Integrated analysis of infectious animal diseases and food-borne zoonoses

Availability of related models and methods at SSG

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Preface

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Summary

This project is part of the preparation phase in the development of a multi-disciplinary framework for the integrated analysis of infectious animal diseases and zoonoses by Wageningen University and Research Centre (Wageningen UR). In this project we made an inventory of the currently available knowledge (models and methods) within the Social Sciences Group of Wageningen UR on these topics.

In total 23 models and methods were identified. Epidemiological models and methods focus on the introduction of an infectious animal disease into the Dutch agricultural system and on the spatial spread or the spread of a disease in the supply chain. Economic models and methods encompass the calculation of financial effects for individual companies confronted with a specific disease (FMD, CSF, AI, IBR, salmonella, campylobacter) to (inter)national welfare consequences, including global effects. Possible relationships between the models as a base for a disease specific framework were established. It is concluded that the current available models and methods can form a base for the proposed framework, but the specific inputs and outputs of the different models make the actual development of the framework a challenge.

Furthermore, a short inventory of a future research agenda includes 1) the development of an emerging risk and an early warning system, 2) the calculation of (inter)national costs and impacts of disease outbreaks and of the subsequent (optimal) control strategies, 3) the handling of the spread risk during an outbreak, 4) the role of hobby and recreational farming, and 5) the possible risk of transmission of zoonoses from animals to humans.

Finally, some points of attention for the proposed framework are 1) the possibility to include both infectious animal diseases and zoonoses, 2) the possibility to consider short and long-term effects both in the agricultural production chain and in non-agricultural sectors, 3) the possibility to adapt the framework to 'new' (emerging) diseases and new eradication and control strategies, and 4) the flexibility to handle different information sources, datasets and computer programs. Furthermore, the building of an all-inclusive expert system is not advised because of 1) the dependency on one person (developer/maintainer), 2) the high costs of maintenance and 3) possible lack of user friendliness (black box idea).

1. Introduction

Animal health and animal diseases have an important national and international dimension (Bruschke, 2004). Recent outbreaks of CSF, FMD, and AI in the Netherlands showed a big impact on the primary sector and on society as a whole (Mangen & Burrell, 2003; Tacken et al., 2003; Huirne et al., 2002). Socio-economic problems arose like the killing of a large number of animals, the loss of export markets, the closure of infected areas, and spillover effects to other markets. Increasing globalisation, trade liberalisation and human mobility will further facilitate the spread of infectious diseases and increase the risks and effects of an outbreak. The increasing threat of (emerging) animal diseases turning into zoonoses, make animal diseases a human health problem as well. Thus, in terms of animal suffering, economics, and human health possible social 'losses' of future outbreaks can be very high. The development of new, fast methods for the prevention and eradication of diseases and zoonoses and the continually changing social values necessitate a regular, sound socio-economic (re-)evaluation of the eradication strategy at hand to determine the strategy with minimal social 'losses'.

Wageningen University and Research Centre (Wageningen UR) plays an important advisory role on the eradication of infectious animal diseases (e.g. Berentsen et al., 1990; Huirne et al., 2002; Mangen et al., 2002; Mangen & Burrell, 2003; Tacken et al., 2003; cVEE, 2004). It has readily available knowledge about preventive and corrective measures to reach a healthy livestock production and to react adequately on outbreaks of (emerging) animal diseases. It has an increasing readily available knowledge about the intervention costs and effects of preventive and corrective measures to reduce risks of food borne zoonoses (Van der Gaag, 2004; Mangen et al., 2005). This knowledge is mostly available at four Wageningen UR institutes:

1. ASG, QVE with knowledge about modelling data (originating from actual disease outbreaks) to support decision making to contain the spread of these diseases;
2. SSG, BE with knowledge about (modelling) the epidemiological spread of infectious animal diseases, about the calculation of socio-economic consequences (in the agro sector) of outbreaks, and about the calculation of optimal control strategies of zoonoses in animal production chains;
3. SSG, LEI with knowledge about the calculation of socio-economic consequences of outbreaks (agro and non-agro sectors) and about the calculation of optimal control strategies of zoonoses in animal production chains;
4. ESG, ALTERRA with knowledge about the use of spatial information to reduce the risk of the spread of a disease.

Until recently cooperation to combine this knowledge took place on a project base. Although until now a satisfying method to analyse socio-economic consequences, to retain Wageningen UR's current position as one of the leading policy advisory institutes for the eradication of infectious animal diseases and food borne zoonoses, in the future a more firm and integrated method is necessary. Therefore Wageningen UR wants to develop a framework for the integrated analysis of infectious animal diseases and zoonoses. This framework is an interdisciplinary method (including epidemiology, risk-assessment, social-economics and ethics) to exchange, compare and weigh information to evaluate the effects of potential outbreaks of animal diseases and zoonoses.

1.1 Goal of the project

This project is part of the preparation phase of a long-term project in cooperation with ASG[1] to develop this framework. The goal of this project is to provide background information on the currently[2] available knowledge at SSG (both BE and LEI) on the field of animal diseases and zoonoses and to determine the 'starting point' for the framework.

1.2 Research method

The current 'starting point' of the framework was determined with four phases:

1. to make an inventory of the available quantitative and qualitative models and methods on the field of animal diseases and zoonoses within SSG;
2. to determine the mutual relationships between the models and methods;
3. to determine the reach of the existing knowledge (based on e.g. science field, disease, level of detail, location in the supply chain, time to answer);
4. to gather background information on experiences with the development of integrated frameworks, on a future research agenda for Wageningen UR, and on infectious animal diseases and zoonoses eligible for the framework.

The current knowledge was gathered by making an inventory of existing models and methods developed within the SSG (LEI and BE) in the field of animal diseases and zoonoses. Information was gathered in interviews with the persons who developed and/or currently maintain the model[3]. Models without a relation to animal diseases or zoonoses and models that are not used anymore (it was concluded that further use would be too difficult) are not part of the survey. Model descriptions provide the following data:

1. purpose of the model;
2. technical information as name of the model, type of model, technique, output and input;
3. information as regards content: type of pathogen, animal species, descriptions of the underlying assumptions and the operation of the model, position within the framework;
4. general information as maintenance and possibilities to adjust the model and available background information.

Based on this information the mutual relationships between the models, the reach of the models and the current 'starting point' of the framework were determined. We used in-depth

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[1] Currently ESG is not a partner in the development of the framework. In the overall project cooperation with ESG will be pursued.

[2] At the end of 2004.

[3] In this report 'model' is an abbreviation of 'model and method'.

interviews with experts from Wageningen UR to gather information on experiences on the development of integrated frameworks and on a future research agenda. A literature review was used to make a short inventory of infectious animal diseases and zoonoses eligible for the framework.

1.3 Structure of the report

Chapter 2 describes the infectious animal diseases and zoonoses. Chapter 3 describes the available models at SSG and provides the relationship between these models. Chapter 4 addresses some preconditions for developing a framework for the integrated analysis. Finally, chapter 5 gives concludes.

2. Infectious animal diseases and zoonoses

This chapter gives an overview of infectious animal diseases (paragraph 2.1) and zoonoses (paragraph 2.2). For diseases and zoonoses that are referred to in the models a short description of the diseases and of their potential effects is provided.

2.1 Infectious animal diseases

This paragraph describes the most important infectious animal diseases using the formerly OIE list A diseases and OIE list B diseases.[1]

Formerly OIE List A

List A diseases, according to the OIE Classification of diseases, are transmissible diseases that have the potential for serious and rapid spread, irrespective of national borders, that is of serious socio-economic or public health consequences and that is of major importance in the international trade of animals and animal products (www.oie.int/eng/maladies/en_classification.htm). The OIE list A diseases includes the following diseases:

- foot and mouth disease (FMD);
- swine vesicular disease;
- peste des petits ruminants;
- lumpy skin disease;
- bluetongue;
- african horse sickness;
- classical swine fever (CSF);
- newcastle disease (ND);
- vesicular stomatitis;
- rinderpest;
- contagious bovine pleuropneumonia;
- rift Valley fever;
- sheep pox and goat pox;
- african swine fever;
- highly pathogenic avian influenza (AI).

At SSG models have been developed for FMD, CSF and AI.

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[1] From the beginning of 2005 the OIE list A and OIE list B are not used anymore. The diseases are combined in one list of 'Diseases Notifiable to the OIE'. Because this research was conducted in 2004 we list the most important animal diseases using the formerly OIE list A and OIE list B.

FMD

FMD is one of the most contagious viral diseases affecting all cloven-hoofed animals. It has a high morbidity rate. Mortality is often high in young animals, but low in adult animals. Generally, infected animals recover within 8 to 15 days. Clinical signs include fever, anorexia, shivering, lesions and blisters in the area of the mouth and the feet/claws. Transmission occurs mainly directly or indirectly via droplets, animate vectors (animals, humans), inanimate vectors (vehicles, machines). In temperate zones, airborne transmission is possible up to 60 km overland and 300 km overseas. The virus can survive in milk, milk product, bone marrow and lymph glands.

FMD may also affect humans. This, however, occurs rarely. Clinical signs are mild headache, fever, fluid-filled vesicles on hands feet and oral blisters on tongue and palate. Humans recover within a week after occurrence of blisters.

There is no treatment of FMD. In case of an outbreak EU regulations require the slaughter of all infected animals followed by a proper destruction of exposed cadavers and animal products. Trade effects occur as no trade of live animals between FMD-infected and FMD-free countries is allowed and heavy restrictions on the trade of livestock products from FMD-infected to FMD-free countries exist. Thus, the presence of FMD in a country can have a serious affect on the export of other agricultural products to FMD-free countries. Furthermore, restrictions of local trade of animals and movements of people when outbreak occurs can affect tourism and recreation.

If (preventive) vaccination is allowed animals are not destructed anymore, but this can have significant consequences. First, for countries involved in international trade it may harm the international trade status from 'disease free without vaccination' to 'disease free with vaccination'. Second, some vaccines do not protect against the infection but only against the clinical signs. Hence, the disease can spread further among animals. Third, annual re-vaccination is required, with is costly and time consuming.

CSF

CSF is a viral disease in pigs. Mortality of the CSF virus can approach 100% in young pigs. Usually, death occurs 5-15 days after the onset of illness. Most important clinical signs of an acute CSF include fever (41°C), anorexia, haemorrhages and bruises, cyanosis of the skin (especially of ears, limbs, tail and snout) and constipation followed by diarrhoea. Natural reservoirs for the CSF virus are wild boars and pigs. Transmission occurs through direct contact between animals via secretions, excretions, semen or blood, and through indirect contact via vehicles, humans (veterinarians, pig trader etc.), instruments, needles, and insufficiently cooked waste food. The virus can also transmit through the placenta and infect the unborn piglets. Subsequently, congenitally infected piglets may carry the virus for months in their bloodstreams. Outside the animals the virus survives well in cold conditions and can survive some forms of meat processing, such as curing and smoking. CSF is endemic in major parts of Asia, Central and South America, and parts of Europe and Africa.

CSF cannot be treated. Measures to be taken in case of an outbreak are the slaughtering of all pigs on affected farms, the disposal of carcasses and beddings, thorough disinfections, designation of infected zone and controlled pig movements, detailed epidemiological investigation with tracing of possible sources and spreads and the surveillance of the infected zone and surrounding area. Trade barriers, comparable to FMD, can occur between CSF-infected and CSF-free regions or countries. Furthermore, restrictions of local trade of animals and movements of people when outbreak occurs can affect tourism and recreation.

Highly pathogenic Avian Influenza (AI)

AI is a highly contagious viral disease affecting poultry. It is generally assumed that all avian species are susceptible to infection of AI. Mortality can reach 100%. Most important symptoms are severe depression, in appetence, drastic decline of egg production, and swollen and cynotic combs and wattles. Transmission occurs through direct contact with secretion (faeces, in particular) from infected birds, contaminated feed, water, equipment and clothing. Waterfowl and sea birds that do not show any clinically signs may introduce the virus into poultry flocks. Furthermore, broken contaminated eggs can infect chicks in the incubator. The AI virus can remain viable for long periods in tissues, faeces and also in water.

AI cannot be treated. Measures to be taken in case of outbreaks are slaughtering of all birds, disposal of carcasses and all animal products, cleaning and disinfection, and a waiting period of at least 21 days (EU-regulation) before restocking. Trade barriers can occur between AI-infected and AI-free regions or countries. Furthermore, restrictions of local trade of animals and movements of people when outbreak occurs can affect tourism and recreation.

Formerly OIE List B

List B diseases, according to the OIE Classification of diseases are transmissible diseases, which are considered to be of socio-economic, and/or public health importance in countries and which are significant in the international trade of animals and animal products (www.oie.int/eng/maladies/en_classification.htm). More than 90 OIE list B diseases were distinguished for cattle, sheep and goats, horses, pigs, poultry, rabbits, bees, fish, molluscs, and crustaceans (appendix 1). At SSG models have been developed for IBR, a cattle disease.

IBR

IBR is a highly infectious respiratory disease caused by the bovine herpes virus 1 (The BHV-1 exists in two variations, BHV-1.1 and BHV-1.2, of which the BHV-1.2 causes Infectious Pustular Vulvovaginitis (IPV), a venereal disease of cattle). It affects various types of cattle of all ages. Typical clinical signs are acute inflammation of the upper respiratory tract, fever, dry cough, anorexia, an increased respiratory rate, and a decline in milk production. Transmission among animals takes place via droplets from nasal secretions, semen and fetal fluids. After an infection has occurred, the virus persists in the animal all its life and may be reactivated in cases of stress and lowered resistance. In such a case, the animal again excretes the virus and affects its flock members, which again may cause an outbreak.

Eradication and vaccination are the two main methods for controlling IBR. Since the compulsory vaccination program in the Netherlands has been stopped in February 1999 (because of several cases of illness and death caused by contaminated vaccines) the protection level is declining and the risk of outbreaks is increasing.

2.2 Zoonoses

Table 2.1 gives a selection of zoonoses with current or potential risks for human health and some possible sources of human infection (Wolfswinkel et al., 2001; EC DG Health & con sumer protection, 2001; Van der Giessen et al., 2004). Serious threats occur from the trade

Table 2.1 Selection of zoonoses and possible sources of human infection

Zoonose	Possible sources of human infection
Borreliose	
Botulism	
Brucellose c)	
BSE	Beef
Calicivirus	
Campylobacter c)	Poultry meat, pork, raw milk, pets
Clostridium	Meat, heated products
Cryptosporidium parvum	Livestock, water supplies, meat
Cysticercose	
Ebola haemorrhagic fever	
Echinococcus c)	Pets
Enterohaemorrhagic Escherichia coli a)	
Giardia	
Hanta virus disease	Wild rodents
Hepatitis A virus	
Hepatitis E virus (HEV)	
Influenza a)	
Influenza A virus	Wild birds
Leptospirose	
Listeria c)	Raw milk, soft cheese made of raw milk
Monkeypox	Wild rodents
Mycobacterium Paratuberculose	Veal meat and beef, raw milk
Neurocysticercose	
Plague	Wild rodents
Psittacosis	
Q fever b)	
Rabies	
Salmonella a) c)	Poultry meat, eggs, pork, raw milk, pets
- Salmonella enteritica DT 104	
- Newport	
SARS	
Shigellosis	
Tapeworm from cattle (Taenia Saginata)	Veal meat and beef
Tapeworm from pigs (Taenia Solium)	Pork
Toxoplasmose gondii	Veal meat, pets
Trichinella c)	Pork, horsemeat, game
Tuberculosis (Mycobacterium bovis) a) c)	
Tularaemia b)	
Verotoxigenic Escherichia coli c)	Animal faeces, contaminated water
Vibriose	
Yersiniose	
Viral zoonoses	
Viral haemorrhagic fevers a)	

a) Dedicated surveillance networks are in place (Directive 2003/542/EC); b) Amended by Decision 2003/534/EC; c) Zoonotic diseases to be covered by the Community network according to Decision 2000/96/EC.

and consumption of meat from exotic animals and the emergence of new strains that are more virulent or resistant to antibiotics. At SSG models have been developed for Salmonella and Campylobacter.

