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Cost Effectiveness Analysis: Methodology for the Food Chain Area

Final Report

Competence Centre on Microeconomic Impact Evaluation (CC-ME)

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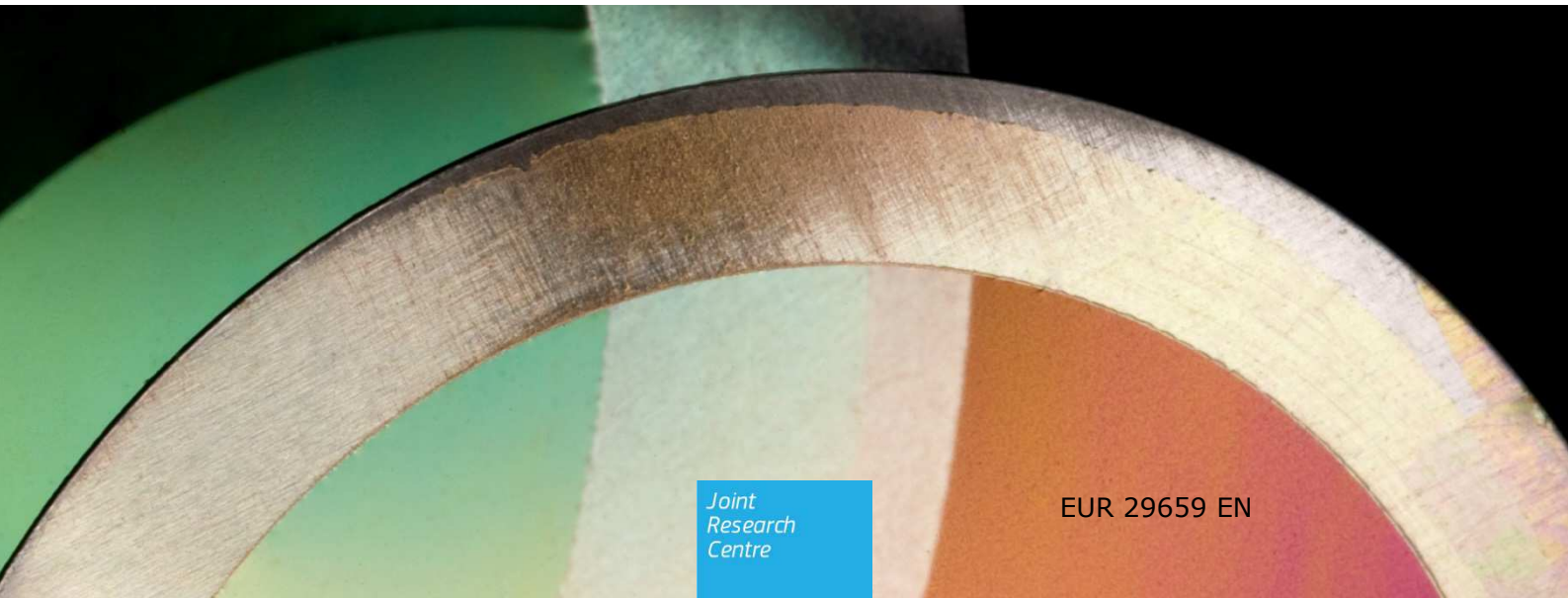

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Contact information
Address: European Commission - Joint Research Centre
Competence Centre on Microeconomic Evaluation
Via E. Fermi 2749, TP 361
Ispra (VA), I-21027, Italy

JRC Science Hub
https://ec.europa.eu/jrc/en
https://ec.europa.eu/jrc/en/microeconomic-evaluation

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Authors

Sophie GUTHMULLER

Montezuma DUMANGANE

Licia FERRANNA

Ludovica GIUA

Palma MOSBERGER

Executive summary

This report provides a methodological guidance on cost-effectiveness analysis in the view of future evaluations of the EU interventions currently funded under the Common Financial Framework of the food chain area (CFF, Regulation (EU) No 652/2014). The report was commissioned by DG SANTE.

Under the CFF, the EU is either funding or co-funding eligible costs faced by Member States when implementing phytosanitary and veterinary programmes, official control activities, and veterinary and phytosanitary emergency measures. These interventions aim at contributing to a high level of health for humans, animals and plants along the food chain, by preventing and eradicating diseases and pests and by ensuring a high level of protection for consumers and the environment, while enhancing the competitiveness of the Union food and feed industry.

This report presents a methodology on how to address relevant policy questions such as: "Should more funding be awarded to prevention measures or to control measures to reduce the risk of outbreaks of classical swine fever in pigs?" or "is the introduction of new e-learning tools for official staff more effective in increasing the quality of the official controls compared to workshops?" This report provides evaluation methods to answer this type of questions and illustrates the methodology introduced for specific CFF related policy questions. These methods are based on disaggregated data and regression techniques.

