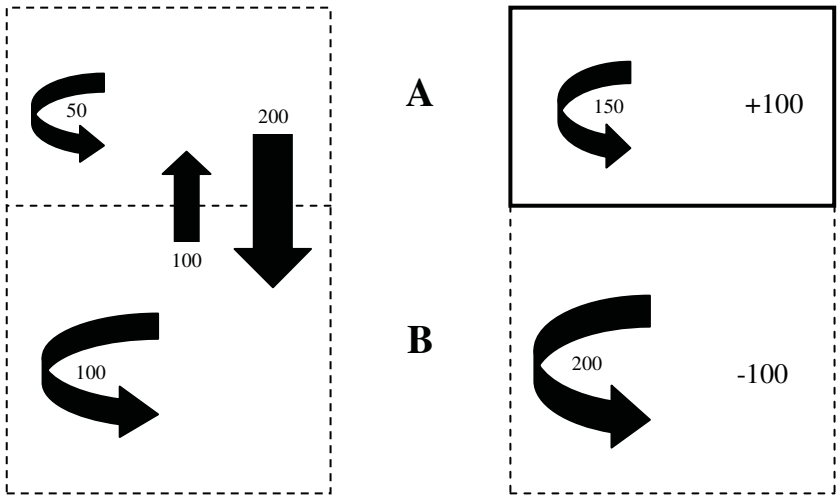

Figure 3: Example of trade volumes between and within a movement restriction zone (A) and the rest of the market (B) in which A is a net supplier in the Aujeszky's disease free situation.

- **type of animal and type of farm**: Given supply and demand and the consequential price effects as described above it matters for a farm where it is located, but also if one wants to buy or to sell piglets. If one wants to buy piglets and the price is high, this is adverse to that farmer, but if the price is low it is beneficial for the farmer. The opposite is true for selling piglets. Farrow-to-finish farms should not be any the worse for the price effects for piglets, but price effects for slaughter pigs will still affect these farms.
- **vaccination status**: Within the movement restriction zone all pigs are vaccinated. As long as the movement restrictions are operative no non-vaccinated pigs are present in the zone, except for piglets that are born from (twice) vaccinated sows. Vaccinated pigs are not allowed to be transported to areas that are free of Aujeszky's disease and where pigs are not vaccinated (Article 10 status). This limits the sales possibilities which may result in lower prices for vaccinated pigs. Vaccinated pigs can be transported to non-Article 10 status regions (e.g. Belgium). This can involve oversupply on the market in that region and consequently lower prices.
  In practice there is some freedom to transport pigs to outside the zone as long as they are meant for slaughter (PVE, 2009).
- **region**: Control measures are different for the Netherlands and for Lower-Saxony and North Rhine-Westphalia and therefore it matters where an outbreak takes place. In the German states culling of infected farms reduces supply of pigs in the short run and may result in peak demand when the movement restrictions are lifted and the empty farms can restock again.
- **stage of outbreak**: Three stages are important for the costs resulting from Aujeszky's disease.
  - **virus circulation**: In this stage the disease is spread. This stage is divided in the high risk period (HRP) and the post-HRP. In the HRP virus spread is not limited by control measures, because these are operative only in the post-HRP. Most of the direct costs are made during this stage.

- **transition**: In this stage the virus is not present any more. Most of the control measures are cut back, but some restrictions on trade of (vaccinated) pigs from the area where Aujeszky's disease was present may still exist. For a good understanding this stage should be divided in a period in which there are still vaccinated pigs and a period in which there are no vaccinated pigs any more, but still effects resulting from the outbreak, e.g. under capacity or not having the Article 10 status again.
- **normal**: There is no virus any more and also there are no vaccinated pigs. All control measures are cut back and the Article 10 status is restored. This stage is before as well as after an outbreak of Aujeszky's disease.

Because the factors that are described above can be present at the same time they can influence supply and demand and prices simultaneously.