Salmonella

Salmonellosis is a food-borne in humans disease caused by the bacteria Salmonella. Most important clinical signs are gastro-enteritis, fever, diarrhoea, and abdominal cramps. Further complications are possible, even leading to death. Transmission from animal(products) to humans mainly occurs through insufficient hygiene and inadequate food preparation.

Susceptible animals are poultry, pigs and cattle. Transmission among animals occurs via manure, fodder, and contaminated drinking water. In manure storage, the salmonella-bacterium can survive between one and two months (possibly longer under favourable circumstances). Financial effects in agriculture include the treatment of sick animals, destocking of farms, testing of animals (breeding stock), and the effects of a reduced feed efficiency and reduced weight gain. Other costs include the costs of food safety regulation programs and the costs of industry for product recalls.

Campylobacter

Campylobacteriosis is a food-borne disease in humans caused by the bacteria Campylobacter. It is one of the most common bacterial causes of diarrhoeal illnesses and may lead to further complications and even leading to death. Major threat to human health is inadequate preparation of contaminated poultry products, pork, beef or milk.

It is of minor significance regarding animals, mainly causing abortions in cattle, sheep and pigs and diarrhoea in pigs and poultry. Financial effects in agriculture include a decline in fertility in cattle, sheep, goats and pigs and the treatment of sick animals as diarrhoea in pigs and poultry. Other costs include the costs of food safety regulation programmes and the costs of industry for product recalls.

According to the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (April 1994) a WTO member state has the right to determine its own level of sanitary and phytosanitary standards (SPS), e.g. testing regulations. Although often inconsistent with domestic standards, many countries impose import restrictions on meat and poultry products. In general, a country is only allowed to impose import restrictions (or ban) if it has a higher health status than the exporting country. It is, however, very unlikely that a country is completely free of either Salmonella or Campylobacter.

3. SSG models related to animal diseases or zoonoses

Paragraph 3.1 describes the models[1] related to animal diseases or zoonoses available at SSG (both BE and LEI). The models are presented alphabetically. A summary is provided in paragraph 3.2. Paragraph 3.3 describes the mutual relationships between these models as a base for the proposed framework.

3.1 Description of the models

The model descriptions vary in detail depending on the availability of the developer or maintainer. The goal of this project is to gather background information on available models and methods and to determine their mutual relationships as a basis for an integrated framework. Therefore a basic description is sufficient. If more detailed information is needed for the actual development of the proposed framework, this can be found using the basic description from this paragraph.

3.1.1 AG-MEMOD

Purpose: To calculate the effects of policy changes on commodity markets: econometric modelling for projections and analysis of EU policies on agriculture, forestry and environment.

Technical information

Organisation: LEI; The Member States of EU-15 built compatible models for the agri-sector in their own country. The models are connected by INRA, France, based on prices and degrees of self-sufficiency (currently 10 models are connected).

Model type: Econometric, recursive, dynamic partial equilibrium model.

Technique: GAMS and MS Excel.

Output:
- estimated parameters for supply, demand and price formation of 27 agricultural commodities;
- land usage, animal numbers, production, food and feed consumption, imports and exports, stocks and prices on the commodity level;

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[1] Although care was taken to include all related models, it is possible that other models have a relationship as well.

- environmental indicators (CH_4, CO_2, N_2O);
- on EU level, the model calculates aggregated supply and utilisation balances for all the commodities of the member states, and determines the EU net-exports and prices.

Input:
- balance sheets for all commodities, which refer to initial stocks, production, imports, human food consumption, feed use, processing and industrial use, exports and ending stocks;
- data are obtained from New-Cronos, FAO, USDA, Statistics Netherlands.

Content

Pathogen: Not specified.

Links in chain: Primary sector, processing industry (limited).

Aggregation level: National (EU-level).

Animal and product type: Livestock products (cattle and beef, sheep and sheep meat, poultry, pigs and pig meat) and dairy products (fluid milk, cheese, skimmed and whole milk powder, butter).

Assumptions:
- production + beginning stocks + imports = domestic use + ending stocks + exports;
- endogenous closure variables (generally export of import variable) for each commodity to ensure supply and demand equilibrium condition;
- markets are linked through substitution and technological relations in production and consumption processes;
- for each commodity, the market of a specific member state is the key market and its respective price is considered as the EU key price. If a key price of a commodity is not defined, the market is influenced by its world market price;
- calculations are subject to a number of macro-economic variables (population growth, real GDP growth, inflation level, exchange rate between Euro and US$), international agricultural market prices, and agricultural policy variables (quotas on production and payment rights, direct (headage or area) payments, intervention prices).

Relation with framework: Incidental outbreaks of animal diseases are indicated in the model by means of dummy variables. Long-term effects (up to 10 year), e.g. a change in health status, can be modelled.

General information

Developed by: EU-project, based on the idea of FAPRI (University of Missouri).

Maintenance: Myrna van Leeuwen and Andrzej Tabeau.

Further use: To calculate policy changes in EU context.

Adaptation possibilities: Easy to adapt.

Background information: User manual:

User description of assumptions and working of the model:

Scientific and other publications:
Van Leeuwen, M.G.A. & A. Tabeau, 2005, *Dutch AG-MEMOD model; a tool to analyse the agri-food sector*, LEI, Den Haag, The Netherlands (forthcoming).

3.1.2 AIOM (Agricultural Input/Output Model)

Purpose: To calculate the changes in economic and environmental variables due to policy changes and incidents.

Technical information

Organisation: LEI.

Model type: Comparative, static, linear input-output model.

Technique: MS Excel and GAMS.

Output: Changes in income, revenues, employment, added value and environmental variables (energy, emission) due to a policy change or an incident (e.g. outbreak of a disease).

Input
- macro-economic input-output table of Statistics Netherlands. Agriculture, horticulture and forestry is treated as one sector and LEI devides this into 18 sub-sectors;
- demand of goods and services of different sectors;
- export, import, consumption;
- income, salaries;
- data are taken from FADN and Agricultural Census of Statistics Netherlands (Landbouwtelling, CBS).

Content

Pathogen: Not specified.

Links in chain: National (Dutch) economy (including tourism and recreation), agro complex (primary sector, processing industry and consumption).

Aggregation level: National with the possibility to regionalise the model (e.g. to province-level).

Animal and product type: Dairy cattle, beef cattle, meat calves, pigs, poultry.

Assumptions:
- fixed input-output coefficients;
- there is always enough capacity;
- fixed prices.

Relation with framework: To calculate the effects of an animal disease outbreak on e.g. income, employment, and added value in different links in the agri-chain and other sectors. It is possible to calculate mid-term effects (+/- 5 years).

General information

Developed by: LEI.

Maintenance: Myrna van Leeuwen and Boudewijn Koole.

Further use: The model is frequently used for calculating the effect of policy changes and other incidents on the whole agro-chain. The maintainers intend to disintegrate the model further into different types of farms (large, small etc.).

Adaptation possibilities: Easy to adapt.

Background information: User manual:

User description of assumptions and working of the model:

Scientific and other publications:

- Van Leeuwen, M.G.A. & A.D. Verhoog, 1995, *The agro complex in 1990 and 1993: An input output analysis*, Research report 138, LEI-DLO, Den Haag, The Netherlands (In Dutch).
- Huirne, R.B.M., M. Mourits, F. Tomassen, J.J. de Vlieger & T.A. Vogelzang, 2002, *FMD: Past, present and future: On prevention and eradication of FMD*, Report 6.02.14, LEI, Den Haag, The Netherlands (In Dutch).
- Tacken, G.M.L., M.G.A. van Leeuwen, B. Koole, P.L.M. van Horne, J.J. de Vlieger & C.J.A.M. de Bont, 2003, *Chain consequences of the outbreak of AI*, Report 6.03.03, LEI, Den Haag, the Netherlands (In Dutch).
- Koole, B. & M.G.A. van Leeuwen, *The Dutch agro complex 2003*, Report 5.03.06, LEI, Den Haag, the Netherlands (In Dutch).
- Koole, B. & M.G.A. van Leeuwen, *The Dutch agro complex 2002*, Report 5.02.14, LEI, Den Haag, The Netherlands (In Dutch).

3.1.3 Calculation model (in)direct costs AI, CSF, FMD (Rekenmodel (in)directe kosten AI, CSF, FMD)

Purpose: To determine the direct and indirect farm costs, the organisation costs and the effects on national production of a simulated outbreak of AI, CSF or FMD for a chosen control strategy.

Technical information

Organisation: LEI.

Model type
Static deterministic calculation (partial budget) model.
The model is part of a framework of 4 models. An epidemiological model (from ASG) calculates 1,000 simulated outbreaks. With the epidemiological output this model calculates (in)direct farms costs, production volume effects and organisation costs. With the production volume effects from this model GTAP calculates total indirect costs in non-agricultural sectors and on farms outside the infected area. The results from these 3 models are combined in a MCA performed at BE.

			5% percentile	**50% percentile**	**95% percentile**	
Number of farms	**infected**		**1**	**3**	**11**	
	preventively		**-**	**-**	**-**	
	vaccinated		**1**	**8**	**27**	
	welfare reasons					
Number of animals	**infected and killed**	laying hen	22.356	67.069	245.921	
		broiler	42.018	126.055	462.203	
		turkey	14.369	43.108	158.063	
		other birds	-	-	-	
		total # of birds	**78.744**	**236.233**	**866.187**	
	preventively slaughtered	laying hen	-	-	-	
		broiler	-	-	-	
		turkey	-	-	-	
		other birds	-	-	-	
		total # of birds	**-**	**-**	**-**	
	vacinated	laying hen	22.356	178.852	603.624	
		broiler	42.018	336.148	1.134.499	
		turkey	14.369	114.955	387.972	
		other birds	-	-	-	
		total # of birds	**78.744**	**629.954**	**2.126.094**	
	welfare reasons slaughtered	laying hen				
		broiler				
		turkey				
		other birds				
		total # of birds	**-**	**-**	**-**	
duration of epidemic			**30**	**34**	**52**	**days**
costs	**direct farm losses**		714.916	2.621.360	8.817.301	**€**
	consequantial farm losses		1.077.258	2.971.165	7.595.848	**€**
	organisation costs		140.346	477.702	1.498.088	**€**
		total costs	**1.932.520**	**6.070.227**	**17.911.237**	**€**
production losses	**eggs**		**106.370**	**405.044**	**1.651.692**	**kg**
	chicken meat		**628.564**	**2.304.734**	**8.538.391**	**kg**
	turkey meat		**687.530**	**2.520.944**	**9.039.836**	**kg**
	other birds meat		**-**	**-**	**-**	**kg**

Technique: MS Excel. Per country, disease and control strategy a separate version is available.

Output: MS Excel with the 5, 50 and 95% percentile of the per simulation calculated number of infected and cleared farms and animals, the associated production losses, the duration of the epidemic, the direct and indirect farm losses, and the organisation costs (example in figure) for a chosen control strategy.

Input:

- this includes a certain number of runs (usually 1,000) from excel from an epidemiological model of ASG with six variables: 1) number of infected farms, 2) number of preventively cleared farms, 3) number of vaccinated farms, 4) duration of the epidemic, 5) cumulative number of farms in MSS area, and 6) cumulative number of movement standstill days of farms within a MSS area. An example is given in the next figure (the numbers after 'stand' and 'intstand' refer to the number of days).

inf(#)	stamp(#)	vac(#)	time(d)	stand(7)	intstand(7)	stand(14)	intstand(14)	stand(21)	intstand(21)
7	7	18	39	0	0	0	0	134	201
16	14	27	54	0	0	0	0	139	208,5
6	6	13	49	0	0	0	0	94	141
2	2	4	35	0	0	0	0	64	96
1	1	3	30	0	0	0	0	33	49,5

- information on the organisational costs of an outbreak;
- zoo-technical data as milk, egg and meat yield, and reproduction numbers;
- data on the regional farm structure (number of farms, average number of animals per farm);
- data on the control strategy (EU-measures, pre-emptive slaughter, vaccination with destruction or with living).

Content

Pathogen: AI-virus, CSF-virus and FMD-virus.

Links in chain: Primary sector.

Aggregation level: Regional in 6 EU-countries.

Animal and product type

- AI - laying hens, broilers, turkeys and other poultry, eggs, chicken meat;
- CSF - pigs, pork;
- FMD - cattle, sheep, goats and pigs, milk (cow, sheep and goat), beef, goat meat, sheep meat, pork, wool.

Assumptions: All susceptible animals have the same susceptibility for a disease (used in the epidemiological model). Thus the model calculates with the average number of animals on farm size over all farms in a region.

Position within framework: Calculating direct and indirect costs and production volume of farms in infected areas and for calculating total organisation costs.

General information

Developed by: Coen van Wagenberg in 2004 for LEI-project 30179.

Maintenance: None foreseen.

Further use: None foreseen.

Adaptation possibilities: Automation of input and output is not difficult. Changing to a stochastic calculations model is possible with for example @risk. Adaptations to other diseases are easy. Changing to other countries is easy, when data is available.

Background information: User manual: No user manual is available.

User description of assumptions and working of the model:

Scientific and other publications:
cVEE, 2004, *Prevention and control of Foot-and-Mouth Disease, Classical Swine Fever and Avian Influenza in the European Union: An integrated analysis of epidemiological, economic, and social-ethical aspects,* draft report Consortium Veterinary Epidemiology and Economics (cVEE), Wageningen, The Netherlands.

3.1.4 Carma farmer

Purpose: To simulate the current total labour income for the whole sector (including farm level) and to estimate the intervention costs (in terms of loss of labour income) when implementing campylobacter intervention measures at farm level.

Technical information

Organisation: LEI.

Model type: Second order stochastic, static simulation model.

Technique: MS Excel and @Risk.

Output: As the model is developed in MS Excel, all intermediate calculations can be presented as output. Both for the situation with and without measures the results are available. Total gross margin of the broiler sector, the gross margin per kg and per one-day-old chicken, labour income at farm level, and the number of broilers in each weight category are presented on a yearly basis.

Input: Input is inserted in the model as parameters. The current model includes data on the Dutch situation on:

- number of farms in The Netherlands in 2000 (fixed);
- distribution of number of stables per farm in 2000 (fixed);
- zoo-technical data (feed conversion, primary production costs, slaughter weights divided in light, middle-weight and heavy, number of flocks per stable per year) in 2000. All parameter values used in different distributions are derived from FADN data from 1999/2000;
- prices of feed and chickens: the distributions are based on the prices from 1993 until 2003, whereby the feed price is highly correlated with the farm-to-gate price.

Content

Pathogen: Campylobacter.

Links in chain: Primary sector.

Aggregation level: Dutch national level.

Animal and product type: Broilers.

Assumptions: The broiler house size (in m2) is identical for all farms.

Position within framework: Calculation of the economic effects of measures to reduce campylobacter incidence at broiler farms. This model can be used with minor changes for other pathogens.

General information

Developed by: Marie-Josée Mangen in 2004.

Maintenance: None foreseen.

Further use: None foreseen.

Adaptation possibilities: Changing the model to calculate other Dutch scenarios requires updating the data using the known sources of information and is relatively easy. Changing the model to other countries implies updating all parameters and is more difficult.

Background information: User manual: A short manual is available.

User description of assumptions and working of the model: A short manual is available.

Scientific and other publications:

- Mangen, M.-J.J., A.H. Havelaar & K.J. Poppe, 2005, *Controlling Campylobacter in the chicken meat chain: estimation of intervention costs*, report 6.05.01, LEI, Den Haag, the Netherlands.
- Mangen, M.-J.J., A.H. Havelaar, M.J. Nauta, A.A. de Koeijer & G.A. de Wit, 2005, *Controlling Campylobacter in the chicken meat chain: Cost effectiveness and cost-utility analysis*, RIVM report 250911007/2005, Bilthoven, the Netherlands.