Economic evaluation is a systematic analysis tool to assess and quantify whether the interventions produce the expected effects, and to help draw conclusions on the cost-effectiveness of the different EU funded programmes. Thus, economic evaluation is a funding allocation tool that allows decision makers with a budget constraint to make informed choices on which interventions to allocate funding to.

When performing economic evaluation, three main challenges need to be addressed; (i) how to measure the costs, (ii) how to quantify the effects, and (iii) how to identify the causal impact of the intervention under evaluation.

Measuring the costs

The costs to include in the evaluation depend first on the perspective chosen as the cost-effectiveness result can be different from the view point of the Member States, the European Commission, or the European citizens. In the broader point of view - the societal perspective- the evaluation would need to account for the costs for the EU but also the costs for the Member States, and the producers and consumers along the food chain.

When the scope of the economic evaluation includes different regions of different Member States, and the evaluation period spans over more than a year, methods that ensure comparable costs across Member States and over time, need to be applied.

Measuring the effectiveness

Three types of effectiveness indicators can be used in the evaluation: (i) output indicators and (ii) result indicators that measure the outcomes that are directly related to the interventions; (iii) impact indicators, which are relevant indirect economic and/or social outcomes induced by the interventions. Which indicators to use depends mainly on the policy question or the type of intervention to evaluate, and the stage of the policy cycle that needs to be evaluated: before, during or after the implementation of the intervention.

A methodology to develop a set of indicators to evaluate the different levels of intervention in the spending areas covered by the CFF is suggested. The proposed indicators update and complement the existing set of 21 technical indicators currently used by DG SANTE.

The collection of these indicators for monitoring or evaluation purposes requires also the collection of data on contextual indicators that frame the environment in which interventions are implemented.

Identifying the causal impact of the intervention

The main challenge of identifying the causal impact of an intervention is to be able to measure what would have happen in the absence of the intervention under evaluation. This counterfactual situation is by definition not observable as regions or Member States are either receiving EU funding or not. The aim of public policy evaluation methods (or counterfactual impact evaluation methods) is then to find the best proxy possible to approximate the counterfactual situation, i.e. to find a so-called "control group". The report discusses possible control groups.

Measuring cost-effectiveness in the food chain area

Possible ways of defining control groups are suggested in the context of the interventions funded in the food chain area. Given the nature of the policy process that defines the working programmes for the spending in animal and plant health, and that aims at a proper identification of the risks for subsequent awarding of funding, it can be assumed that the entire target population receives EU funding. In this case, when the entire target population receives the intervention, the causal impact of an increase in funding over time or a change in the intervention can be identified.

To perform a cost effectiveness analysis regression methods are suggested to evaluate the impact of EU funding. In particular, the Net benefit of a change (new intervention, extended intervention, additional measures within the existing intervention) in the intervention can be computed accounting for contextual indicators using appropriate techniques to solve a potential selection bias.

A list of selected cost-effectiveness indicators (CEI) is proposed for each intervention in the three spending areas i.e. Plant Health, Animal Health, and Official Controls. The feature of these selected CEIs is that they can be computed at different level of aggregation (local areas, regions, MS, by disease or types of disease, for a whole programme, etc.).

Implementation requirements

The methodology described in this report is an in-depth-data-driven technique. This technique is grounded on real data and provides robust ex-post evidence on the impact and the efficiency of interventions. This method then requires careful planning of the monitoring and evaluation of the interventions, in particular on data requirements.

The implementation of this method requires the collection of disaggregated data (e.g. at the level of regions, farmers, laboratories etc.) to compute the effectiveness indicators, the costs, and the contextual indicators.

Valuable sources of data are already available and these are related to the costs, diseases status, implementation of the interventions, farmers and trade and other economic outputs that need to be consolidated to perform a cost-effectiveness analysis.

1 Introduction

1.1 Aim of this guidance

The aim of this report is to provide a guideline on the monitoring and evaluation of the activities currently funded under the Common Financial Framework for the food chain area (CFF, Regulation (EU) No 652/2014).

More specifically this report shall:

- Propose a methodology to evaluate the impact of the interventions funded under this CFF.
- Present methods to measure whether the effectiveness of these interventions is worth the costs and discusses their advantages and their limits.
- Serve as guidance to support policy makers in the upcoming preparatory work for the proposal for a post-2020 food chain programme, planned to start in the second half of 2017.
- Provide policy makers with the evaluation tools to perform a first cost-effectiveness analysis (CEA) in view of the CFF ex-post evaluation, to be carried out by June 2022 (Article 42 of Regulation (EU) No 652/2014).

1.2 Outline of the report

The report is organised as follows; the remainder of Chapter 1 provides an overview of the type of interventions and the framework logic of the CFF for the food chain area. The concepts of monitoring, economic evaluation and cost-effectiveness analysis (CEA) are also introduced.

