Scenario tree modelling to analyse the probability of Classical Swine Fever virus introduction into member states of the European Union

De Vos, C.J.[1], Saatkamp, H.W.[1], Nielen, M.[2] & Huirne, R.B.M.[1]
[1] Farm Management Group, Department of Social Sciences, Wageningen University, Hollandseweg 1,
6706 KN Wageningen, The Netherlands.
[2] Department of Farm Animal Health, Faculty of Veterinary Medicine, Utrecht University, Yalelaan 7,
3584 CL Utrecht, The Netherlands.

**Summary**
The main aim of this model is to analyse which pathways (i.e. carriers and mechanisms that can transmit the virus from an infected to a susceptible animal) contribute to the $P_{CSFV}$ for a particular country and from where these pathways originate. The annual $P_{CSFV}$ into the Netherlands calculated by the model is quite low when compared with expert estimates and recent history. The model most probably underestimates the overall annual $P_{CSFV}$ as not all pathways contributing to the $P_{CSFV}$ were included in the model, nor were third countries. Absolute values of model outcome should therefore not be considered as true values for the $P_{CSFV}$. The ultimate aim of the model was, however, not to give exact estimates of the $P_{CSFV}$, but to obtain more quantitative insight into the main factors determining the $P_{CSFV}$ into a country. As such, it shows which countries of origin and which pathways contribute most to the overall annual $P_{CSFV}$. This information can help policy makers in setting priorities for strategic preventive measures.

## Introduction

The introduction of classical swine fever virus (CSFV) into a country free of disease without vaccination may have huge consequences in terms of both disease spread and economic losses. In the European Union (EU) a non-vaccination policy has been applied since the early 1990s. Although this policy has proven to be quite successful, the introduction of CSF remains a continuing threat to the pig production sector of the EU. Sporadic outbreaks in the domestic pig population still occur, some resulting in large epidemics incurring high economic losses. In addition, CSF occurs in an endemic form in wild boar populations in some areas of Germany, France, and Italy, representing a permanent CSFV reservoir. In recent years infected wild boar were also found in Austria, Belgium and Luxembourg.

Many factors contribute to the probability of CSFV introduction ($P_{CSFV}$) and their relative importance will differ for each country. The major causes of CSFV introduction for a country have to be known in order to optimally use resources available for prevention. For this purpose a model was constructed that calculates the annual $P_{CSFV}$ into member states of the EU. The main aim of this model is to analyse which pathways (i.e. carriers and mechanisms that can transmit the virus from an infected to a susceptible animal) contribute to the $P_{CSFV}$ for a particular country and from where these pathways originate.

## Model description

*Model contents*

The model calculates the $P_{CSFV}$ into the domestic pig population of a country by different pathways. Pathways can either be exogenous or endogenous. Exogenous pathways are linked with virus sources outside the country where they might cause a primary outbreak, whereas endogenous pathways reside within the country affected. The countries where exogenous pathways may come from are called countries of origin, whereas the country affected is called the target country.

A selection was made of all pathways that possibly contribute to the $P_{CSFV}$ for inclusion in the model. Two selection criteria were used: (i) expected importance for CSFV introduction and (ii) availability of knowledge and data to quantify the underlying probabilities. Based on these criteria, the exogenous pathways import of domestic pigs, import of pork products, and returning livestock trucks were included, as well as the endogenous pathways direct and indirect contact with wild boar.

All 15 EU member states were included in the model as possible countries of origin. The model was run with the Netherlands as the target country. Trade statistics from 1999 were used.

*Modelling approach*

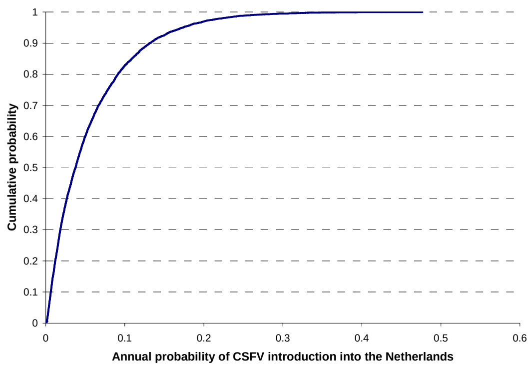
The scenario pathway approach (Vose, 1997) was used as a modelling technique, as this approach requires relatively little computing time and can easily calculate extremely low probabilities.

For each pathway in the model, a scenario tree was constructed, containing the sequence of events that would ultimately lead to CSFV introduction into the domestic pig population of the target country. Each event in the scenario trees was assigned a probability that it will occur. To calculate the $P_{CSFV}$ for a certain pathway, all probabilities along its scenario tree were multiplied. The scenario trees for the exogenous pathways were calculated separately for each country of origin. Combining the outcome of all scenario tree calculations gave insight into the relative contribution of countries of origin and pathways to the $P_{CSFV}$ for the target country.