3.1.5 Carma slaughterhouse

Purpose: To calculate financial effects of intervention measures on slaughterhouse level by partial budgeting.

Technical information

Organisation: LEI.

Model type: Second order stochastic, static simulation model.

Technique: MS Excel and @Risk. For each intervention measure a separate model is available.

Output: As the model is developed in MS Excel all intermediate calculations can be presented as output. Only the additional costs of the measures are presented. The current output describes total annual investment costs and annual maintenance costs of measures (total, per chicken and per kg) for the whole sector in the Netherlands.

Input:
- fixed and variable costs of measures to reduce campylobacter prevalence in the Dutch slaughterhouses;
- data on the 23 biggest broiler slaughterhouses in the Netherlands (size, number of slaughter lines, number of slaughtered broilers per year);
- possible production effects of measures.

Content

Pathogen: Campylobacter.

Links in chain: Slaughterhouse.

Aggregation level: Dutch national level.

Animal and product type: Broilers and chicken meat.

Assumptions:
- all firms are identical (type and size);
- intervention measures apply for whole broilers.

Position within framework: Calculation of the economic effects of measures to reduce campylobacter during the processing of chicken meat in a slaughterhouse.

General information

Developed by: Marie-Josée Mangen in 2004.

Maintenance: None foreseen.

Further use: None foreseen.

Adaptation possibilities: Relatively easy.

Background information: User manual: A short manual is available.

User description of assumptions and working of the model: A short manual is available.

Scientific and other publications:

- Mangen, M.-J.J., A.H. Havelaar & K.J. Poppe, 2005, *Controlling Campylobacter in the chicken meat chain: estimation of intervention costs*, report 6.05.01, LEI, Den Haag, the Netherlands.
- Mangen, M.-J.J., A.H. Havelaar, M.J. Nauta, A.A. de Koeijer & G.A. de Wit, 2005, *Controlling Campylobacter in the chicken meat chain: Cost effectiveness and cost-utility analysis.* RIVM report 250911007/2005, Bilthoven, the Netherlands.

3.1.6 Costs of public health (ziektekostenstudie)

Purpose: To calculate the yearly medical costs and the yearly loss of labour productivity due to incidences of salmonellosis and campylobacteriosis.

Technical information: Organisation: LEI.

Model type: Static, deterministic calculation method based on a cost-benefit analysis.

Technique: Calculating the direct health costs (e.g. general practitioner costs, costs of medicine use, and hospital costs) and the indirect health care costs using the human capital approach (e.g. productivity losses due to illness, diseases, disablement, and death).

Output: Social costs of incidences of salmonellosis and campylobacteriosis divided in direct and indirect costs.

Input:
- yearly cases of gastro-enteritis in The Netherlands by salmonella and campylobacter infections from poultry meat;
- number of death by gastro-enteritis per year;
- number of disabled fte per year;
- costs of 1 fte per year;
- medical costs per consult;
- medicine costs per person;
- hospital costs per day.

Content

Pathogen: Salmonella and campylobacter.

Links in chain: Consumers.

Aggregation level: National (Dutch).

Animal and product type: Poultry meat.

Assumptions:
- based on the costs of diseases that can occur because of infections with salmonella and campylobacter;
- only the measurable costs are calculated.

Position within framework: Calculation of human health costs of zoonoses.

General information

Developed by: Frank Bunte in 2001 for LEI-project 64311.

Maintenance: None foreseen.

Further use: None foreseen.

Adaptation possibilities: Easy to adapt.

Background information:
User manual:

User description of assumptions and working of the model:

Scientific and other publications:
Bunte, F, M. Wolbrink, J.-P. van Rie & S. Burgers, 2001, *As fit as a fiddle. A cost benefit analysis of a reduction in contamination of poultry meat with salmonella and campylobacter.* Report 3.01.03, LEI, Den Haag, The Netherlands (In Dutch).

3.1.7 DRAM (Dutch Regionalised Agricultural Model)

Purpose: To calculate the effects of policy changes on resource allocation, production, prices and use of inputs and outputs in the agricultural sector.

Technical information

Organisation: LEI.

Model type: Static, deterministic partial equilibrium model (positive mathematical programming).

Technique: GAMS

Output:
- Allocation of inputs and outputs as a result of policy changes;
- Change in economic variables;
- Change in environmental variables.

Input:
- prices of 25 marketable outputs (incl. one by-product);
- prices of 24 intra-sectoral produced inputs (16 different types of animal manure from different types of animals, 6 different types of young animals, 2 types of roughage (grass and fodder maize);
- prices of 12 variable inputs (incl. 7 different types of concentrates for different types of animals);
- 32 agricultural activities with technical (input-output) and economic variables and parameters differentiated by region;
- agricultural policy variables;
- environmental policy variables;
- data are taken from FADN and Agricultural Census of Statistics Netherlands (Landbouwtelling, CBS).

Content:

Pathogen: Not applicable.

Links in chain: Primary sector (farms).

Aggregation level: Regional, national.

Animal and product type: Dairy cattle, beef cattle, meat calves, pigs, poultry.

Assumptions:

- Profit maximisation:
  - Maximises total profit from agriculture subject to economic, technical, environmental, spatial and policy restrictions;
  - Maximisation of profits from individual agricultural activity;
  - Profits are maximised simultaneously over all farms to take into account the relationship between market effects and farmers' behaviour;
  - Optimal resource allocation of agricultural inputs and outputs over the farms (→ maximisation of profits on national level);
  - A region is treated as one farm;
- Resource allocation is not constrained, but results from first-order conditions of profit maximising behaviour.

Relation with framework: Calculation of mid- and long-term effects of structural changes (e.g. effects of a change in health status). It is less suited to explore effects of incidental occurrences (e.g. an outbreak of an animal disease).

General information: Developed by: John Helming, LEI.

Maintenance: John Helming.

Further use: The model is frequently used for calculating the effects of changes of the Common Agricultural Policy (CAP) (Agenda 2000).

Adaptation possibilities: Easy to adapt.

Background information: User manual:

User description of assumptions and working of the model.

Scientific and other publications:
Helming, J.F.M., 2005, *A model of Dutch agriculture based on Positive Mathematical Programming with regional and environmental applications*, PhD-thesis Wageningen University, Wageningen, The Netherlands, LEI-Rapport PS.05.02, ISBN 90-8504-125-2.

3.1.8 DUPIMA

Purpose: To calculate the weekly prices of piglets and hogs during an epidemic.

Technical information: Organisation: DMW, BE.

Model type: Discrete dynamic deterministic sector-level partial equilibrium simulation model.

Technique: GAMS.

Output: Weekly simulated piglet price (25 kg) and hog price during an epidemic. The other weekly piglet prices (of 3-17 days old and of 8 kg) are derived from the simulated weekly piglet price. Used as input for EpiCosts and Economic Welfare Analysis.

Input: Weekly flow of (Dutch) piglets as estimated in EpiPigFlow.

Content

Pathogen: CSF-virus.

Links in chain: Trading of pigs.

Aggregation level: Demand and supply on the Dutch pig and pork market including imports and exports.

Animal and product type: Pigs and pork.

Assumptions:
- piglet supply is completely inelastic (this means that the time span is too short to allow the production of extra piglets outside affected areas);
- national supply of hogs equals national demand of piglets from 17 weeks before (corrected with 2% mortality);
- foreign prices are endogenous.

Position within framework: Estimation of price changes of live pigs due to volume changes of both supply and demand in the Dutch pig market.

General information: Developed by: Marie-Josée Mangen in 2002.

Maintenance: None foreseen.

Further use: The further use of DUPIMA is restricted as it is only a partial equilibrium model and only takes into account the national supply of pork and hogs. It would be better to extend DUPIMA to a GEM, thereby considering spill over effects to other live animal and meat sectors.

Adaptation possibilities: Relatively easy to adapt to all pig related diseases with short-term effects.

Background information: User manual: available

User description of assumptions and working of the model.

Scientific and other publications:

- Mangen, M.-J.J., A.M. Burrell & M.C.M. Mourits, 2004, *Epidemiological and economic modelling of classical swine fever: application to the 1997/1998 Dutch epidemic,* Agricultural Systems 81, pp. 37-54.
- Mangen, M.-J.J. & A.M. Burrell, 2003, *Who gains, who loses? Welfare effects of classical swine fever epidemics in the Netherlands,* European Review of Agricultural Economics Vol 30 (2), pp. 125-154.
- Mangen, M.-J.J., M. Nielen & A.M. Burrell, 2003, *Simulated epidemiological and economic effects of measures to reduce piglet supply during a classical swine fever epidemic in the Netherlands,* Rev. sci. tech. Off. int. Epiz. 22 (3), pp. 811-822.
- Mangen, M.-J.J., 2002, *Economic welfare analysis of simulated control strategies for classical swine fever epidemics,* PhD thesis Wageningen University, The Netherlands, pp. 187, ISBN 90-5808-621-6.
- Mangen, M.-J.J., M. Nielen & A.M. Burrell, 2002, *Simulated effect of pig-population density on epidemic size and choice of control strategy for classical swine fever epidemics in The Netherlands,* Preventive Veterinary Medicine 56, pp. 141-163.

3.1.9 Economic Welfare Analysis

Purpose: To calculate the net economic welfare change for the Dutch economy from a CSF outbreak with a specific control measure.

Technical information

Organisation: DMW, BE

Model type: Calculation (partial and enterprise budget) model.

Technique: MS Excel.

Output: The economic welfare changes of different stakeholders in the pig/pork supply chain aggregated to the net economic welfare change for the Dutch economy.

Input:
- prices of live piglets and hogs in the Netherlands and in other European countries that have a strong bond with the Dutch pork supply chain (from DUPIMA);
- Dutch national piglet and hog supply, Dutch piglet and meat demand from DUPIMA;
- direct losses of farmers, costs of welfare slaughter and of a breeding prohibition, organisational costs, vaccination costs, hygiene measure costs, and changes in producer surplus of piglet producers, hog producers and breeding farms inside a MSS area from EpiCosts.

Content: Pathogen: CSF-virus.

Links in chain: Pig producers, supply chain and consumers.

Aggregation level: (Dutch) national.

Animal and product type: Pigs and pork.

Assumptions:
- gradual restocking of depopulated farms;
- distribution of slaughterhouses in proportion to the pig population;
- only Dutch welfare effects and only the pig/pork sector from farmer to consumer.

Position within framework: Summarising the national net welfare effects of CSF outbreaks in the pig/pork sector.

General information: Developed by: Marie-Josée Mangen in 2002.

Maintenance: None foreseen.

Further use: None foreseen.

Adaptation possibilities: Difficult.

Background information: User manual: A handout is available.

User description of assumptions and working of the model: Described in the handout.

Scientific and other publications:

- Mangen, M.-J.J., A.M. Burrell & M.C.M. Mourits, 2004, *Epidemiological and economic modelling of classical swine fever: application to the 1997/1998 Dutch epidemic,* Agricultural Systems 81, pp. 37-54.
- Mangen, M.-J.J., M. Nielen & A.M. Burrell, 2003, *Simulated epidemiological and economic effects of measures to reduce piglet supply during a classical swine fever epidemic in the Netherlands,* Rev. sci. tech. Off. int. Epiz. 22 (3), pp. 811-822.
- Mangen, M.-J.J. & A.M. Burrell, 2003, *Who gains, who loses? Welfare effects of classical swine fever epidemics in the Netherlands,* European Review of Agricultural Economics Vol 30 (2), pp. 125-154.
- Mangen, M.-J.J., 2002, *Economic welfare analysis of simulated control strategies for classical swine fever epidemics,* PhD thesis Wageningen University, The Netherlands, pp. 187, ISBN 90-5808-621-6.
- Mangen, M.-J.J., M. Nielen & A.M. Burrell, 2002, *Simulated effect of pig-population density on epidemic size and choice of control strategy for classical swine fever epidemics in The Netherlands,* Preventive Veterinary Medicine 56, pp. 141-163.

3.1.10 EpiCost

Purpose: To calculate the financial consequences of CSF outbreaks of governments (EU, national), farms, and related industries in the pork production chain inside the region-with-CSF.

Technical information

Organisation: DMW, BE.

Model type: Discrete dynamic deterministic simulation model. The structure of EpiCost is based on EpiLoss.

Technique: C++.

Output: Output files are generated in ASC-format and contain the iteration number, the day number per iteration, and data on 68 types of costs that are generated: direct losses of farmers, costs of welfare slaughter and of a breeding prohibition, organisational costs, vaccination costs, hygiene measure costs, and changes in producer surplus of piglet producers, hog producers and breeding farms inside a MSS area.

Input:
- output from InterCSF: each row of the input file contains a day number, the unique ID number of each farm and the event the farm is confronted with (the day number when infected, cleared, inside MSS area, outside MSS area, welfare slaughtering, repopulating, ...). Multiple events on one day are represented in multiple rows;
- farm data (type of farm and number of animals);
- price data (daily prices paid for pigs under welfare slaughter);
- loss parameters (e.g. losses per depopulated farm per place per day);
- weekly piglet and hog prices (from DUPIMA).

Content

Pathogen: CSF-virus.

Links in chain: Primary sector, slaughterhouse, animal traders and transporters, feed suppliers.

Aggregation level: Depends on the aggregation level of the input. Usually a regional level is used.

Animal and product type: Pigs, pork.

Assumptions:
- A gradual continuous repopulation of depopulated farms;
- Fixed time length of breeding (115 days) and growing (e.g. 120 days for fattening pigs) periods;

- Fixed zoo-technical data (e.g. 21.5 piglets/sow/year);
- No culling of AI-boars.

Position within framework: Calculation of agriculture related economic financial consequences of pig related disease outbreaks inside a MSS.

General information

Developed by: Marie-Josée Mangen and Monique Mourits in 2001/2002.

Maintenance: None foreseen.

Further use: None foreseen.

Adaptation possibilities: Possibilities to adapt to all pig related diseases.

Background information: User manual: available.

User description of assumptions and working of the model.

Scientific and other publications:
- Mangen, M.-J.J., A.M. Burrell & M.C.M. Mourits, 2004, *Epidemiological and economic modelling of classical swine fever: application to the 1997/1998 Dutch epidemic,* Agricultural Systems 81, pp. 37-54.
- Mangen, M.-J.J. & A.M. Burrell, 2003, *Who gains, who loses? Welfare effects of classical swine fever epidemics in the Netherlands,* European Review of Agricultural Economics Vol 30 (2), pp. 125-154.
- Mangen, M.-J.J., 2002, *Economic welfare analysis of simulated control strategies for classical swine fever epidemics,* PhD thesis Wageningen University, The Netherlands, pp. 187, ISBN 90-5808-621-6.
- Mangen, M.-J.J., M. Nielen & A.M. Burrell, 2002, *Simulated effect of pig-population density on epidemic size and choice of control strategy for classical swine fever epidemics in The Netherlands,* Preventive Veterinary Medicine 56, pp. 141-163.

3.1.11 EpiLoss

Purpose: To calculate the financial consequences of CSF outbreaks of governments (EU, national), farms and related industries in the production chain for the region where the outbreak occurs.

Technical information

Organisation: DMW, BE.

Model type: Discrete dynamic deterministic simulation model.

Technique: Earlier versions in Borland Pascal 7.0, the current version in C++. versions for CSF and for FMD are available.

Output: Output files are generated in ASC-format. Data on 23 types costs are generated: direct and consequential costs of farmers, consequential costs of slaughterhouses, animal traders, breeding organisations, and feed suppliers, costs of welfare slaughter and of a breeding prohibition, organisational costs, vaccination costs, and hygiene measure costs for farmers and organisations within a MSS area.

