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# Culling vs. emergency vaccination: A comparative economic evaluation of strategies for controlling classical swine fever in the EU

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ABSTRACT

Outbreaks of epidemic animal diseases, especially classical swine fever (CSF), are associated with high costs for livestock-producing regions like the European Union (EU). Alternative and complimentary measures exist for dealing with epidemics of animal diseases such as CSF: culling, quarantine, emergency vaccination, preventive vaccination and disease monitoring. In the EU culling in combination with quarantine has remained the only strategy to handle CSF outbreaks. Due to member states' concerns about the tradability of vaccinated pigs and products from vaccinated animals, recent EU decisions have not considered emergency vaccination an appropriate alternative measure although modern DIVA vaccines allow the distinction between infected and vaccinated animals. Concurrently, the potential contribution of DIVA vaccines to the reduction of economic damages of CSF outbreaks has not been thoroughly addressed so far. This research gap motivates to compare the costs of culling and emergency vaccination for the latest outbreak of CSF in the EU exemplarily by applying a self-developed comprehensive simulation tool (TEUS) on the 2006 CSF epidemic in Germany. The results reveal that emergency vaccination involves lower direct costs but higher indirect costs than culling. Especially political interventions by the European Commission, the governments of its member states and the governments of non-EU member states are considered to make an emergency vaccination in case of an CSF outbreak economically unattractive under current conditions. This outcome implies the request for more emergency vaccination friendly EU regulations and OIE requirements.

## 1. Introduction

Between the years 2006 and 2009, outbreaks of epidemic animal diseases caused the loss (death, destruction and slaughter) of 762,212 livestock units worldwide, 21,953 due to classical swine fever (CSF) outbreaks among domestic pigs (World Bank, 2011). The European countries most affected by CSF within the last 20 years were Austria, Belgium, France, Germany, Italy, the Netherlands, Portugal and the UK (OIE, 2015). Among these countries, the worst affected were the Netherlands, the UK and Germany, which suffered significant economic losses and reduced productivity in their pork production sectors as a result of several major recurrent CSF epidemics (OIE, 2015). Germany, the European market leader in pork production, is considered a high-risk-country with regard to CSF due to relatively long epidemic durations and high animal densities in certain regions (Groeneveld, 2007). Therefore, it is concluded with regard to Germany: "The question is not *if* CSF will break out again, but *when* it will break out." (Groeneveld, 2014).

In general, four potential measures exist in addition to basic disease monitoring for dealing with epidemics of animal diseases such as CSF rigorously: culling, quarantine, emergency vaccination and preventive vaccination (Fadiga and Katjiuongua, 2014). EU Directive 2001/89/EC regulates how these measures should be used in combination in case of an animal disease outbreak within the European Union (EU). It defines the following measures: the establishment of protection and surveillance zones as well as the enforcement of animal movement restrictions (quarantine), the culling of animals and emergency vaccination under specific legal constraints. Conversely, preventive vaccination is prohibited so it does not provide any legal basis for potential implementation (European Commission, 2001; BMEL, 2014; BMJ, 2009). This is in line with the rather vaccination-unfriendly attitude of many EU member states (Lehnert, 2012), which have incorporated this directive into national legislation. In Germany, for instance, legislation on CSF (SchwPestV) and animal diseases (TierGesG) provides the legal framework for eradicating CSF among (specifically) domestic and wild pigs (BMEL, 2014; BMJ, 2009). Furthermore, the EU can decide to tighten the regulations in order to change measures against CSF if the EU determines that a member country is not capable of containing the

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spread of the disease. This happened in 2006 during the latest epidemic in Germany, when the EU forced the culling of all pigs within the protection zone based on the EU Decision 2006/346/EC and tightened the trade restriction on pig products based on EU Decisions 2006/346/EC and 2006/411/EC (European Commission, 2006a, 2006b).

Despite the existence of modern marker vaccines, such as the DIVA vaccine,[1] which allow to clearly distinguish between infected and vaccinated animals, preventive vaccination of pigs against CSF is still forbidden in the EU and has been since the early 1990s. Moreover, emergency vaccination after a CSF outbreak is neither suggested nor enforced and has not yet been successfully used even though it is legally allowed and is associated with the same success rate as pre-emptive culling as well as with lower costs for epidemic control (Groeneveld, 2014; Bätza, 2012; Nigsch and Depner, 2012; Thulke et al., 2011). Furthermore, promoting emergency vaccination with DIVA vaccines would address increasing public concerns about food waste and animal welfare among European consumers; therefore, researchers and the majority of the EU member states have requested that EU regulation should be made more vaccination-friendly. But despite the potential advantages of DIVA vaccination over culling, consumer acceptance of meat from vaccinated pigs is low, even within the EU member states, and major concerns about the tradability of vaccinated pigs and products from vaccinated pigs remain among companies in the meat supply chain, such as food processors and retailers. These concerns can lead, on the one hand, to the exclusion of such products from the product assortment of food retailers and the non-acceptance of vaccinated pigs by slaughterhouses and, on the other hand, to immense pressure on politicians by the food industry not to enforce the option of emergency DIVA vaccination in legislation.