The annual $P_{CSFV}$ into the target country is not a single or constant value, because it depends on the occurrence of CSF in the countries of origin, the contacts (e.g. trade) between these countries and the target country and the presence of infected wild boar populations in the target country, all of which are not constant over time. To take into account the variability of some of these input parameters, probability distributions were used and model calculations were iterated using Latin Hypercube sampling, resulting in a range of possible output values for the $P_{CSFV}$ into the target country.

## Results

In Fig. 1 the cumulative distribution function (cdf) for the overall annual $P_{CSFV}$ into the Netherlands is shown. The mean value for the overall annual $P_{CSFV}$ is 0.0560, indicating that the Netherlands can expect CSFV introduction on average once every 18 years from the pathways and countries of origin included in the model.




| Cumulative probability | Annual $P_{CSFV}$ |
|---|---|
| 0.05 | $3.72*10^{-3}$ |
| 0.25 | $1.52*10^{-2}$ |
| 0.50 | $3.76*10^{-2}$ |
| 0.75 | $7.84*10^{-2}$ |
| 0.95 | $1.74*10^{-1}$ |

**Fig. 1. Cumulative** probability distribution for the annual probability of CSFV introduction into the Netherlands.

Figure 2 gives insight into the main countries of origin contributing to the annual $P_{CSFV}$ into the Netherlands. Both the average probability per epidemic and the average probability per year are shown. Germany, Belgium and the United Kingdom are the countries of origin that contribute most to the annual $P_{CSFV}$ into the Netherlands.

Figure 3 presents an overview of the relative contribution of pathways to the annual $P_{CSFV}$ into the Netherlands. On average, returning livestock trucks contribute most to the $P_{CSFV}$ with 64.8%. This is mainly due to the large number of pathway-units present: the Netherlands is a major exporter of pigs ($5.14*10^6$ pigs exported versus $5.40*10^5$ pigs imported in 1999). The contribution of the endogenous pathways direct and indirect contact with wild boar is zero, as no CSF infections have occurred in Dutch wild boar populations in recent years.

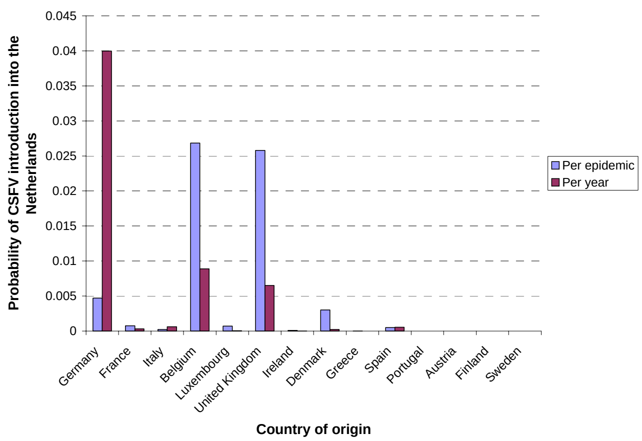



**Fig. 2.** Probability of CSFV introduction into the Netherlands per epidemic and per year from each country of origin in the model (all EU member states).

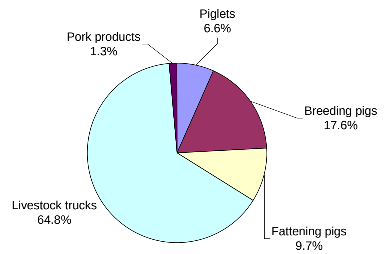



**Fig. 3.** Relative contribution of the pathways in the model to the overall annual probability of CSFV introduction into the Netherlands.

## Discussion

The annual $P_{CSFV}$ into the Netherlands calculated by the model is quite low when compared with expert estimates and recent history. The model most probably underestimates the overall annual $P_{CSFV}$ as not all pathways contributing to the $P_{CSFV}$ were included in the model, nor were third countries. Absolute values of model outcome should therefore not be considered as true values for the $P_{CSFV}$.

The ultimate aim of the model was, however, not to give exact estimates of the $P_{CSFV}$, but to obtain more quantitative insight into the main factors determining the $P_{CSFV}$ into a country. As such, it shows which countries of origin and which pathways contribute most to the overall annual $P_{CSFV}$ (Fig. 6 and 7). This information can help policy makers in setting priorities for strategic preventive measures. Furthermore, the probability of CSFV being introduced into the target country during a single epidemic in each country of origin has been calculated, indicating in which circumstances additional tactical preventive measures are required. The model can estimate the impact of both strategic and tactical preventive measures as well by changing relevant input parameters.

## References

Vose, D.J. (1997). Risk analysis in relation to the importation and exportation of animal products. *Revue Scientifique et Technique de Office International des Epizooties*, *16*, 17-29.