Input:

- output from InterCSF/InterFMD: each row of the input file contains a day number, the unique ID number of each farm and the event the farm is confronted with (the day number when infected, cleared, inside MSS area, outside MSS area, welfare slaughtering, repopulating, ...). Multiple events on one day are represented in multiple rows;
- farm data (type of farm and number of animals);
- price data (daily prices paid for pigs under welfare slaughter);
- loss parameters (e.g. losses per depopulated farm per place per day).

Content

Pathogen: CSF-virus / FMD-virus.

Links in chain: Primary sector, slaughterhouse, animal traders and transporters, feed suppliers, breeding organisations within the outbreak region.

Aggregation level: Depends on the aggregation level of the input. Usually a regional level is used.

Animal and product type: Pigs, pork and veal.

Assumptions:
- a gradual continuous repopulation of depopulated farms;
- fixed time length of breeding (115 days) and growing (e.g. 120 days for fattening pigs) periods;
- zoo technical data (e.g. 21.5 piglets/sow/year);
- the financial consequences are only calculated for the outbreak region.

Position within framework: Calculation of the agriculture related economic effects of an outbreak of CSF.

General information

Developed by: Miranda Meuwissen in 1998. Adapted by Alien Jalvingh in 1998/99 and by Marie-Josée Mangen and Monique Mourits in 2001.

Maintenance: None foreseen.

Further use: None foreseen. The use of the output in other models is difficult.

Adaptation possibilities: Possibilities to adapt to all pig related diseases.

Background information:
User manual:

User description of assumptions and working of the model:

Scientific and other publications:
- Mangen, M.-J.J., A.W. Jalvingh, M. Nielen, M.C.M. Mourits, D. Klinkenberg & A.A. Dijkhuizen, 2001, *Spatial and stochastic simulation to compare two emergency-vaccination strategies with a marker vaccine in the 1997/1998 Dutch classical swine fever epidemic*, Preventive Veterinary Medicine 48, pp. 177-200.
- Meuwissen, M.P.M., S. H. Horst, R.B.M. Huirne & A.A. Dijkhuizen, 1999, *A model to estimate the financial consequences of classical swine fever outbreaks: principles and outcomes*, Preventive Veterinary Medicine 42, pp. 249-270.

3.1.12 EpiPigFlow

Purpose: To calculate the weekly supply of piglets during an outbreak of CSF, the weekly correction factor for the demand of growers, and the weekly correction factor for the supply of finisher pigs.

Technical information

Organisation: DMW, BE.

Model type: Discrete dynamic deterministic micro-economic simulation model.

Technique: C++.

Output: The change in number of live pigs traded during an epidemic compared to the situation without the epidemic. Used as input in DUPIMA.

Input: Output from InterCSF, farm data and a parameter data input file.

Content

Pathogen: CSF-virus.

Links in chain: Primary sector.

Aggregation level: National (Dutch).

Animal and product type: Piglets and fattening pigs (no sows, rearing gilts and replacement gilts).

Assumptions:
- a gradual continuous repopulation of depopulated farms;
- fixed time length of breeding (115 days) and growing (e.g. 120 days for fattening pigs) periods;
- zoo-technical data (e.g. 21.5 piglets/sow/year);
- all piglets are sold on the market.

Position within framework: Calculation of the number of live pigs affected by a CSF outbreak, thus translating the epidemiological outputs of a pig related disease into changes in the weekly supply of pigs on the national market.

General information

Developed by: Marie-Josée Mangen and Monique Mourits in 2001/2002.

Maintenance: Monique Mourits.

Further use: Non Foreseen.

Adaptation possibilities: Possibilities to adapt to all pig related diseases.

Background information: User manual: Handouts for version 1.0.

User description of assumptions and working of the model:

Scientific and other publications:

- Mangen, M.-J.J., A.M. Burrell & M.C.M. Mourits, 2004, *Epidemiological and economic modelling of classical swine fever: application to the 1997/1998 Dutch epidemic*, Agricultural Systems 81, pp. 37-54.
- Mangen, M.-J.J. & A.M. Burrell, 2003, *Who gains, who loses? Welfare effects of classical swine fever epidemics in the Netherlands*, European Review of Agricultural Economics Vol 30 (2), pp. 125-154.
- M.-J.J. Mangen, M. Nielen & A.M. Burrell, 2003, *Simulated epidemiological and economic effects of measures to reduce piglet supply during a classical swine fever epidemic in the Netherlands*, Rev. sci. tech. Off. int. Epiz. 22 (3), pp. 811-822.
- Mangen, M.-J.J., 2002, *Economic welfare analysis of simulated control strategies for classical swine fever epidemics*, PhD thesis Wageningen University, The Netherlands, pp. 187, ISBN 90-5808-621-6.
- Mangen, M.-J.J., M. Nielen & A.M. Burrell, 2002, *Simulated effect of pig-population density on epidemic size and choice of control strategy for classical swine fever epidemics in The Netherlands*, Preventive Veterinary Medicine 56, pp. 141-163.

3.1.13 GTAP (Global Trade Analysis Project Model)

Purpose: To determine and analyse the quantitative global economy-wide effects of policy measures and other shocks in international economic issues.

Technical information

Organisation: LEI (amongst others).

Model type: Dynamic deterministic general equilibrium model.

Technique: General Equilibrium Modelling Package (GEMPACK).

Output:
- percentage changes in all the endogenous variables;
- domestic price indices, e.g. the regional terms of trade or the price index for private household expenditure;
- the percentage change in the value of GDP, which can also be broken down into a price and a quantity component;
- the overall change in welfare for each region and for the world as a whole;
- world market price index for traded commodities;
- the changes in regional commodity-specific trade balances and the change in the regional current account are provided in value terms (i.e. in million 1997 US$).

Input: There are three files used in the modelling process:
- data file with the base data in value terms at three price levels: agents' prices, market prices and world prices;
- parameter file with substitution and income elasticity parameters;
- set file where various sets of commodities and regions are defined.

This data is collected through national input-output tables of the participating countries. Further shocks like changes in policy intervention through taxes and subsidies, technical change of various kinds, population growth, or other endowment shocks can be added as changes in commodity flows in terms of percentages.

Content

Pathogen: Not applicable.

Links in chain: World economy. This includes the food production chain and all other important economic sectors.

Aggregation level: World divided in different countries (all EU-15 countries are recognised individually) and regions.

Animal and product type: More than 50 sectors are distinguished. Agriculture related sectors include:

- ctl: bovine cattle, sheep and goats, horses (live) (CPC=0211);
- oap: other animal products include live swine, poultry and other animals (CPC=0212);
- rmk: raw milk; (number of cows)
- mil: dairy products;
- wol: raw animal materials used in textile;
- cmt: fresh, chilled or frozen meat of bovine animals, sheep, goats, horses;
- omt: fresh, chilled or frozen meat of swine;
- ofd: include prepared and preserved fish;

Assumptions:

- there is a one-to-one relationship between sectors and commodities, i.e. each sector in the model produces only one good;
- there are three primary endowments, i.e. land, labour, and capital. Their initial levels are fixed for each region.
- the GTAP database is formulated in value terms, e.g. the value of imports of a certain commodity from one region to another, or the value of a certain endowment used for the production of a certain commodity. Each of these value terms can be described by a *quantity variable and a price variable*;
- an AGE model has to be closed in a sense that all value flows have to be accounted for, i.e. in equilibrium there are no surpluses and profits;
- welfare is calculated as the Hicksian measure of Equivalent Variation (EV);
- private demand is non-homothetic in nature, i.e. the expenditure shares of various commodities change as the level of income changes. Moreover, a welfare increase, e.g. through trade liberalisation, is likely to change the structure of private consumption. For the private household utility function the so-called constant difference of elasticity's (CDE) form has been chosen.

Position within framework: To determine the global worldwide effects of changes in production volume in a country due to an outbreak or measures to prevent outbreaks, and the effects on national welfare.

General information

Developed by: Purdue University, West Lafayette, USA.

Maintenance: GTAP Consortium, including from LEI Frank van Tongeren and Andrzej Tabeau.

Further use: Used continually.

Adaptation possibilities: Difficult.

Background information: Background information is available at http://www.gtap.agecon.purdue.edu/.
User manual:

User description of assumptions and working of the model:

Scientific and other publications:

- Lotze, H., 1998, *Integration and transition on European agricultural and food markets: policy reform, European union enlargement, and foreign direct investment*, PhD dissertation, Humboldt-Universität, Berlin, Germany.
- Hertel, T.W. (ed.), 1997, *Global Trade Analysis: Modeling and Applications*, Cambridge University Press.

3.1.14 ImportFMD

Purpose: To determine the (estimated) risk of importing FMD (and bovine tuberculosis and leptospirosis) in the Netherlands through livestock trade for different future cattle import scenarios (especially from the new EU member states).

Technical information

Organisation: LEI, in cooperation with ASG, QVE.

Model type: Estimation model and stochastic epidemiological simulation model.

Technique: A range of economic techniques to derive an estimate of cattle imports in the Netherlands in combination with quantitative risk assessment.

Output:
- estimates for the growth of cattle imports in the Netherlands;
- values for different factors involving the risk of importing FMD through cattle import.

Input:
- data from different EU-countries;
- the Mid Term Review of the Common Agricultural Policy;
- an estimate of the impact of liberalisation of quota for cattle imports;
- data to estimate the spread of the FMD-virus after the first infection of an animal has occurred during the HRP;
- data on the cattle stock and cattle consignments in the Netherlands;

Content

Pathogen: FMD-virus.

Links in chain: Primary sector.

Aggregation level: National (Dutch).

Animal and product type: Cattle

Assumptions:
- estimation of the future cattle import in the Netherlands;
- exponential outbreak model.

Position within framework: To calculate the risk of introducing FMD in the Netherlands with the import of live cattle.

General information

Developed by: Thom Achterbosch and Dörte Döpfer (ASG, QVE)

Maintenance: Thom Achterbosch and Dörte Döpfer (ASG, QVE)

Further use: none foreseen.

Adaptation possibilities:

Background information:
User manual:

User description of assumptions and working of the model:

Scientific and other publications:
Achterbosch, T.J. & D.D.V. Döpfer, 2005, *Cattle trade and the risk of importing animal diseases from the new member states into the Netherlands*, draft LEI report, LEI Den Haag, the Netherlands (forthcoming).

3.1.15 InterCSF

Purpose: To simulate the daily spread of CSF between farms through local spread and contacts (animals, vehicles, persons) whereby the spread is affected by different control measures.

Technical information

Organisation: DMW, BE.

Model type: Spatial dynamic stochastic simulation model (epidemiological model).

Technique: C++.

Output: Automated output as text or ASC files. Output files contain rows with a day number, the unique ID number of each farm and the event the farm is confronted with (the day number when infected, cleared, inside MSS area, outside MSS area, welfare slaughtering, repopulating, ...). Multiple events on one day are represented in multiple rows. Aggregation of this data is possible.

Input:
- BRBS-dataset ((X,Y)-coordinates farm location, farm size, farm type, and animal types, available from the Gezondheidsdienst voor Dieren);
- file containing control measure parameters;
- file containing epidemiological parameters (spread of infection, probabilities of infection when in contact).

Content

Pathogen: CSF-virus.

Links in chain: Primary sector.

Aggregation level: Region till country.

Animal and product type: Pigs (farm type fatteners, sows, closed, breeding).

Assumptions:
- national (Dutch), no export contacts;
- the model uses the average contact structure of a farm type for each farm of that type. The contact structure is deduced from the I&R dataset (dataset containing all transactions of live animals in The Netherlands);
- expert judgment on probabilities of getting infected through different infection routes (animal contact, infected neighbour, air).

Position within framework: Regional epidemiological spread of CSF.
InterCSF uses specific inputs on the spatial distribution of farms and on the contact structure between farms. Gathering the necessary data is difficult and time consuming. This model can help to gain good insight into underlying parameters. For quick jobs the model is less well suited.

General information

Developed by: Alien Jalvingh developed the first version simulating the 1998/1999 CSF epidemic in the Netherlands. Marie-Josée Mangen and Monique Mourits later developed a generic model.

Maintenance: Management: Monique Mourits. No maintenance foreseen.

Further use: None foreseen.

Adaptation possibilities: Almost impossible to adapt.

Background information: User manual: A detailed manual is available.

User description of assumptions and working of the model: A detailed description on the assumptions is available.

Scientific and other publications:

- M.-J.J. Mangen, M. Nielen & A.M. Burrell, 2003, *Simulated epidemiological and economic effects of measures to reduce piglet supply during a classical swine fever epidemic in the Netherlands*, Rev. sci. tech. Off. int. Epiz. 22 (3), pp. 811-822.
- Mangen, M.-J.J., M. Nielen & A.M. Burrell, 2002, *Simulated effect of pig-population density on epidemic size and choice of control strategy for classical swine fever epidemics in The Netherlands*, Preventive Veterinary Medicine 56, pp. 141-163.
- Mangen, M.-J.J., A.W. Jalvingh, M. Nielen, M.C.M. Mourits, D. Klinkenberg & A.A. Dijkhuizen, 2001, *Spatial and stochastic simulation to compare two emergency-vaccination strategies with a marker vaccine in the 1997/1998 Dutch classical swine fever epidemic*, Preventive Veterinary Medicine 48, pp. 177-200.
- Jalvingh, A.W., M. Nielen, H. Maurice, A.J. Stegeman, A.R.W. Elbers & A.A. Dijkhuizen, 1999, *Spatial and stochastic simulation to evaluate the impact of events and control measures on the 1997-1998 classical swine fever epidemic in The Netherlands: I. Description of the model*, Preventive Veterinary Medicine 42, pp. 271-295.
- Nielen, M., A.W. Jalvingh, M.P.M. Meuwissen, S.H. Horst & A.A. Dijkhuizen, 1999, *Spatial and stochastic simulation to evaluate the impact of events and control measures on the 1997-1998 classical swine fever epidemic in The Netherlands: I. Comparison of control strategies*, Preventive Veterinary Medicine 42, pp. 297-317.

3.1.16 InterFMD

Purpose: To simulate the daily spread of FMD between farms through local spread and contacts (animals, vehicles, persons) whereby the spread is affected by different control measures.

Technical information

Organisation: DMW, BE.

Model type: Spatial dynamic stochastic simulation model (epidemiological model).

Technique: C++.

Output: Automated output as text or ASC files. Output files contain (approximations of) aggregates on number of cleared animals, total days in a MSS area, etc. In theory, events per day per farm can be produced, but the large number of susceptible farms and the large number of events make the output file too large.

Input:
- BRBS-dataset ((X,Y)-coordinates farm location, farm size, farm type, and animal types, available from the Gezondheidsdienst voor Dieren);
- file containing control measure parameters;
- file containing epidemiological parameters (spread of infection, probabilities of infection when in contact).

Content

Pathogen: FMD-virus.

Links in chain: Primary sector.

Aggregation level: Region till country.

Animal and product type: Cattle (farm type milk, beef, mixed), pigs (farm type fattener, sow, closed and breeding), sheep and goats (farm type sheep, goat, mixed).

Assumptions:
- national (Dutch), no export contacts;
- the model uses the average contact structure of a farm type for each farm of that type.
- the contact structure is deduced from the I&R dataset (dataset containing all transactions of live animals in The Netherlands);
- expert judgment on probabilities of getting infected through different infection routes (animal contact, infected neighbour, air).

Position within framework: Regional epidemiological spread of FMD.
InterFMD uses specific inputs on the spatial distribution of farms and the contact structure between farms. Gathering the necessary data is difficult and time consuming. This model helps to gain good insight into underlying parameters. For quick jobs this model is less well suited.

General information

Developed by: Alien Jalvingh and Monique Mourits.

Maintenance: Management: Monique Mourits. No maintenance foreseen.

Further use: None foreseen.

Adaptation possibilities: Almost impossible to adapt.