When performing economic evaluation, three main challenges need to be addressed; (i) how to measure the costs, (ii) how to quantify the effects, and (iii) how to identify the causal impact of the intervention under evaluation.

Chapter 2 focuses on the costs and describes what type of costs should be considered in the evaluation and how to measure them.

Chapter 3 defines indicators to measure effectiveness. The current list of indicators covering all CFF spending areas is reviewed and new indicators are proposed, in view of future economic evaluation.

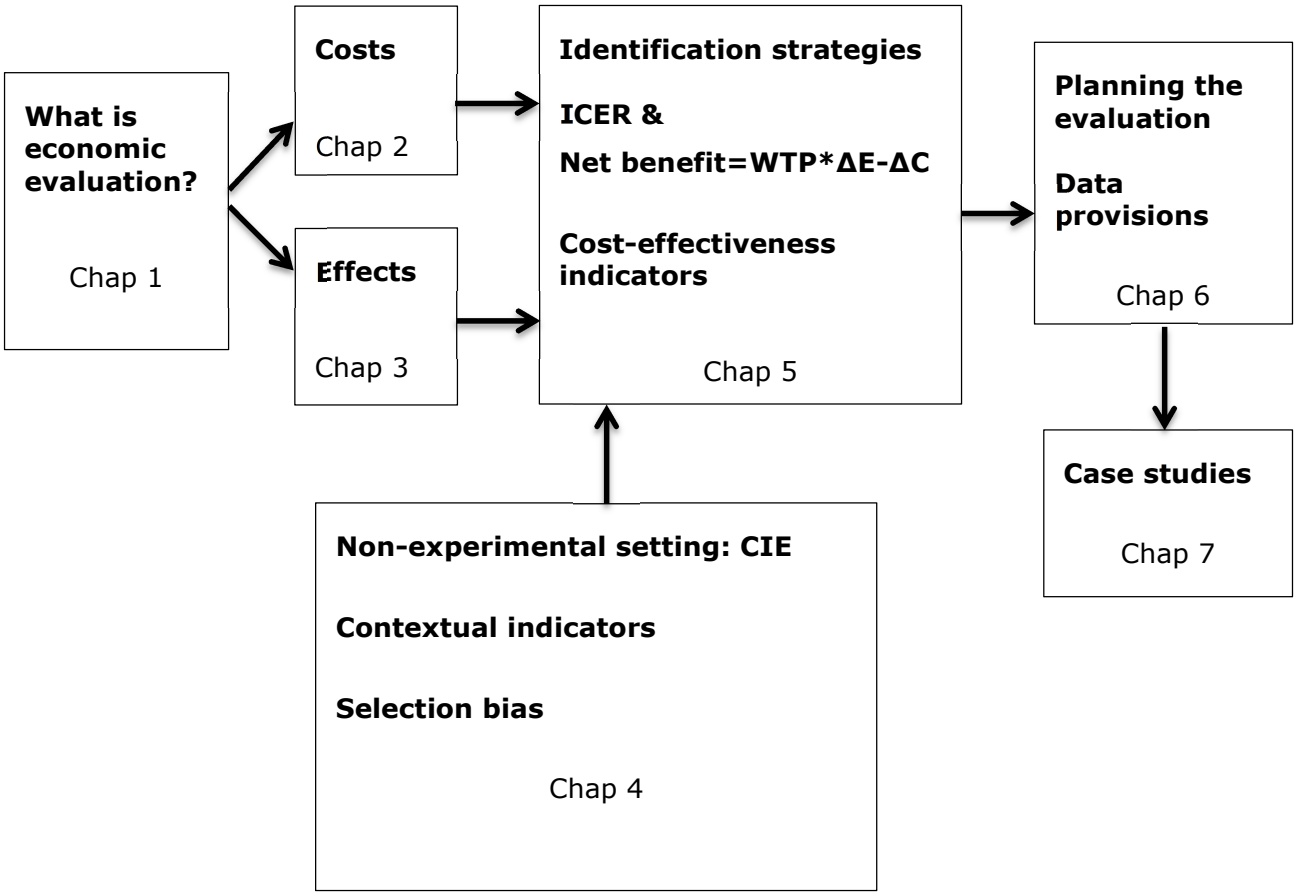
The challenges of causal analysis in non-experimental settings are tackled in Chapter 4. The necessity to account for contextual indicators and potential selection bias is explained. Counterfactual Impact Evaluation (CIE) and the concept of counterfactual in public policy evaluation methods are introduced.

Chapter 5 describes how to measure cost-effectiveness for the interventions funded in the food chain area. Possible identification strategies are discussed based on the design of the interventions. The Incremental Cost-Effectiveness Ratio (ICER) and how to measure it with econometric based techniques is presented. The use of the Net Benefit to measure the Incremental Cost Effectiveness Ratio (ICER) for different Willingness to Pay (WTP) is also introduced. Finally based on the indicators presented in Chapter 3, a list of Cost-Effectiveness Indicators for each intervention funded under the CFF is proposed.