Controlling costs play a major role from both an industry and a political perspective especially because animal disease outbreaks can have catastrophic economic effects on all actors along the meat supply chain (Näther and Theuvsen, 2015; Fadiga and Katjiuongua, 2014; Hartnack et al., 2009; Bätza, 2012; Nigsch and Depner, 2012; Thulke et al., 2011). Taking these issues into account, this study investigates whether the use of DIVA vaccines causes lower economic damage in case of CSF outbreaks than culling in combination with quarantine and whether emergency vaccination should be introduced as a potential strategy within EU legislation and, thus, also within the national legislation of EU member countries. This implies that there is an urgent need for more collective approaches in order to combine aspects of economics and animal health management as it has been highlighted in recent literature by other researchers (Jarvis and Valdes-Donoso, in press). Therefore, a comprehensive analysis of the economic effects of the implementation of the alternative animal disease control strategies is highly relevant. The costs of epidemic control in animal disease outbreaks can be evaluated ex ante or ex post (Fadiga and Katjiuongua, 2014; Jarvis and Valdes-Donoso, in press). While ex ante evaluations are well documented in the literature (Rich and Winter-Nelson, 2007; Bennett, 2003; Gueye, 2007; Egbendewe-Mondzozo et al., 2013; Rushton, 2009; Perry and Grace, 2009; Randolph et al., 2002; Fadiga and Katjiuongua, 2014; Gohin and Rault, 2013), ex post evaluations and simulations are still underrepresented and a current comprehensive framework for conducting such analyses does not exist. This is due to data-uncertainty–based difficulties in considering and specifying cost items (choice of the appropriate variables and their level of abstraction) and their amounts for the calculations (availability of the specific relevant data) when conducting ex post evaluations of animal disease epidemics (Fadiga and Katjiuongua, 2014). Previous research attempts (such as the studies by Saatkamp et al., 2000; Meuwissen et al., 1999; Mangen and Burrell, 2003) to calculate the costs of CSF outbreaks ex post remained too fragmentary and vague to derive concrete policy implications. Furthermore, DIVA vaccines have never been taken into account as an appropriate alternative to culling in these studies since they represent the newest generation of marker vaccines, which were registered in the year 2014; this is the only set of marker vaccines that provides the appropriate practicability for use in case of a CSF outbreak, and, as a result, it offers the only realistic alternative to culling. Therefore, there is a clear research gap regarding the assessment of the economic effects of implementing alternative disease control strategies. In order to fill this research gap, this study seeks to develop a comprehensive simulation tool (TEUS), as recommended in earlier methodological literature (Fadiga and Katjiuongua, 2014), for comparing the costs of the two alternative measures, i.e. culling and emergency DIVA vaccination[2] (both in combination with quarantine). To test the economic usefulness of the latter measure, we applied this tool to the analysis of the 2006 CSF epidemic in Germany. Based on the results, concrete policy implications will be derived.

## 2. Background

### 2.1. Major classical swine fever outbreaks in the EU since 1996

In the last two decades, CSF epidemics have occurred in domestic pig populations in many European countries since it is endemic in the wild pig population. Germany (2006), the Netherlands (1997/1998), Spain (2001/2002) and the UK (2000) were especially affected, and a great number of pigs had to be culled (see Fig. 1). The dimensions of these epidemic outbreaks varied greatly with regard to the number of outbreaks, animals culled, and pigs culled per outbreak (OIE, 2015; LEJ, 2006). Even though CSF has not been detected in the EU since 2006, experts expect further outbreaks in the future (Groeneveld, 2014). The chronology of and the economic damage inflicted by the major European CSF outbreaks will be discussed below.

The first major CSF epidemic in the EU in the past two decades took place in the years 1997 and 1998 and primarily affected the Netherlands but also spread to other European countries. During these outbreaks, 429 infected herds (with approx. 700,000 pigs) were culled and 1286 herds (with approx. 1.1 million pigs) slaughtered preventively in the Netherlands alone. Furthermore, protection zones, surveillance zones and animal movement restrictions were implemented in keeping with EU legislation (Elbers et al., 1999). Due to the consistent enforcement of these measures, the Netherlands were able to control the epidemic without EU intervention within only six weeks (Groeneveld, 2007). Meuwissen et al. (1999) estimated in their simulations that the total costs of this epidemic were about US$ 2.3 billion (including costs of US$ 423 million for farmers and of US$ 596 million for the related food industry), of which less than 50% were covered by the Dutch government. While the primary outbreak in the Netherlands was detected in February 1997, the first pigs to be infected with the same type of virus had already been identified in Paderborn, Germany, in January 1997. Experts consider it likely that the virus was transported in infected pigs from Germany to the Netherlands in the second half of December 1996. Within months, infected pigs were discovered in Italy in February, in Spain in March and in Belgium in July (Elbers et al., 1999; Edwards et al., 2000). Therefore, the total costs of the 1997/1998 CSF outbreak are much higher than the numbers for the Netherlands presented by Meuwissen et al. (1999).

In 2000 CSF reappeared in the United Kingdom after an absence of 14 years (Arzt et al., 2010; Paton, 2002). During this outbreak, several pig farms in East Anglia became infected between mid-June and early August 2000. As a result, 850 farms were subjected to protection zones, surveillance zones and animal movement restrictions. Nevertheless, the virus spread to other farms and regions (e.g., North Norfolk) until the

[1] DIVA = Differentiating Infected from Vaccinated Animals.

[2] The preventive DIVA vaccination has been excluded from the simulation due to the unrealistic nature of its implementation and the lack of a legal framework for its use in a simulation (European Commission, 2001; Lehnert, 2012).