Background information:
User manual:

User description of assumptions and working of the model:

Scientific and other publications:

- Mourits, M.C.M., M. Nielen & C.D. Léon, 2002, *Effect of control measures on the course of simulated foot and mouth disease epidemics that started on different farm types in various Dutch areas*, In: Proc. of SVEPM, Cambridge, England, pp. 190-200.
- Huirne, R.B.M., M. Mourits, F. Tomassen, J.J. de Vlieger & T.A. Vogelzang, 2002, *FMD: past, present and future. On prevention and eradication of FMD*, report no. 6.02.14, LEI, Den Haag, The Netherlands (In Dutch).
- Sanson, R.L., 1993, *The development of a decision support system for an animal disease emergency*, PhD-thesis, Massey University, New Zealand.

3.1.17 InterIBR

Purpose: To simulate the daily spread of BHV1 between farms through local spread and contacts (animals, vehicles, persons) whereby the disease spread is affected by different control measures.

Technical information

Organisation: DMW, BE.

Model type: Spatial dynamic stochastic simulation model (epidemiological model).

Technique: C++.

Output: Automated output as text or ASC files. Output files contain (approximations of) aggregates on number of cleared animals, total days in a MSS area, etc. In theory events per day per farm can be produced, but the large number of susceptible farms and thus the large number of events make the output file too large.
In MS Excel a calculation programmed is available that calculates organisational costs and consequential losses (without export losses).

Input:
- BRBS-dataset ((X,Y)-coordinates farm location, farm size, farm type, and animal types, available from the Gezondheidsdienst voor Dieren);
- file containing control measure parameters;
- file containing epidemiological parameters (spread of infection, probabilities of infection when in contact).

Content

Pathogen: Bovine Herpesvirus1 (leading to IBR).

Links in chain: Primary sector.

Aggregation level: (Dutch) national level.

Animal and product type: Cattle (farm type milk, beef, mixed).

Assumptions:
- *n*ational (Dutch), no export contacts;
- the model uses the average contact structure of a farm type for each farm of that type. The contact structure is deduced from the I&R dataset (dataset containing all transactions of live animals in The Netherlands);
- expert judgment on probabilities of getting infected through different infection routes (animal contact, infected neighbour, air).

Position within framework: Regional epidemiological spread of IBR.
InterIBR uses specific inputs on the spatial distribution of farms and the contact structure between farms. Gathering the necessary data is difficult and time consuming. This model helps to gain good insight into underlying parameters. For quick jobs this model is less well suited.

General information

Developed by: A. Vonk Noordegraaf in 2000-2002.

Maintenance: Management: Monique Mourits. No maintenance foreseen.

Further use: None foreseen.

Adaptation possibilities: Almost impossible to adapt.

Background information:
User manual: A detailed manual is available.

User description of assumptions and working of the model:

Scientific and other publications:

- Vonk Noordegraaf, A., A. Labrovic, K. Frankena, D.U. Pfeiffer, & M. Nielen, 2004, *Simulated hazards of loosing infection-free status in a Dutch BHV1 model*, Preventive Veterinary Medicine 62, pp. 51-58.
- Vonk Noordegraaf, A., 2002, *Simulation modelling to support national policy making in the control of bovine herpesvirus 1*, PhD-thesis Wageningen University, Wageningen, the Netherlands.
- Vonk Noordegraaf, A., M. Nielen, P. Franken, A.A. Dijkhuizen, 2002, *Simulation modelling of BHV1-control programme at national level, with special attention to sensitivity analysis*, Livestock Production Science 76, pp. 153–170.
- Vonk Noordegraaf, A., A.W. Jalvingh, M.C.M. de Jong, P. Franken, & A.A. Dijkhuizen, 2000, *Evaluating control strategies for outbreaks in BHV1-free areas using stochastic and spatial simulation*, Preventive Veterinary Medicine 44, pp. 21-42.
- Vonk Noordegraaf, A., J.A.A.M. Buijtels, A.A. Dijkhuizen, P. Franken, J.A. Stegeman, & J. Verhoeff, 1998, *An epidemiological and economic simulation model to evaluate the spread and control of infectious bovine rhinotracheitis in the Netherlands*, Preventive Veterinary Medicine 36, pp. 219-238.

3.1.18 REM (Ruimtelijk Economisch Model, Spatial Economic Model)

Purpose: To evaluate different land use scenario's according to their social costs and benefits.

Technical information

Organisation: LEI.

Model type: Cost-benefit analysis model.

Technique: MS Excel, MS Access.

Output: Social costs and benefits of different land use scenarios.

Input:
- land use in a defined area: every hectare is described according to its function (e.g. 20 ha nature, 10 ha residential area, ...);
- added value of every function per hectare;
- investment costs of different scenario's;
- management and control costs of different functions.

Content

Pathogen: Not specified.

Links in chain: Dairy farming, (biological) arable farming, horticulture (under glass), forest, nature, recreation, infrastructure, industry, water, residential area, camping, hotel etc.

Aggregation level: Regional, local.

Animal and product type: Dairy farming.

Assumptions: Fixed added value per function.

Relation with framework: Calculation of social costs and benefits and alternative land use patterns if e.g. the added value of a hectare with dairy farming changes due to changes in the national health status of due to an outbreak of a disease.

General information

Developed by: Stijn Reinhard and Aris Gaaff.

Maintenance: Marieke Koning.

Further use: The REM will be used for projects with social cost-benefit analyses.

Adaptation possibilities: Easy to adapt.

Background information:
User manual:

User description of assumptions and working of the model:

Scientific and other publications:

- Gaaff, A., M. Strookman & S. Reinhard, 2003, *Costs and benefits of alternative land use of the Holstermeerpolder*, Report 4.03.09, LEI, Den Haag, The Netherlands (In Dutch).
- Gaaff, A., M. Strookman & S. Reinhard, 2003, *Alternative land uses in the Apeldoornskanaal region; Application of a social cost benefit analysis in an interactive process,* Report 4.03.08, LEI, Den Haag, The Netherlands (In Dutch).
- Reinhard, S., J. Vreke, W. Wijnen, A. Gaaff & M. Hoogstra, 2003, *Integral consideration of land use*, Report 4.03.03, LEI, Den Haag, The Netherlands (In Dutch).

3.1.19 Salmon I

Purpose: To simulate the introduction and spread of Salmonella from multiplying through slaughter, with special emphasis on Critical Control Points to prevent or reduce Salmonella contamination.

Technical information

Organisation: DMW, BE and ASG (Applied Research)

Model type: Stochastic state-transition simulation epidemiological model combined with an economic deterministic calculation (partial budgeting) model.

Technique: The epidemiological model is developed in Delphi 5. A standalone executable has been made with input and output files in MS Access. The economic model is developed in MS Excel.

Output: Prevalence of salmonella in each link in the pork supply chain from multiplying to slaughter. The prevalence is defined as the percentage of animals/products status (susceptible with negative serology, infected with negative serology, infected with positive serology, carrier, susceptible with positive serology, re-infected with positive serology).
By changing probabilities between two or more states, the effects of measures are simulated. Comparing the output of the base run with the output of the run with the adapted probabilities gives insight into the effects on chain level.
The economic model calculates the costs of measures.

Input: The following input is used for the epidemiological model:

- links in the supply chain;
- values of the transition probabilities within and between each link. These probabilities depend on the proposed measure.

In general, the model uses a large amount of input (transition probabilities between all possible states) and data on most of the input is not readily available.
Inputs for the economic model are the costs of measures.

Content

Pathogen: Salmonella.

Links in chain: Piglet multiplying, finishing, transport, lairage and slaughter.

Aggregation level: (Dutch) national level.

Animal and product type: Pigs and pork.

Assumptions: The model is based on the transition of salmonella through different states using the SIR-methodology.

Position within framework: An epidemiological model of the introduction and spread of Salmonella in a supply chain.

General information

Developed by: Monique van der Gaag from 2000-2004.

Maintenance: None foreseen.

Further use: None foreseen. Further use of the model is difficult as input requirements are high. Especially during a crisis, time-consuming gathering of data is not possible. Therefore, Monique van der Gaag suggests to use the underlying ideas and to develop a simplified and less detailed model.

Adaptation possibilities:

- altering input is relatively easy. Changes to other diseases, animals and links in the supply chain are possible as the model has a general structure. Gathering the correct input is difficult;
- changing the Delphi code is difficult;
- the economic model is easily adapted.

Background information:
User manual: A manual exists and is available from Monique van der Gaag. Due to the huge amount of input and the lack of user-friendly input screens the use of the model is rather difficult even with this manual.

User description of assumptions and working of the model: The underlying assumptions are described in the scientific publications.

Scientific and other publications:
Van der Gaag, M.A., 2004, *Epidemiological and economic simulation of Salmonella control in the pork supply chain*, PhD-thesis Wageningen University and Applied Research of Animal Sciences Group, Wageningen UR, Wageningen, The Netherlands.

3.1.20 Salmon II

Purpose: To optimise incentive mechanisms between slaughterhouse and pig farms for salmonella control considering the historical situation of individual farms.

Technical information

Organisation: LEI.

Model type: Discrete dynamic stochastic optimalisation model.

Technique: Matlab.

Output: Automated output with the costs per unit product at the optimal control strategy on farm level, the optimal control strategy on slaughterhouse level, the optimal testing strategy and the optimal differentiation between primary contamination levels. Three models are available for minimisation of 1) total chain costs, 2) slaughterhouse costs, and 3) farm level costs, given a breakeven on slaughterhouse level.

Input: The following input sets are needed:
- set of technical relations about the costs of measures on farm level and the related serological prevalence;
- set of technical relations about the costs of measures on slaughterhouse level and the related distributions of bacteriological prevalence given the serological levels on farm level;
- set with revenue prices of products and costs of testing strategies for salmonella.

Content

Pathogen: Salmonella.

Links in chain: Primary sector and slaughterhouse.

Aggregation level: One slaughterhouse and the related group of pig farms.

Animal and product type: Pigs and pork.

Assumptions:
- expert opinion on the distribution of serological prevalence for each of the control packages on farm level;
- expert opinion on the relationship between the serological prevalence on farm level and the bacteriological prevalence on slaughterhouse level for each of the control packages on slaughterhouse level.

Position within framework: Calculation of the minimal costs of an optimal incentive mechanism for salmonella control between pig farms and a slaughterhouse considering the historical situation of individual farms.

General information

Developed by: Gé Backus and Rob King in 2004.

Maintenance: Gé Backus and Rob King.

Further use: No concrete initiative, but intended.

Adaptation possibilities: Easily adaptable because of the structure of Matlab. More attention could be given to the variety of testing strategies.

Background information:
User manual: None.

User description of assumptions and working of the model:

Scientific and other publications:
King, R.P., G.B.C. Backus, & M.A. van der Gaag, 2005, *Incentive systems for food quality control with repeated deliveries: salmonella control in pork production*, forthcoming.

3.1.21 Salmonella Chicken (SalmonellaKip)

Purpose: To calculate the monitoring costs of different monitoring scenario's from broiler till slaughterhouse.

Technical information

Organisation: LEI.

Model type: Deterministic calculation (partial budgeting) model.

Technique: MS Excel.

Output: Monitoring costs of the 'action plan 2000+' and the costs of various types of logistic slaughtering.

Input: Measures in the action plan 2000+ and the costs of implementing these measures.

Content

Pathogen: Salmonella.

Links in chain: Primary sector (great-grand parents until broilers), transport, lairage and slaughter.

Aggregation level: (Dutch) national level.

Animal and product type: Chickens and chicken meat.

Assumptions:

Position within framework: Calculation of the costs of measures to reduce the risk of spread of salmonella in the chicken meat supply chain.

General information

Developed by: Linda Puister in 2004.

Maintenance: Linda Puister.

Further use: None foreseen.

Adaptation possibilities: Easy.

Background information:
User manual:

User description of assumptions and working of the model:

Scientific and other publications: Forthcoming.

3.1.22 Salmonella chicken supply chain (Salmonella in de kipketen)

Purpose: To calculate the costs of measures to reduce the incidence of salmonella in the chicken meat supply chain.

Technical information

Organisation: LEI.

Model type: Deterministic calculation (partial budgeting) model.

Technique: MS Excel.

Output: Costs of measures to reduce the incidence of salmonella in chicken meat. The proposed measures are part of the 'action plan 2000+'.

Input: Results from a transmission model of salmonella in the chicken meat supply chain:
- possible measures in each link of the supply chain;
- costs of the measures;
- probabilities of reducing the risk on salmonella for different measures.

Content

Pathogen: Salmonella.

Links in chain: Primary sector (great-grand parents until broilers), transport, lairage and slaughter.

Aggregation level: Brace of broilers. With the number of chickens the impact on (Dutch) national level can be calculated.

Animal and product type: Chickens and chicken meat.

Assumptions: Assumptions for the underlying epidemiological model:
- vertical transmission of salmonella in the whole supply chain;
- contamination process in the chain is calculated by determining the change in contamination level at each link;
- unit is a brace of broilers.

Position within framework: Calculation of the costs of measures to reduce the risk of spread of salmonella in the chicken meat supply chain.

General information

Developed by: Peter van Horne in 1998 and 2001.

Maintenance: None foreseen.

Further use: None foreseen as the underlying epidemiological model is out of date.

Adaptation possibilities: Easy.

Background information:
User manual: none.

User description of assumptions and working of the model: none.

Scientific and other publications:
- Van Horne, P.L.M., 2002, *Costs of monitoring the action plan Salmonella and Campylobacter in the chicken meat sector.* Internal report LEI, Den Haag, The Netherlands (In Dutch).
- Van Horne, P.L.M., R.C.A. Soons & M.J. Nauta, 2001, *Economic evaluation Action plan Salmonella chicken meat 2000+*, internal report LEI, Den Haag, The Netherlands (In Dutch).
- Van Horne, P.L.M., 1998, *Economic evaluation of reducing salmonella and campylobacter in the chicken meat supply chain*, Internal report LEI, Den Haag, The Netherlands (In Dutch).

3.1.23 Scenario treat model for CSF interaction

Purpose: To give insight into the origin and the risk factors involved with the origin of CSF-epidemics in the Netherlands and thereby stimulating better preventive measures on the import of CSF.

Technical information

Organisation: DMW, BE.

Model type: Stochastic static non-linear calculation model (decision tree analysis).
The choice for a simulation model is less suitable because risk and possibilities are very small and the number of simulations to present viable output should be very large making it a time consuming method.

Technique: MS Excel and @risk.

Output:

- annual probability of CSF virus introduction from each country of origin per epidemic (in the country of origin);
- annual probability of CSF virus introduction by exogenous pathways (legal and illegal imports of pigs, pork products, genetic material, returning livestock trucks, air currents);
- annual probability of CSF virus introduction by endogenous pathways (laboratories, wild boars);
- overall annual probability of CSF virus introduction.

Input: No separate input files are needed, input directly into the model. Input is:

- the observed values of pathways in a certain year (e.g. number of trucks entering the Netherlands from Germany, Belgium, etc. (EU-15), number of live animals imported from Germany, Belgium, etc., import of animal products);
- information on the incidence of CSF epidemics in the countries exporting to the Netherlands;
- values for the probability that a pathway is infected (given an epidemic in the country of origin), the probability that a virus survives a treatment (cleaning, disinfections,..), and the probability that a life virus actually infects a herd in The Netherlands thus starting an epidemic. These are based on expert opinions and literature research.

Content

Pathogen: CSF-virus.

Links in chain: Primary sector, including animal products as a pathway.

Aggregation level: (Dutch) national level.

Animal and product type: Pigs.

Assumptions:
- only countries of origin from the EU-15 are considered because imports from other countries are marginal and information on the occurrence of CSF in third countries was insufficiently available;
- tourism as a pathway for the introduction of CSF is not included in the model;
- risk are calculated on a yearly basis;
- epidemics (number of infected farms, duration of the high risk period, duration of the total epidemic) of all countries are based on the same underlying probability distribution. This is based on the CSF epidemic in the Netherlands in 1997/1998;
- multiple simulated epidemics per year in a country have the same characteristics;
- all countries of origin are homogenous entities without taking spatial variability into account.