Chapter 6 tackles the prerequisites for implementing the methodology, the evaluation plan and the data requirements. Examples of studies are proposed in Chapter 7.

The results of a literature review on food crisis, animal diseases and plant pests are reported in Annex 1. The focus of the review is on the costs of plant pests and animal diseases outbreaks in Europe, North America and Australia for the period of 1997-2017.

Figure 1 – Overview of the report



Note: CIE= Counterfactual Impact Evaluation, ICER= Incremental Cost-Effectiveness Ratio, WTP= Willingness to Pay, ΔE=variation in effect, ΔC=variation in cost.

1.3 Overview of the EU interventions funded in the food chain area

The general aim of the European Union interventions under EU Regulation No 652/2014 is to contribute to a high level of health for humans, animals and plants along the food chain, by preventing and eradicating diseases and pests, or at least prevent further spread into the Union territory, and by ensuring a high level of protection for consumers and the environment, while enhancing the competitiveness of the Union food and feed industry. The ceiling for EU funding is almost 1.9 billion EUR for the current seven year financial period (MFF 2014-2020) in these interventions.

1.3.1 Types of interventions funded

Animal health

The European Union co-finances specific measures in order to prevent and reduce the number of outbreaks of animal diseases and zoonoses, which pose a risk to human and animal health. It provides co-funding through the **Veterinary programme** for eradication, control and surveillance and the **Emergency measures**.

Grants in the **Veterinary programmes** for eradication, control and surveillance might be awarded to Member states (MS) annually or multi annually. The Union sets the list of eligible diseases for which funds are granted for national programmes (Annex II to Regulation (EU) No 652/2014) and then prioritise them based on the threat they pose to human health (zoonosis), the impact on animal livestock production, trade and new epidemiological developments (annual/multi-annual work programmes adopted by the Commission). This list can be supplemented.

Within the **Veterinary programmes** the **Eradication programme** aims to achieve biological extinction of an animal disease or zoonosis, while the **Control programme** aims to maintain the prevalence of the disease or zoonosis below a sanitary acceptable level. The **Surveillance programme** collects and record data on specific diseases in defined populations to assess the epidemiological evolution and target measures for control and eradication.

The Union co-finances measures including sampling, testing, cost of compensation for the market value of slaughtered or culled animals, cost of compensation for the market value of destroyed animal products, vaccination, cost of cleaning, disinfection, and disinfestation.

Grants for **Emergency measures** are awarded to countries to control epidemics that are likely to constitute threat to the Union due to their significant impact on human or animal health and agricultural production. The Union sets the list of eligible diseases (Annex I to Regulation (EU) No 652/2014), but might also supplement the list in case of a new disease. The eligible costs include the compensation for the market value of slaughtered or culled animals, the market value of destroyed products, cost of cleaning, disinfection, disinfestation, transport and disposal of carcasses, and destruction of the contaminated feeding stuff and vaccination.

Plant health

The European Union co-finances specific measures in order to protect plants and plant products from harmful pests (harmful organism, HO) which can have devastating effects on EU agriculture, environment and economy. It provides co-funding through the national **Survey programme** concerning the presence of pests and the **Emergency measures**.

Grants might be awarded to MS for annual or multiannual **Survey programmes** that survey the presence of pests in accordance with a predefined list and pests not included in the list that represent imminent danger to the Union. The programme co-finances measures including visual examination, sampling, testing and trapping.

Emergency funding is awarded to countries to eradicate pests from an infested area, or if this is no longer feasible, at least contain their presence and to prevent their further spread into the Union territory. Funding might be award to MS neighbouring countries with the presence of pests to prevent the entry of the pest to Union territory. The

programme co-finances the market value of destroyed plants and plant products (since January 2017), cost of treatment, destruction, removal, cleaning, and disinfection.

Official controls

The EU official controls ensure the enforcement of regulatory requirements, and that the EU MS authorities carry out the existing rules in order to maintain the safety of humans, animals and plants along the food chain. The two main activities funded include the **EU Reference Laboratories (EURLs)** and the **Better Training for Safer Food** initiative.

The **EURLs** aim to guarantee uniform testing in the MSs and take part in the risk assessment in the area of laboratory analysis to ensure compliance with the EU food chain regulatory rules. Their tasks include providing National Reference Laboratories (NRLs) with analytical methods and diagnostic techniques, training NRL staff and experts from developing countries, assisting the Commission scientifically and technically, collaborating with the competent laboratories in non-EU countries and assisting actively in the diagnosis of animal disease outbreaks in MS.