Economic instruments

The costs that result from the disease and the control of the disease can possibly be reduced by introducing additional, economic oriented measures. These measures can be directed at reducing the supply and demand problems and minimizing the price effects. The main interest of the research is in these measures and their consequences. The dashed lines to and from the box economic instruments in figure 1 indicate that these measures are optional in the control of an outbreak of Aujeszky's disease. Measures that can be introduced when there is an outbreak of Aujeszky's disease are:

- **canalization** of vaccinated live piglets or of meat of vaccinated pigs. Vaccinated piglets from an Article 10 area where Aujeszky's disease is present are not allowed to be exported to other Article 10 areas. These vaccinated pigs can not always stay in the affected area, canalization can create possibilities to place the pigs somewhere else in the Netherlands outside the affected area and give guarantees to trade partners that the exported pigs are not vaccinated.
- establishment of **extended economic zones** around movement restriction zones for sales of vaccinated pigs. This can be a solution for problems with excess supply of pigs in a movement restriction zone if the ratio between places for piglets and hogs is askew. A disadvantage is that an extra number of farms will get involved.
- **slaughter at lower weight** can reduce excess supply of (vaccinated) pigs. A lower weight results in lower revenues, so it is not clear whether it reduces the economic consequences. Another effect is that it increases turn-over of pigs and therefore increases demand for piglets.
- **sooner slaughter of vaccinated animals** can shorten the period in which there are vaccinated animals present in an area and can so accelerate the lifting of the movement restrictions and other control measures.
- **storage of meat**: When movement restrictions are lifted the supply of pigs to slaughter houses can be much larger than usual. The extra meat can be stored to mitigate price effects due to a sudden large supply of pig meat to the market.
- **less requirements concerning animal welfare** so that more animals can be kept per unit of floor area.

In addition to the measures described above flanking instruments are required to increase the willingness to cooperate among farmers, e.g.

- **compensation**: Farmers can be compensated for any economic losses due to participation in the extra economic measures, but someone has to pay this compensation. The question is who is willing to pay. Another problem can be that compensation gives incentives to farmers to be less careful in farm management.

- **insurance**: Farmers can insure their business against possible direct consequential costs to avoid large losses.

The economic instruments (and the veterinary instruments as well) should be taken according to ethical beliefs and legal settings. Also flanking instruments are needed so that the measures and the products are accepted as good and safe by third countries. These instruments include certification/guarantees, communication and checks on the taken measures.

Risk

These measures should not involve any risk of increasing the outbreak, or in other words, the economic instruments can be implemented as long as no more farms become infected and the outbreak will not last longer.

PhD research

The main interest of the PhD research is how (economic) measures on top of veterinary measures can mitigate the economic consequences of any outbreak of Aujeszky's disease. In order to find an answer to this question the following research activities are carried out:

1. **Cross-border simulation of outbreaks of Aujeszky's disease**
   The situation in which the virus is re-introduced and at least one farm is infected with ADV is the starting point of this simulation. The risk of virus introduction and the possible introduction itself is not investigated. The outbreaks are simulated for the different control strategies of the Netherlands, Lower-Saxony and North Rhine-Westphalia, but also for a harmonized strategy. The simulations are done using InterSpread Plus and the results are inputs for the economic analysis.
2. **Economic analysis**
   The costs of control are calculated based on the output from InterSpread Plus (i.e. the number of affected animals and farms) and the control strategies. Then the consequential costs and aftermath costs are calculated, based on supply and demand dynamics of vaccinated and non-vaccinated piglets and slaughter pigs and on price effects as a consequence of the changes in demand and supply in case of an outbreak. The baseline situation is a situation in which there is an outbreak of AD and the disease is controlled by current control measures without any economic instruments. This situation is compared to situations in which economic instruments are used on top of the veterinary control measures to mitigate the economic effects of the outbreak.

This will give insight in which economic instruments are helpful to mitigate the economic consequences of an outbreak of Aujeszky's disease in a given situation, e.g. when a large outbreak is expected or when the outbreak takes place in an area with a large surplus of piglets.

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