Position within framework: The model determines the probability of starting a CSF epidemic in a country. The output can be used as input in an epidemiological model.
An economic module in MS Excel was developed to evaluate the cost effectiveness of the distinguished preventive measures. Only the costs related to the measures and the reduction in risk of introduction are considered. No relation has been made with the (costs of an) expected outbreak.

General information

Developed by: Clazien de Vos (PhD and EU-project DPLA).

Maintenance: None foreseen.

Further use: None foreseen. Problem is the availability of data.

Adaptation possibilities:
- input can be easily adapted;
- to calculate the probability of starting a CSF epidemic for a different country than The Netherlands is possible, but lack of epidemiological data and of data about the different pathways makes this difficult;
- adding a new pathway (e.g. tourism) is more difficult. As the model is programmed in Excel, this is relatively easy (adding extra rows/columns and ensuring correct summations);
- adaptations in flexibility and layout of the output are to be considered.

Background information:
User manual: No user manual is available.

User description of assumptions and working of the model: Background information on the underlying assumptions and principles is available (not for the latest version).

Scientific and other publications:

- De Vos, C.J., H.W. Saatkamp, M. Nielen & R.B.M. Huirne, 2004, *Scenario tree modeling to analyze the probability of classical swine fever virus introduction into member states of the European Union.* Risk Analysis, Vol. 24, No. 1, pp. 237-253.
- De Vos, C.J., H.W. Saatkamp, R.B.M. Huirne & A.A. Dijkhuizen, 2003, *The risk of the introduction of classical swine fever virus at regional level in the European Union: a conceptual framework.* Rev. sci. tech. Off. Int. Epiz., Vol. 22 (3), pp. 795-810.

3.2 Summary of the characteristics of the models

Table 3.2 Most important characteristics of the models

	Epidemiology	Economy	Method	Level of input and analysis	Level of output	Disease or Pathogen	Animal species
AG-MEMOD		X	PEM	EU-15 Country	EU		
AIOM		X	I/O-model	NL	NL		
Calculation model (in)direct costs CSF, FMD, AI		X	Partial budgeting	Farm	region	CSF, FMD, AI	pigs, cattle, goats, sheep, poultry
Carma farmer		X	Simulation, Enterprise budgeting	Farm	NL	Campylobacter	broilers
Carma slaughterhouse		X	Simulation, Financial analysis	Processing plant	NL	Campylobacter	chicken meat
Costs of public health		X	Cost-benefit analysis	NL	NL	Salmonella, Campylobacter	chicken meat
DRAM		X	PEM	Region	NL		
DUPIMA		X	PEM	NL	NL		pigs
Economic Welfare Analysis		X	Welfare analysis	Company	NL		pigs
EpiCosts		X	Simulation	Farm	region	CSF	pigs
EpiLoss		X	Financial analysis	Farm	region	CSF	pigs
EpiPigFlow		X	Simulation	Farm	NL		pigs
GTAP Model		X	GEM	Country	world		
ImportFMD	X		Various economic, risk assessment	Country	Country	FMD	cattle
InterCSF	X		Dynamic, stochastic, spatial simulation	Farm	region	CSF	pigs
InterFMD	X		Dynamic, stochastic, spatial simulation	Farm	region	FMD	cattle, pigs, goats, sheep
InterIBR	X		Dynamic, stochastic, spatial simulation	Farm	region	IBR	cattle
REM		X	Cost-benefit analysis	Region	region		
Salmon I	X		Dynamic simulation	Animal	country	Salmonella	pigs
Salmon II		X	Dynamic optimisation	Farm / slaughterhouse	Farm / slaughterhouse	Salmonella	pigs
Salmonella Chicken		X	Partial budgeting	Farm / company	NL	Salmonella	broilers/ chicken meat
Salmonella chicken supply chain		X	Partial budgeting	Farm / company	NL	Salmonella	broilers/ chicken meat
Scenario treat model for CSF interaction	X		Decision tree analysis	NL	NL	CSF	pigs

Table 3.2 gives a summary of the most important characteristics of the models. Within SSG epidemiological models for the spatial spread of CSF, FMD, and IBR, and for the spread in the supply chain for salmonella exist. Most of these models use stochastic dynamic simulation and include uncertainty or risk. Economic models exist for CSF, FMD, salmonella and campylobacter and use a range of methods from financial analysis (e.g. partial or enterprise budgeting) to simulation. The simulation models and part of the enterprise and partial budgeting models include risk and uncertainty. The level of input relates to the level of detail of the input, whereas the level of output relates to the aggregation level of the model. Most models use input data on farm level, do calculations on farm level, and aggregate the results to present output on regional or country level.

3.3 Relationship between the models

The models described in paragraph 3.2 focus on different levels of aggregation, diseases or pathogens and animal species. For some models the output is can be input for another model. Hence, a combination of these models increases the analysis possibilities. This paragraph describes the relationship between the models for the different animal diseases (paragraph 2.3.1) and zoonoses (paragraph 2.3.2). Because some models use very specific input and generate very specific output, the actual development of these relationships in a framework could be rather difficult.

3.3.1 Infectious animal diseases

CSF

Figure 3.1 gives the relationship between the CSF related models. *Scenario Treat Model* is an epidemiological model that can simulate the introduction of the CSF virus into a country. Once the virus is present, the epidemiological model *InterCSF* can simulate the spatial spread of the virus between farms, resulting in the time period and the extent (number of farms) of the outbreak. EpiPigFlow can calculate the resulting change in production and trade of piglets and fattening pigs. This induces a change in price, which can be calculated by *DUPIMA*. This price change can alternatively be calculated with the equilibrium models *AG-MEMOD* or *GTAP*. *EpiLoss* calculates the direct costs related to control measures and direct and indirect losses of farmers and related industries inside the MSS area. *EpiCosts* calculates direct costs related to control measures and the welfare effects of all producers inside the MSS area. Farmer costs can alternatively be calculated with the *Calculation model CSF*. *Economic Welfare Analysis* calculates the financial consequences for the whole supply chain until the consumer, thereby implicitly using the method of multi criteria analysis to weigh the different welfare effects. Alternatively, *AIOM* can calculate the income effects in the agro-chain and in non-agricultural sectors. The changes of supply and demand on national level can be used as an input for *AG-MEMOD* to calculate the effects on EU level. *GTAP* can do this on global level.

FMD

Figure 3.2 gives the relationship between the FMD related models. *Import FMD* calculates the costs of intervention measures to reduce the risk of introduction of FMD in the Netherlands. *InterFMD* is an epidemiological model and it can simulate the spatial spread of the FMD virus for different scenarios depending on the chosen control measure. The occurrence of FMD leads to changes in production volume (in the supply chain) and control costs (for farmers, the supply chain and the government). These can be calculated with the *Calculation model FMD*. This model furthermore calculates the organisation costs for the government. Subsequently, the outcomes of the *Calculation model FMD* can be used as an input for *AIOM* to calculate the income effects in the agro-chain and in non-agricultural sectors. The outcomes of *AIOM* can be used for as an input in *AGMEMOD* to calculate the changes in supply, demand and trade of a number of different agricultural products on EU level. *GTAP* can do this on global scale.

AI

The relationship between the AI related models are given in figure 3.3. There are no epidemiological models for AI. The *Calculation model AI* calculates the direct and indirect costs of farms, the changes in production volume and the organisation costs for the government resulting from an AI outbreak. The results of these calculations can be used as an input for *AIOM* to calculate the income effects in other agricultural related sectors, such as the feed and processing industry. Furthermore, *AIOM* can give indications about the effects on non-agricultural sectors, such as recreation and tourism. The outcomes of *AIOM* can be used as an input for *AGMEMOD* to calculate the changes in supply, demand and trade of a number of different agricultural products on EU level. *GTAP* can do this on global scale.

IBR

There is only one model included for IBR, *InterIBR* (figure 3.4). *InterIBR* simulates the spread of the Bovine Herpes Virus (BHV1) between farms through local spread and contacts via animals, humans or vehicles whereby the disease spread is affected by different control measures. A calculation module is available to calculate the economic consequences of the different control measures.

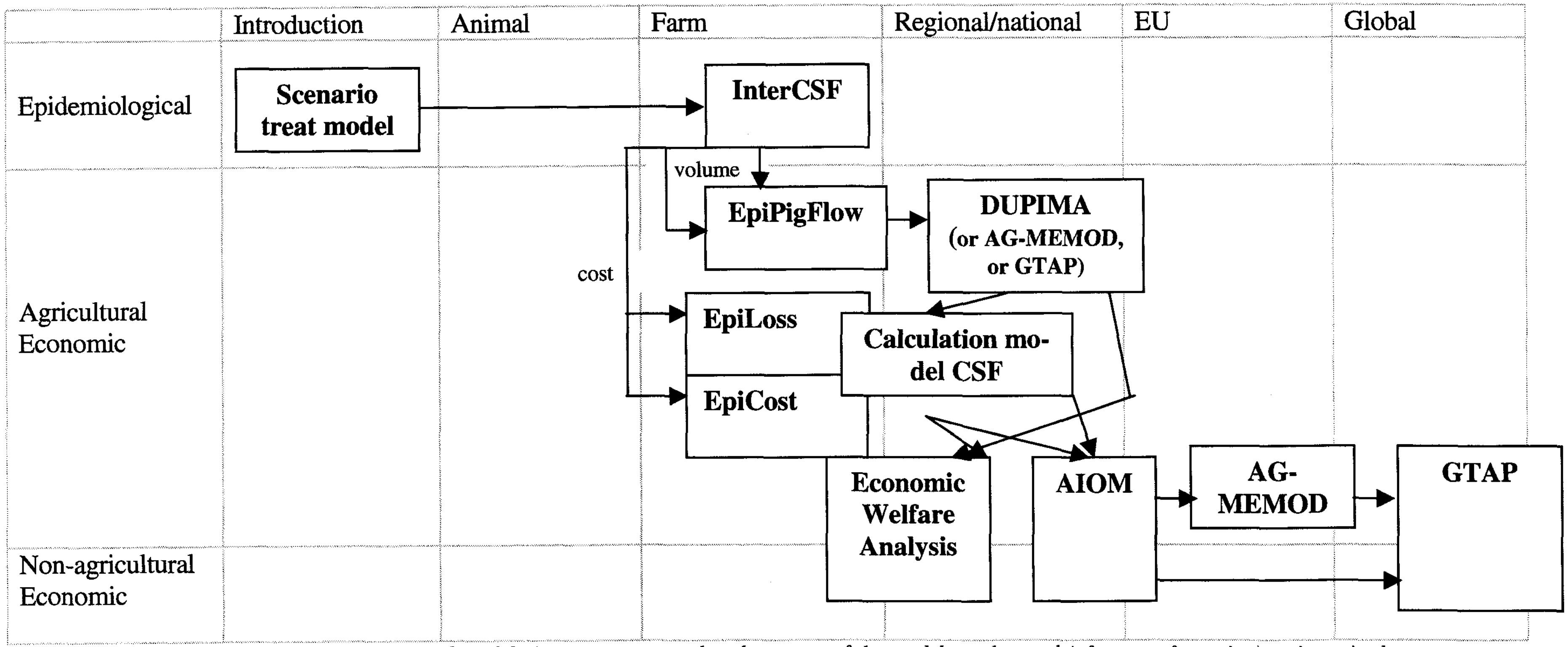

Figure 3.1 *Relationship between CSF related models (an arrow means that the output of the model can be used (after transformation) as input in the next model)*

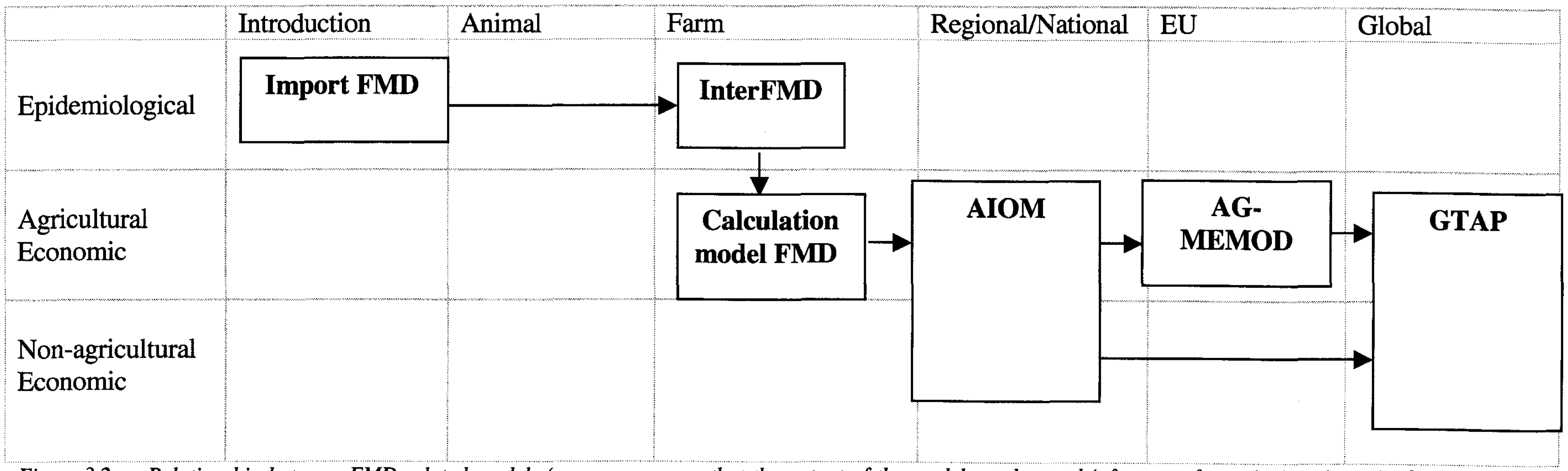

Figure 3.2 *Relationship between FMD related models (an arrow means that the output of the model can be used (after transformation) as input in the next model)*

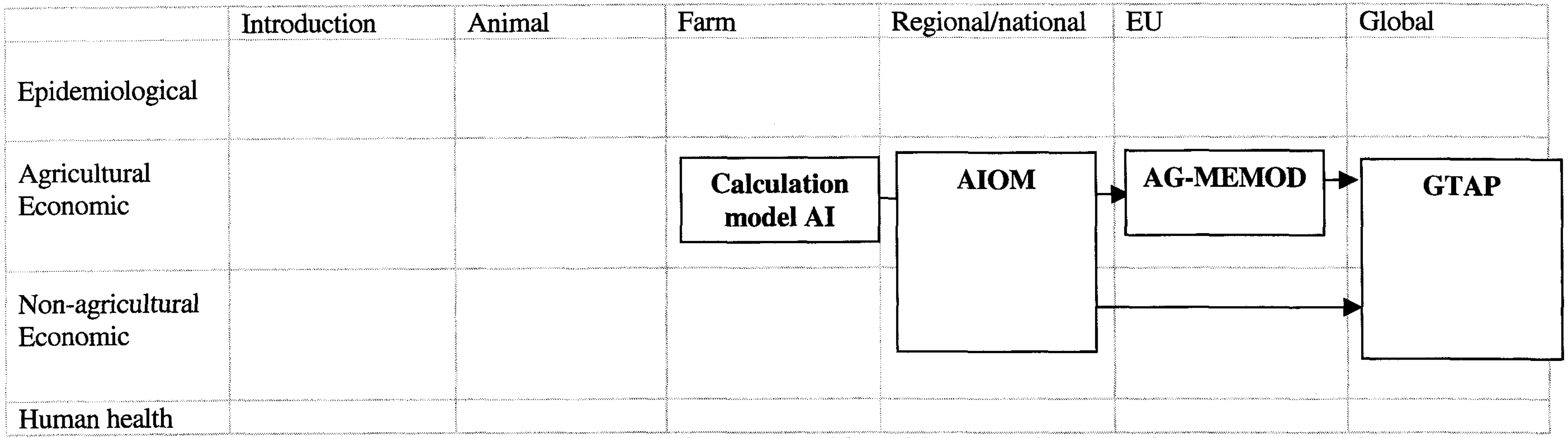

Figure 3.3 *Relationship between AI related models (an arrow means that the output of the model can be used (after transformation) as input in the next model)*