The **Better Training for Safer Food** trains MS and candidate country national authority staff involved in official controls in areas of food and feed law, animal health, and plant health. The trainings are designed to keep authority staff up-to-date with the EU law and ensure controls are carried out in a uniform, objective and efficient manner in all MS. Trainings are open to third country participants also, especially to developing country participants to ensure they are familiar with EU import requirements and EU funding.

1.3.2 Financial framework regulation

The CFF for the food chain area defines eligible costs, the timeline for application, and the list of diseases for which each MS (and neighbouring third countries) can submit an application.

Eligible costs

For animal and plant health interventions the basic co-financing rate is 50% of the eligible costs. The rate can be increased to 75% in case of cross-border activities implemented together by two or more MS or for MS whose gross national income per capita is less than 90% of the Union average. Furthermore, the rate might be increased to 100% for measures designed to avoid human casualties or major economic disruptions in case of serious human, plant and animal risk for the Union. The rate might be also increased to 100% in case the interventions are implemented in third countries.

The Commission provides 100% funding for EURLs activities as well as for the Better Training for Safer Food trainings.

Timeline for grant application

The timeline for animal and plant health programmes is the following. MSs shall submit by 31 May their national programmes applications, which are due to start in the following year. The national programme description must contain information about the epidemiological situation of the disease; the description of the geographical area where the programme is to be applied, the duration of the programme, the measures, the estimated budget, the targets, and the indicators to measure the achievements. The Commission evaluates the applications, addresses additional questions to the MSs, modifies and adapts the list of programmes, measures and amount and by the 31 January notifies MSs about the grant decisions. MSs submit the interim report by the end

of August and the final reports and payment requests by the end of April of the following year. The Commission reimburses the eligible co-financing payments at the end of July.

The timeline for animal health emergency funding is the following. Within one month after confirmation of the occurrence of outbreak the MS requests financial support from the Commission, and provides information on the ongoing and planned actions. Within two months the MS submits a detailed budget plan and co-financing request, then within the next two months the Commission notifies the MS about the financing decision. The MS submits the detailed payment application 6 months after the eradication was completed, then no later than within 3 months the Commission assesses the financing request and reimburses the eligible cost.

The timeline for plant health emergency funding is similar, but with extended deadlines. Within two months after the outbreak the MS submits its financial request and preliminary information, and no later than 6 months the detailed budget plan. Then within the next 6 months the Commission evaluates the request and notifies the MS about the decision. The final request for payment is submitted within 6 months after the eradication or containment of pests and the eligible cost is reimbursed within 3 months.

1.4 What is economic evaluation?

1.4.1 Difference between monitoring and evaluation

Monitoring is a process of data collection about a programme in order to identify implementation problems and to generate information for future evaluations. The data collected will reflect changes both due to the EU interventions and also to those that are caused by other factors.

While monitoring looks at "what" changes have occurred since the implementation of a policy intervention, evaluation looks at "whether" the intervention has had an impact in relation to its objectives by examining the results chain (inputs, activities, outputs, outcomes and impacts), processes, contextual factors and causality.

1.4.2 Evaluation criteria

When performing an evaluation of the CFF in the food chain area the responsible authorities are required to follow the Better Regulation Toolbox, and hence to use the following five main evaluation criteria at each stage of the interventions' lifecycle: effectiveness, efficiency, coherence, relevance, and EU added value. Additional criteria can be added to this list.[1]
This guidance focuses on the methods to assess the first two criteria: effectiveness and efficiency. Economic evaluation looks at the relation between the impact (or the effectiveness) generated by the intervention and the cost of the intervention, the two cornerstones of efficiency analysis.

[1] See Tool #47. Evaluation criteria and questions. https://ec.europa.eu/info/sites/info/files/file_import/better-regulation-toolbox-47_en_0.pdf

1.4.3 What is cost-effectiveness analysis (CEA)? [2]

Cost-effectiveness analysis (CEA) assumes that the decision maker seeks to maximize achievement of a defined objective by using a given budget. It also assumes that the decision of whether an intervention is worthwhile is made using an external standard (a budget constraint or threshold cost-effectiveness ratio). (Definition from Drummond, M., et al., 1997)

CEA is a type of "full economic evaluation" where both the cost and the impact of interventions are examined in a comparative analysis, in opposition to a partial evaluation in which only costs (cost evaluation) or only impacts (impact evaluation) are compared between interventions. When only the cost-effectiveness of one intervention is examined the partial evaluation is called cost-effectiveness description.

This method of evaluation comes from the health sector which usually makes use of experimental settings, where for instance the cost-effectiveness of two types of intervention needs to be compared and assessed. Patients are randomly assigned to one group receiving one intervention (A) or to another group receiving another intervention (B).