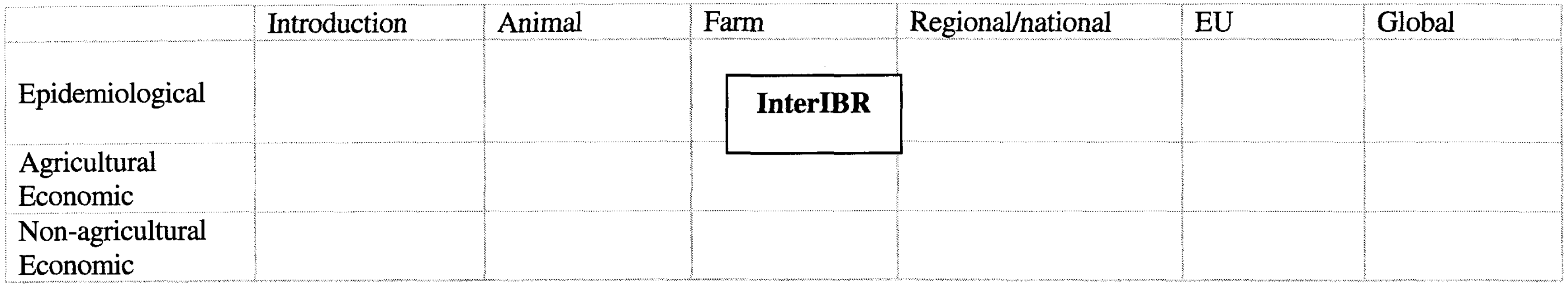

Figure 3.4 *Relationship between IBR related models*

3.3.2 Zoonoses

Campylobacter

Figure 3.5 gives the relationship between the Campylobacter related models. *Carma Farmer* and *Carma Slaughterhouse* are models to calculate the economic consequences of Campylobacter control measures on broiler farm level and chicken meat processing level respectively. Resulting added costs can be used in *DRAM* to calculate structural regional changes in national primary production. The results from *DRAM* can be used in *AIOM* to calculate the expected effect in non-agricultural sectors. The production costs from the Carma models can be used to calculate the national welfare effect of a change in international trade in chicken meat considering European agricultural markets in *AG-MEMOD* or global markets in *GTAP*. Using the underlying effects on infection probability *Cost of Public Health* can estimate the costs of human infections with Campylobacteriosis.

Salmonella in chickens and chicken products

Figure 3.6 gives the relationship between the Salmonella in chickens and chicken products related models. *Salmonella chicken* and *Salmonella chicken meat supply chain* are models to calculate the economic consequences of Salmonella control measures on broiler farm level and broiler slaughterhouse level respectively. The calculated added costs can be used in *DRAM* to calculate structural regional changes in national primary production. The results from *DRAM* can be used in *AIOM* to calculate the expected effect in non-agricultural sectors. The added production costs from the Salmonella models can be used to calculate the national welfare effect of a change in international trade in chicken meat considering European agricultural markets in *AG-MEMOD* or global markets in *GTAP*. Using the underlying effects on infection probability *Cost of Public Health* can estimate the costs of human infections with Salmonellosis from chicken meat.

Salmonella in pigs and pork

Figure 3.7 gives the relationship between the Salmonella in pigs and pork related models. *Salmon I* is an epidemiological model to calculate the spread of Salmonella in a group of pigs and in a batch of meat in a slaughterhouse. *Salmon II* calculates the financial optimal control strategy on farm and slaughterhouse level and the financial optimal testing strategy to reach a certain level of bacteriological prevalence on pork. *Cost of Public Health* can use prevalence data to estimate the costs of human infections with Salmonellosis from pork. The added costs from *Salmon II* can be used in *DRAM* to calculate structural regional changes in national primary production. The results from *DRAM* can be used in *AIOM* to calculate the expected effect in non-agricultural sectors. The added production costs from the Salmonella models can be used to calculate the national welfare effect of a change in international trade in chicken meat considering European agricultural markets in *AG-MEMOD* or global markets in *GTAP*.

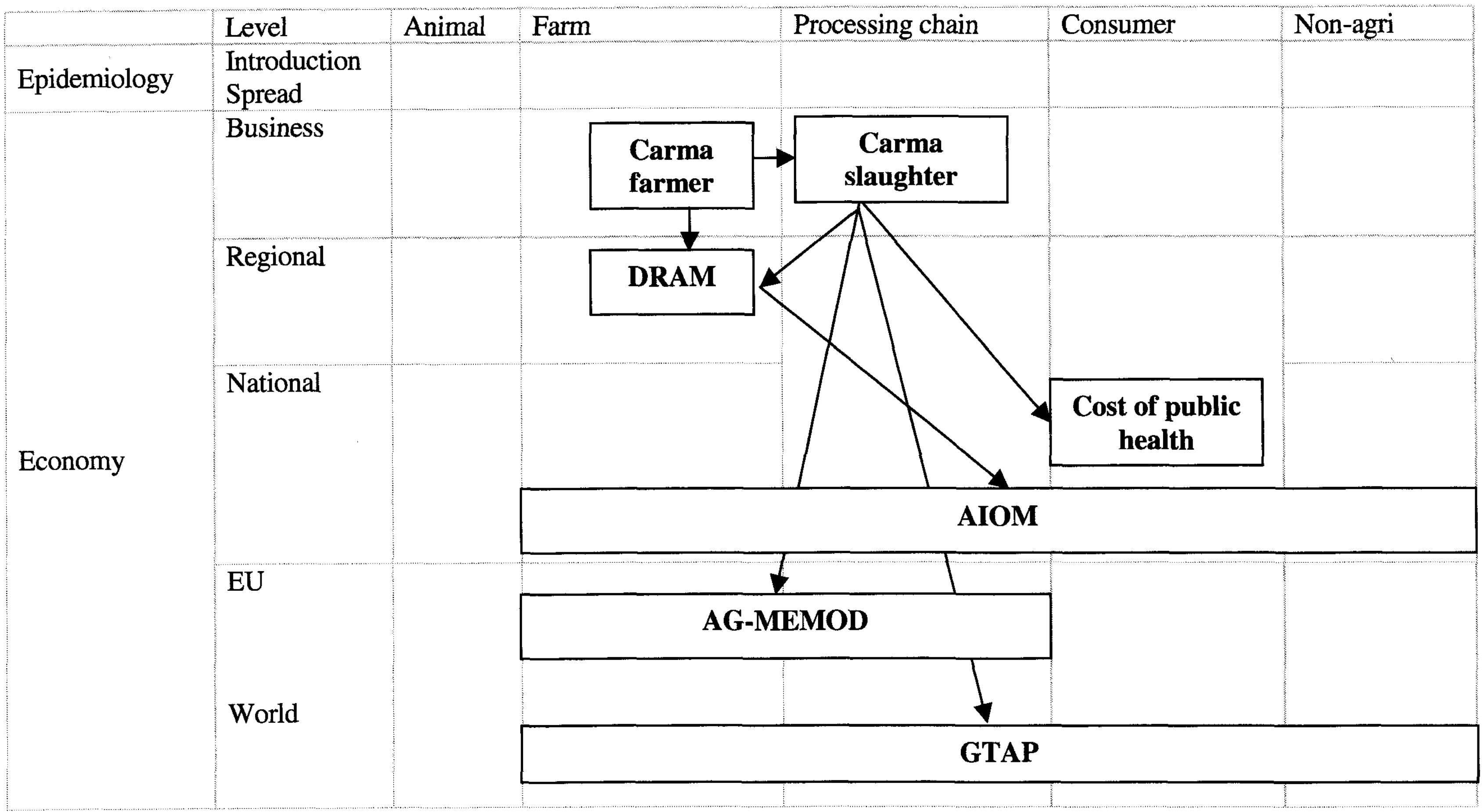

Figure 3.5 *Relationship between Campylobacter related models (an arrow means that the output of the model can be used (after transformation) as input in the next model)*

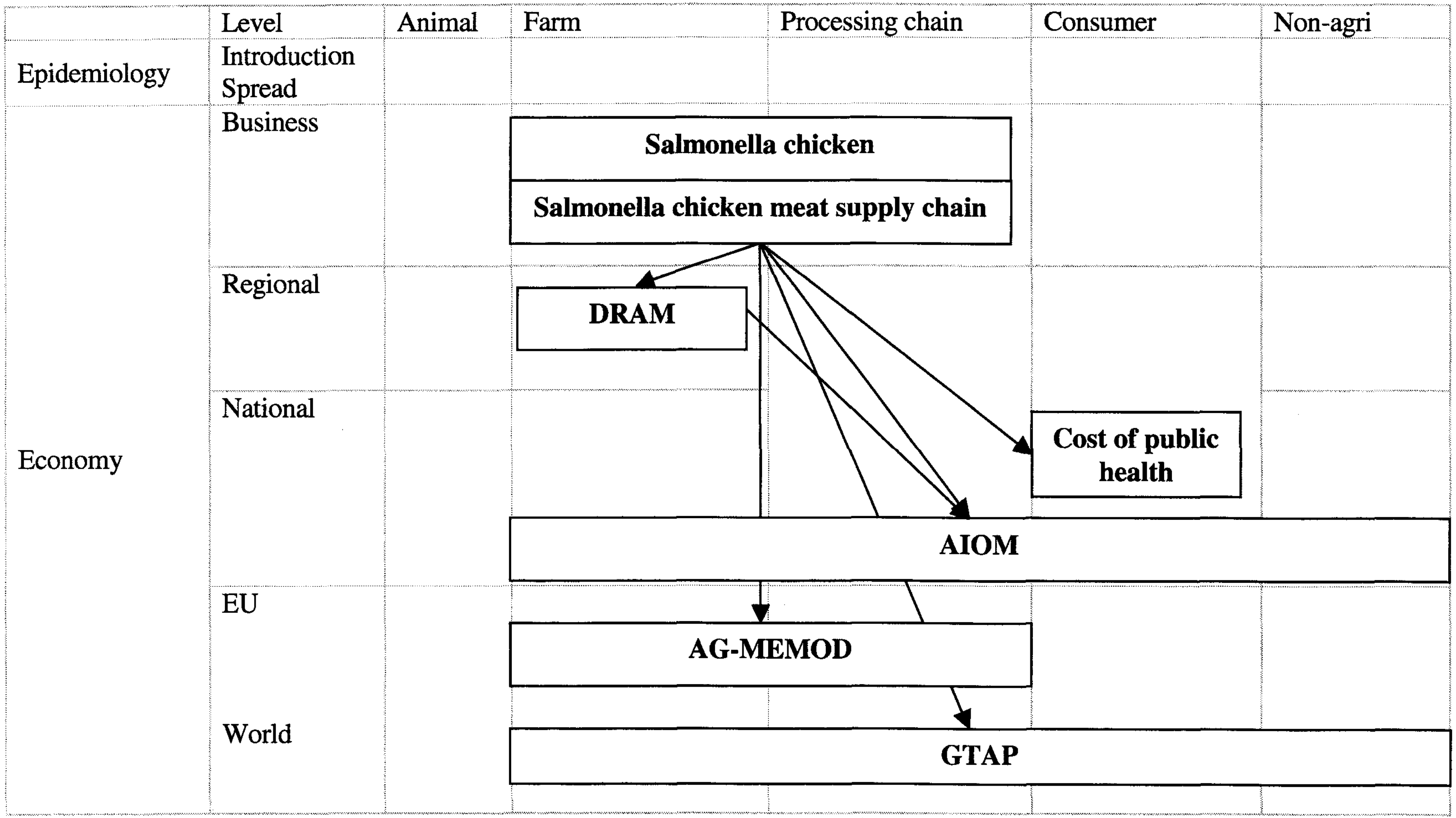

Figure 3.6 *Relationship between Salmonella in chickens and chicken meat related models (an arrow means that the output of the model can be used (after transformation) as input in the next model)*

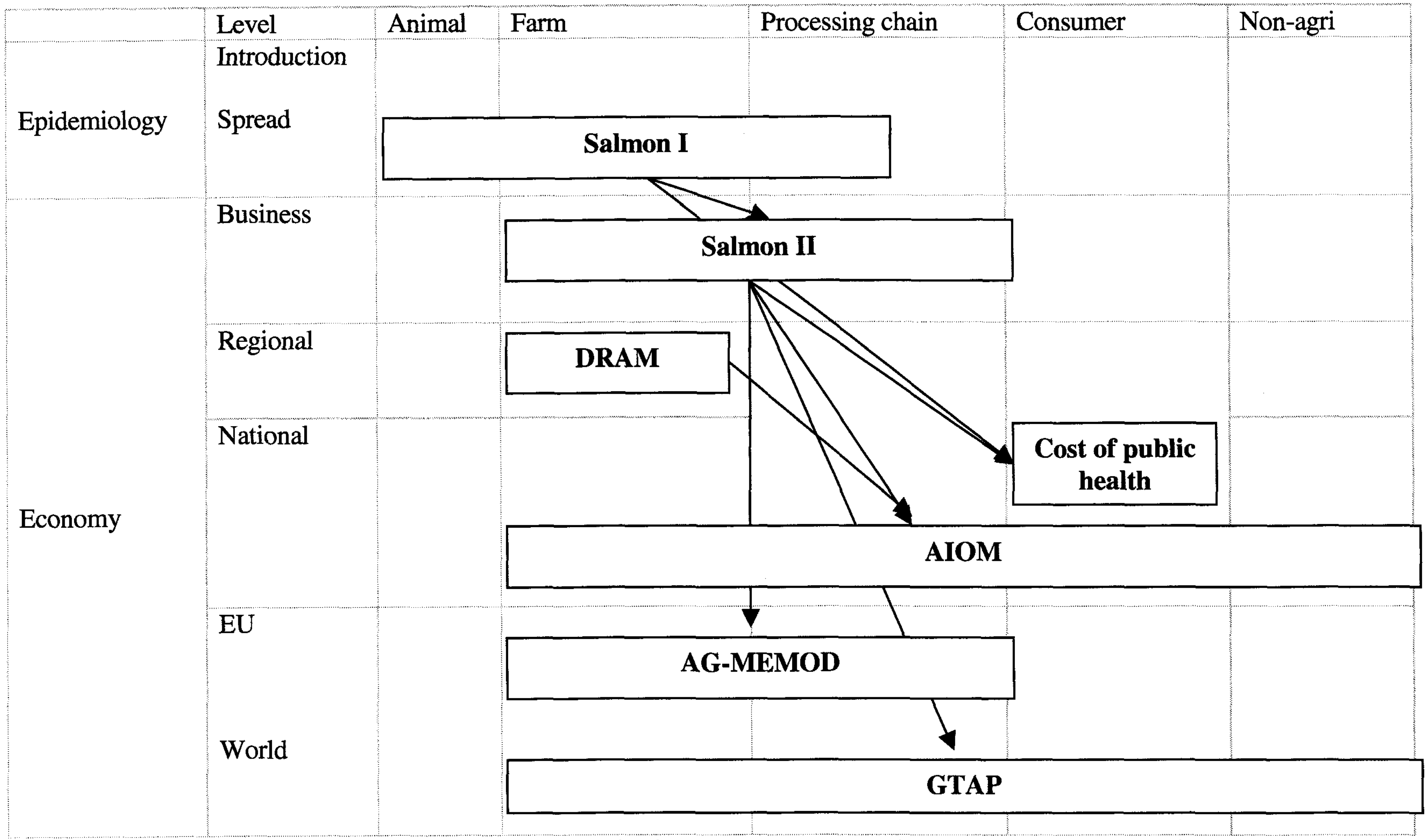

Figure 3.7 ***Relationship between Salmonella in pigs and pork related models (an arrow means that the output of the model can be used (after transformation) as input in the next model)***

4. Preconditions for the framework

For the framework for the integrated analysis of animal diseases and zoonoses to be successful 1) the content has to reflect real problems and 2) the functionality of the framework must be easy to handle and maintain. Paragraph 4.1 gives insight into a future research agenda. Paragraph 4.2 describes experiences on constructing expert systems for the analysis of animal diseases. Finally, paragraph 4.3 summarises points of attention for the construction of the framework.

4.1 Future research agenda

Interviews with two Wageningen UR cluster managers (A. Meijering, cluster manager animal health, and G. van der Peet, cluster manager transition sustainable agriculture) on a future research agenda for contagious animal diseases and zoonoses were conducted. Both cluster managers have direct and frequent contact with relevant policy makers. As the current project has an internal focus, policy makers themselves were not interviewed. Under follows a full list of subjects they mentioned, although currently a part of these subjects are already under research (with or without the presented models).

A. Meijering, cluster manager animal health (interviewed on 2-12-2004):

- the development of an emerging risk system;
- the development of an early warning system;
- influence of specific infection routes on the actual infection probability, e.g. insects (mosquitoes) on the probability of Blue Tongue. Can these mosquitoes survive in the Netherlands? How can we model and limit the risks of imported animal products?
- standard questions concerning contingency plans of infectious animal diseases: How to react if confronted with an outbreak? With social support (MCA). What is the national and international impact of a different control or eradication strategy?
- epidemiology of zoonoses in food supplies chains. How can we cost efficiently eradicate zoonoses? What canalisation measures are available? Is radiation of products possible (financial and ethical)?
- how does cross contamination of zoonoses from animal to human work?
- in order to gain insight into human health reaction, we need more insight into doses-response models of zoonoses. Can segmentation of the population help?
- how to handle keepers of hobby animals?
- what are the underlying principles of cross contamination of hobby animals?

G. van der Peet, cluster manager transition sustainable agriculture (interviewed on 11-11-04):

- national detection speed of infectious animal diseases: How fast do we want to detect a disease? At what costs?

- what is the optimal control strategy if an outbreak of an infectious animal disease occurs?
- what are the effects on costs and risks of measures from the General Food Law?
- what are the effects of 'above legal' measures on the risks and on the costs? What is the (cost) optimal combination of 'above legal' measures?
- if firms are separated into different risk classes for a certain disease (e.g. multiple contacts or a non-disinfected truck is a high risk factor, a closed firm is low risk factor), the control strategy can be adapted to the risk class. What is the optimal control strategy for each risk class?
- what is the impact of hobby and recreational farming on the spread of animal diseases? What measures to control an outbreak are then cost effective?
- what is the optimal way of firms to react in crises (e.g. dioxin in feed)?

After the 2001 outbreak of FMD in the Netherlands Van der Zijpp et al. (2002) formulated a research agenda concerning FMD. They concluded the following so called 'white spots':

- international framework for policy renewal;
- the future role of animal husbandry in rural development related to FMD eradication;
- attention for supply chain and consumer and the influence of supply chain partners and consumers on the effects of policy;
- social cost benefit analysis of crises;
- interdisciplinary interaction, especially communication;
- the process of management decision support models and the actual behaviour during an outbreak and during the preparation for eradication.

They translate these 'white spots' into a research agenda with the following topics (only the for the proposed framework relevant topics):

- update the contingency plans every three years by organising a 'bottom-up' FMD regional analysis and include social changes;
- regularly testing the contingency plans;
- evaluate different vaccination scenarios considering veterinary, economic, trade and psychological consequences during an outbreak. Investigate the possibilities for local MSS area without losing the export status of FMD free areas;
- investigate the transmission and spread of FMD in relation with infrastructure and transport;
- stimulate the development of a marker vaccine and fast diagnostic tests;
- investigate the impact of differences between rural economies in different EU countries on the optimal control strategy;
- investigate the processes of government in the different EU countries;
- develop a new communication strategy before, during and after an outbreak.

4.2 Experiences with expert systems on animal diseases

Experience on building all-inclusive expert systems on animal diseases is available and mostly non-positive. In an interview by telephone Miriam Nielen of the Department of Farm Animal Health of Utrecht University (9-11-2004) explained her experience on three of these projects: 1) expert system on mastitis, 2) expert system on FMD, and 3) expert system on CSF. The reasons for the expert system to fail varied: 1) The mastitis expert system failed because the developers of the expert system left the organisation after finishing the project and nobody remained to maintain the source code. 2) The FMD expert system failed because the maintenance of the expert system became too expensive. The system consisted of different combined models in different programming languages. New versions of these programs came onto the market repeatedly. The system became impossible to handle as new versions usually meant reprogramming (part of) the system. Furthermore, retaining the most updated versions became too expensive. 3) Finally, the CSF expert system was never constructed as the intended users beforehand refused to use the system because they saw it as a 'black box'.

A different problem encountered in all three systems was the lack of expert knowledge on the disease at hand of the programmers. Thus, they constructed non-realistic and unusable models. Therefore, Nielen advises to work with independent models combined through procedures. A good base is an inventory of currently existing models and methods (as described in this report).

4.3 Points of attention for the framework

Based on the future research agenda and the experiences on building expert systems for animal diseases general points of attention for the proposed framework can be concluded:

- the framework must include both infectious animal diseases (animal health effects) and zoonoses (human health effects);
- the framework must include short-term and long-term effects inside and outside the agricultural sector;
- the framework must include all relevant aspects like epidemiology, economy, ethics, and social aspects;
- the framework must be able to handle feedbacks (between models) if parameters become endogenous;
- the framework must be adaptable to new emerging diseases, new insights, new control and eradication strategies;
- the framework must include the introduction and the spread of diseases and zoonoses;
- the framework must include the whole production chain from primary production, processing chain to consumers;
- the framework must address professionally kept animals and hobby animals;
- the calculated results from the framework must be easily traceable and verifiable;
- the framework must be able to generate answers on a general and detailed level;
- the framework can handle different information sources and datasets;
- the framework must be user friendly.

5. Conclusions

The main conclusions are:

- the underlying report gives an overview of 23 current readily available models and methods at SSG (both LEI and BE) on the field of infectious animal diseases and zoonoses. All focus on epidemiology and economics. Epidemiological models and methods focus on the introduction of an infectious animal disease into the Dutch agricultural system and on the epidemiological spread of a disease through the system. Economic models and methods encompass the calculation of financial effects for individual companies confronted with a specific disease (FMD, CSF, AI, IBR, salmonella, campylobacter) to national welfare consequences including global effects;
- the available models and methods form a base for the development of a disease specific framework for the integrated analysis of animal diseases and zoonoses in general. Because they were developed in different projects at LEI and BE, the (practical) connection is not always easy. This, together with the lack of models and methods outside the field of epidemiology and economy, make the development of a framework a challenging project;
- points of attention for the proposed framework are 1) to include both infectious animal diseases and zoonoses, 2) to consider short and long-term effects both in the agricultural production chain and in non-agricultural sectors, and 3) the possibility to adapt the framework to 'new' (emerging) diseases and new eradication and control strategies. Furthermore, the building of an all-inclusive expert system is not advised because of 1) the dependency on one person (developer/maintainer), 2) the high costs of maintenance and 3) possible lack of user friendliness (black box idea).

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http://www.gtap.agecon.purdue.edu/, 8-12-2004.

Appendix 1 Formerly OIE List B animal diseases

(http://www.oie.int/eng/maladies/en_classification.htm)

Multiple species diseases
- Anthrax
- Aujeszky's disease
- Echinococcosis/hydatidosis
- Heartwater
- Leptospirosis
- New world screwworm (Cochliomyia hominivorax)
- Old world screwworm (Chrysomya bezziana)
- Paratuberculosis
- Q fever
- Rabies
- Trichinellosis

Cattle diseases
- Bovine anaplasmosis
- Bovine babesiosis
- Bovine brucellosis
- Bovine cysticercosis
- Bovine genital campylobacteriosis
- Bovine spongiform encephalopathy
- Bovine tuberculosis
- Dermatophilosis
- Enzootic bovine leukosis
- Haemorrhagic septicaemia
- Infectious bovine rhinotracheitis/infectious pustular vulvovaginitis
- Malignant catarrhal fever
- Theileriosis
- Trichomonosis
- Trypanosomosis (tsetse-transmitted)

Sheep and goat diseases
- Caprine and ovine brucellosis (excluding B. ovis)
- Caprine arthritis/encephalitis
- Contagious agalactia
- Contagious caprine pleuropneumonia
- Enzootic abortion of ewes (ovine chlamydiosis)
- Maedi-visna

- Nairobi sheep disease
- Ovine epididymitis (Brucella ovis)
- Ovine pulmonary adenomatosis
- Salmonellosis (S. abortusovis)
- Scrapie

Equine diseases
- Contagious equine metritis
- Dourine
- Epizootic lymphangitis
- Equine encephalomyelitis (Eastern and Western)
- Equine infectious anaemia
- Equine influenza
- Equine piroplasmosis
- Equine rhinopneumonitis
- Equine viral arteritis
- Glanders
- Horse mange
- Horse pox
- Japanese encephalitis
- Surra (Trypanosoma evansi)
- Venezuelan equine encephalomyelitis

Swine diseases
- Atrophic rhinitis of swine
- Enterovirus encephalomyelitis
- Porcine brucellosis
- Porcine cysticercosis
- Porcine reproductive and respiratory syndrome
- Transmissible gastroenteritis

Avian diseases
- Avian chlamydiosis
- Avian infectious bronchitis
- Avian infectious laryngotracheitis
- Avian mycoplasmosis (M. gallisepticum)
- Avian tuberculosis
- Duck virus enteritis
- Duck virus hepatitis
- Fowl cholera
- Fowl pox
- Fowl typhoid
- Infectious bursal disease (Gumboro disease)
- Marek's disease
- Pullorum disease

Lagomorph diseases
- Myxomatosis
- Rabbit haemorrhagic disease
- Tularemia

Bee diseases
- Acariosis of bees
- American foulbrood
- European foulbrood
- Nosemosis of bees
- Varroosis

Fish diseases
- Epizootic haematopoietic necrosis
- Infectious haematopoietic necrosis
- Oncorhynchus masou virus disease
- Spring viraemia of carp
- Viral haemorrhagic septicaemia

Mollusc diseases
- Bonamiosis (Bonamia exitiosus, B. ostreae, Mikrocytos roughleyi)
- Marteiliosis (Marteilia refringens, M. sydneyi)
- Mikrocytosis (Mikrocytos mackini)
- MSX disease (Haplosporidium nelsoni)
- Perkinsosis (Perkinsus marinus, P. olseni/atlanticus)

Crustacean diseases
- Taura syndrome
- White spot disease
- Yellowhead disease

Other List B diseases
- Leishmaniosis

Appendix 2 Additional related publications on infectious animal diseases

This appendix gives an overview of additional related publications from SSG on infectious animal diseases.

The following publications provide additional background literature on FMD:

- Tomassen, F.H.M., A. de Koeijer, M.C.M. Mourits, A. Dekker, A. Bouma & R.B.M. Huirne, 2002, *A decision-tree to optimise control measures during the early stage of a foot-and-mouth disease epidemic*, Preventive Veterinary Medicine 54, pp. 3001-324.
  A decision-tree is developed to minimise direct costs and export losses of FMD epidemics under several scenarios of measures during the first days after the declaration of an outbreak. Ring-vaccination is the economically optimal control strategy for DPLA's whereas ring culling is the economically optimal control strategy for SPLA's.
- Tomassen, F.H.M., M.C.M. Mourits, M.P.M. Meuwissen & R.B.M. Huirne, 2004, *Economic modeling of FMD control in data-abundant situations, a multi-stakeholder model*, In: Proc. SVEPM, Viñar del Mar, Chile.
  The paper describes an integrated epidemiological and economic model to analyse the economic impact of FMD.

The following publications provide additional background literature on FMD and CSF:

- Horts, H.S., 1998, *Risk and economic consequences of contagious animal disease introduction*, Mansholt studies 11, Mansholt Institute, Wageningen, the Netherlands.
  A combination of a Monte Carlo simulation virus introduction model (CSF and FMD, with @risk), an epidemiological model (InterCSF, InterFMD) and an economic model is used to quantify the losses due to epidemics of CSF and FMD.

The following publications provide additional background on FMD, CSF and AI:

- Wilpshaar, H., M.P.M. Meuwissen, F.H.M. Tomassen, M.C.M. Mourits, M.A.P.M. van Asseldonk & R.B.M. Huirne, 2002, *Economic decision making to prevent the spread of infectious animal diseases*, In: Proc. O.I.E. Regional Commission for Europe, Finland.
  A questionnaire to all CVO's of 'European' OIE countries to gather information on FMD, CSF and AI is used as input for an epidemiological and an economic model to calculate the expected size of an epidemic and the expected economic losses. The paper demonstrates the importance of reliable and complete data.
- Huirne, R.B.M., M.P.M. Meuwissen, M.A.P.M. van Asseldonk, F.H.M. Tomassen & M.C.M. Mourits, 2003, *Financing losses of infectious livestock diseases in Europe: An economic risk analysis*, In: Proc. FSVEE & DSVEE, Leuven, Belgium.
  A questionnaire to all CVO's of 'European' OIE countries to gather information on FMD, CSF and AI is used as input for an epidemiological and an economic model to calculate the expected size of an epidemic and the expected economic losses. The paper demonstrates the importance of reliable and complete data.

The following publications provide additional background literature on Aujeszky:

- Buijtels, J.A.A.M., 1997, *Computer simulation to support policy-making in Aujeszky's disease control*, PhD-thesis Wageningen Agricultural University, Wageningen, the Netherlands.

  This report describes a computer stochastic simulation environment to perform 'what-if' scenarios to explore the epidemiological and economic effects of different Aujeszky's disease control programs. The framework consists of a state-transition epidemiological simulation model and a flexible stochastic economic simulation model.

Appendix 3 Interviewees

Interviews on models:

Name	**Model**	**Organisation**
Achterbosch, Thom	ImportFMD	LEI
Backus, Gé	Salmon II	LEI
Bunte, Frank	Cost of public health	LEI
Gaag, Monique van der	Salmon I	BE
Helming, John	DRAM	LEI
Horne, Peter van	Salmonella chicken supply chain	LEI
Koning, Marieke	REM	LEI
Leeuwen, Myrna van	AIOM, AG-MEMOD	LEI
Mangen, Marie-Josée	Carma farmer, Carma slaughterhouse, Dupima a), Economic Welfare Analysis a), EpiCosts a), Epiloss a), EpiPigFlow a)	LEI
Mourits, Monique	InterCSF, InterFMD, InterIBR	BE
Puister, Linda	Salmonella Chicken	LEI
Tabeau, Andrzej	GTAP	LEI
Vos, Clazien de	Scenario treat model	BE
Wagenberg, Coen van	Calculation model (in)direct costs AI, CSF, FMD	LEI

a) Developed by M.-J. Mangen during her stay at BE.

Interviews on expert opinion:

Name	**Organisation**
Burrell, Alison	SSG, AEP (Agricultural Economics and Rural Policy Group)
Döpfer, Dörte	ASG, QVE
Meijering, Albert	ASG (cluster manager animal health)
Nielen, Mirjam	Department of Farm Animal Health, Faculty of Veterinary Medicine, Utrecht University
Peet, Geert van der	ASG (cluster manager transition sustainable agriculture)
Perez Soba, Marta	ESG, ALTERRA
Saatkamp, Helmut	SSG, BE

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