When assessing the cost-effectiveness of the two interventions A and B, the difference in cost is then compared with the difference in effect, in an incremental analysis, the Incremental Cost-Effectiveness Ratio (ICER).[3]

$$\text{Incremental Cost-Effectiveness Ratio (ICER)} = \frac{Cost_B - Cost_A}{Effect_B - Effect_A} = \frac{\Delta C}{\Delta E}$$

The random assignment of the patients to either intervention B or A ensures that the difference in cost and the difference in effect measured by the ICER is only due to the difference in interventions (and not for instance because patients receiving intervention B have different characteristics such as being older, or having less risk factors than patients receiving intervention A).

The cost-effectiveness plane in Figure 2 displays the four possible cases: in quadrant IV intervention B is less effective and more costly than intervention A; in quadrant II, B is more effective and less costly than intervention A; in quadrants IV and II, the ICER is negative. In quadrant (IV) intervention A dominates as intervention B is less effective and more costly. In quadrant (II), it is intervention B that dominates as it is less costly and more effective than intervention A.

The most frequent cases are usually found in quadrant I and quadrant III, in which respectively intervention B is more costly and more effective, or less costly but also less effective than intervention A. In these cases, the ICER is positive and the public authorities would need to assess the cost-effectiveness of intervention B given their willingness to pay (WTP) per effective unit and compare it to a ceiling not to be exceeded. The region to the right of the dotted line in Figure 1 is the cost-effectiveness region determined by the maximum acceptable ICER or willingness to pay (WTP). Intervention B is then cost-effective if ICER <WTP equivalently if WTP*$\Delta E - \Delta C > 0$.

[2] See Chapter 2 "Basic types of economic evaluation" and Chapter 5 "Cost-effectiveness analysis" in Drummond, M., et al., Methods for the economic evaluation of health care programmes. 2nd edition ed. Oxford Medical Publications. 1997, Oxford.

[3] See Chapter 2 "Basic types of economic evaluation" and Chapter 5 "Cost-effectiveness analysis" in Drummond, M., et al., Methods for the economic evaluation of health care programmes. 2nd edition ed. Oxford Medical Publications. 1997, Oxford.

WTP*$\Delta E - \Delta C$ is the Net Monetary Benefit (NMB) of intervention B, that is the increase in effectiveness (ΔE), multiplied by the amount the decision-maker is willing to pay per unit of increased effectiveness (WTP), less the increase in cost (ΔC)".[4]

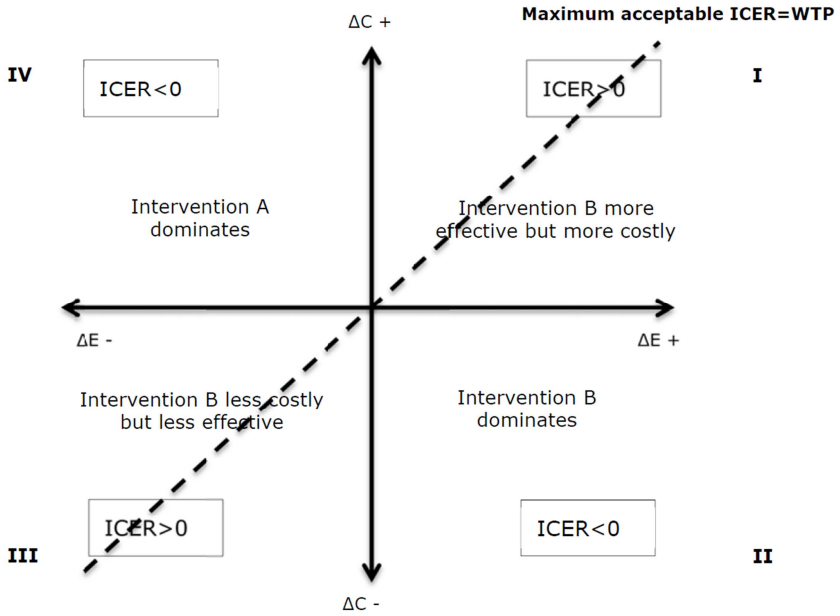
CEA mainly differs from other types of economic evaluation in the way the effect of the intervention is measured. In CEA, effects are measure in "natural" units compared for instance to Cost-Benefit Analysis (CBA) where the effects are quantified in monetary value.[5] For this reason, CEA is usually used to evaluate health care interventions where effects are more difficult to value in monetary terms.

It is important to stress that WTP is a policy parameter given as a key input to CEA.

[4] See Chapter 5 "Cost-effectiveness analysis" in Drummond, M., et al., Methods for the economic evaluation of health care programmes. 2nd edition ed. Oxford Medical Publications. 1997, Oxford.

[5] See Tool #57. Analytical methods to compare options or assess performance. https://ec.europa.eu/info/sites/info/files/file_import/better-regulation-toolbox-57_en_0.pdf

Figure 2 - The Cost-Effectiveness Plane



Source: Authors' figure adapted from Drummond, M., et al, 1997

In the case of the evaluation of EU interventions or more generally in social policy, the interventions to be assessed are already in place, and the assignment to these interventions is not random, but are allocated to MS in need and follow specific rules. Hence, this situation is outside an experimental framework, and appropriate methods need to be applied, see Chapter 4.

1.5 Why is economic evaluation important?

Economic evaluation is important since it is based on the linkage between the inputs and the outputs, i.e. the linkage between the interventions funded by the EU and their consequences with causal impact evaluation, policy makers are able to assess and quantify whether the inputs produce the expected effects, and to help draw conclusions on whether the costs of EU interventions are worth the effects.

Economic evaluation is a systematic analysis method that allows the clear identification of relevant alternatives and enables responsible authorities in the EU to make informed choices.

Box 1: Aim of this report

This report addresses the three main methodological challenges to tackle when performing an economic evaluation of EU funded interventions, especially in the food chain area:

— Measuring costs

— Quantifying the effects

— Identifying the causal impact in absence of experimental settings (randomisation).

2 Measuring costs[6]

The evaluation of the interventions' efficiency within the food chain area requires the collection or the availability of information on costs in relation with the achievement of the interventions' objectives. This section discusses how costs should be estimated and which types of costs need to be considered in the evaluation, that mainly depend on the chosen perspective.

2.1 The perspective

The evaluation could follow the "budget perspective approach" or "EU funding perspective": the purpose is to help allocate the EU funding budget. This perspective considers EU funding only and compares the resources allocated to MS with the effects they cause.

The evaluator could choose a broader perspective called "societal perspective" or "decision maker approach" and take into consideration the value of a broader range of costs and consequences and present them in a way that helps MS/EU decision makers form a better judgement. This perspective uses the economic concept of "opportunity cost" which will be explained in more detail in the subsequent sections.

2.2 Costs to include in the evaluation

2.2.1 View point and opportunity costs

The costs to include in the evaluation depend mainly on the perspective chosen for the analysis. The view point of the evaluation is important as an intervention might be cost-effective from the perspective of the EU or the MS but not from the point of view of the individuals such as farmers.

If the evaluation considers the EU's point of view, the costs to account for in the evaluation would be the amount of funding the EU allocates to the food chain area. The European Commission may also take a broader point of view as the aim of the EU is to provide a safe environment of food consumption, assure the health of animal, plants and humans, and economic development in Europe. In this societal perspective, the evaluation would analyse the costs for the EU but also the costs for the MS and the producers and consumers of the food chain area.

The societal perspective would require the collection and the valuation of private costs or expenses but also what is referred to in economics as opportunity costs. Opportunity costs are the costs of the time spent on an activity or a task and that cannot be spent on another. This cost may include for instance the cost of the farmer that needs culling its animals and buy younger animals to replace the culled ones accounting for the time needed until the younger animals can be used for production. Farmers might also need to invest in materials/lands/buildings or acquire new skills to adhere to the EU control and security recommendations.

[6] See Chapter 8 on "Methods, models and costs and benefits" of the Better Regulation tool box gives valuable advice on how to identify and assess costs. http://ec.europa.eu/smart-regulation/guidelines/docs/br_toolbox_en.pdf

2.2.2 Follow-up time

The follow-up time deals with how long the costs but also the effects should be tracked and included in the evaluation. The follow-up time may not correspond only to the duration of the funding period under evaluation but shall be extended until the effects and costs are expected to happen.

In the context of the food chain area, the duration of the follow up period will depend on the evaluation question and the chosen outcomes. The type of outcomes (output, result and impact indicators) and study question examples will be explained in detail in Chapter 3 and Chapter 5.

One may need to control also for cost information from previous funding periods, as the outcomes of interest may be affected by interventions or measures implemented before the observed effectiveness of the intervention under evaluation.

2.2.3 Costs of the intervention at the margin

Identifying costs related to the intervention is not always straightforward and will depend on the level of disaggregation of the cost data. In the case in which disaggregated data (at farm, or regional levels) are available, cost data for the evaluation should be gathered considering whether, according to the question and the scope of the evaluation, the costs related to the intervention reflect additional costs compared to the present situation.

For instance, when an outbreak occurs, farmers are required to move or confine their animals in a specific area. This would require resources to contain the animals in designated area. If the resources are already available, these costs would not be included in the evaluation.

Another type of cost that is difficult to include in the evaluation is the overhead costs, such as additional time needed for existing staff or farmers to implement the emergency measures.

2.3 Comparability of costs over time and across Member States

When the scope of the cost-effectiveness analysis includes different regions from different MS and the evaluation period spans over more than a year, one needs to make sure that the costs are comparable across MS.

Once cost data are gathered, they need to be converted into a common unit adjusting for inflation, exchange rates and year of implementation of the intervention, following the two steps described below:

1. *Common currency*: Costs need to be converted into a common currency (Euros) using the exchange rates of the year the costs occurred.
2. *Real costs of the analysis year:* Costs need to be converted to costs in terms of the year of analysis (the current year or the end of the financial period) using average annual inflation rates between the ocurrence of costs and the chosen common year. For instance, if the year of the analysis is 2013, the costs for the

years 2007 to 2012 will be converted to costs in 2013 value using the following formula:

Year X =2013

Year Y= 2007, …, 2012

$$Year\ Y\ value\ in\ year\ X\ prices = Year\ Y\ value * \frac{Index\ number\ for\ year\ X}{Index\ number\ for\ year\ Y}$$

The index number can be for instance the GDP deflator or the Harmonised Indices of Consumer Prices (HICP).

Box 2: Measuring the costs

The costs to include in the evaluation:

- can be of the following types (the perspective of the analysis):
  - A) Only EC level
  - B) EC level + MS level
  - C) EC level + MS level + Business level
- additional costs or costs at the margin related the intervention
- costs in the follow-up time defined as the period until the intervention is expected to have an effect

3 Measuring effectiveness

This chapter presents a methodology to develop a set of indicators to monitor and evaluate the implementation of the CFF spending at different levels of intervention. These indicators update and complement the existing set of 21 technical indicators currently used by DG SANTE.

3.1 Definitions

Developing a framework to assess the cost effectiveness of the EU spending in the food chain area under the CFF starts by considering a set of indicators able to provide information on the degree of implementation and on the evaluation of the interventions.

Indicators are quantitative measures of the outcomes generated by the policy interventions that are related to the objectives and the intervention logic, and allow monitoring, analysing and comparing the performance of an intervention over time, across countries or regions etc.

The general objective of the CFF is to contribute to a high level of health for humans, animals, and plants along the food chain and in all related areas. The policies implemented in each spending area are designed to achieve the specific objectives defined in the Regulation (EU) No 652/2014, through the implementation of a set of interventions.

For the animal and plant health spending areas these interventions are set taking into account the recent evolution and current state of plant pests and animal diseases in the MS and the possible threats for the EU territory arising from third countries. While in this context these interventions take the form of planned actions, on the other hand emergency measures are foreseen to address the occurrence of new animal diseases or plant pest outbreaks.

In both cases – planned and emergency measures - the CFF foresees a set of measures whose implementation contributes to meeting the (specific and therefore overall) objectives that can be substitutes or complements.

For the purpose of monitoring and evaluation these measures can be considered individually or grouped in correspondence with the particular objectives they aim to achieve. For simplicity, this hierarchy of interventions that characterizes the spending area activities can for simplicity be classified in four levels according to the following outline:

- Level 1: The first level of intervention considers the spending area – animal health, plant health and official controls[7]
- Level 2: The second level corresponds to the interventions within each spending area, as defined in the Regulation (EU) No 652/2014, e.g. Emergency measures (in both AH and PH), national veterinary programmes (AH), national survey programmes (PH) and the BTSF programme and the EURLs activities (OC). For the animal and plant health areas these interventions are framed around four main pillars: prevention; surveillance and early detection; early reaction and; cure and eradication.
- Level 3: The third level (sub-interventions) groups and covers measures within a given activity that contributes to a particular objective (e.g.

[7] The interventions funded in animal health, plant and official controls contribute to food safety. As there are no specific measures or criteria to ensure food safety except from special guarantees for Salmonella on eggs and poultry meat, Trichinella, TSE, BSE, scrapie in certain Member States, indicators specifically for this spending area not presented.

eradication and containment measures within the veterinary programmes or sampling methods within the survey programme for plants).

- Level 4: Finally, the fourth and lowest level covers measures that can be either complementary or substitute in respect to the target defined within a given sub-intervention (e.g. decontamination or compensation measures within the eradication sub-intervention for animal health)[8].

For each type of intervention the rational for the choice of the indicators is described in two steps. First, a brief summary of the intervention is provided to establish the link between the objectives of the intervention and its corresponding targets. Secondly, the set of indicators associated with the targets is proposed, according to a classification presented and discussed in the following sub-sections.

3.1.1 The intervention summary

The intervention summary provides a characterisation of how the intervention is expected to work. Understanding and defining the scope of the actions to be undertaken allows establishing a link between the measures and the targets to be achieved. Therefore for each level of intervention relevant concepts are defined in a sequential order leading to the definition of the target(s):

1) Intervention: this could be either a programme when considering the different components of the spending area, a sub-programme within a programme, or a measure when considering the different components of a particular sub-programme in each spending area[9].
2) Description: the nature of the actions to be undertaken given the type of intervention[10].
3) Objective: given the description it identifies the goals the intervention is expected to achieve. This is often a qualitative achievement or the achievement of a given condition/status.
4) Preliminary CFF indicators: these are the indicators (although not always directly measurable) defined in the CFF Regulation that can be associated to the intervention.
5) If no action: given the description of the intervention and its objective it defines the expected outcomes with respect to the case if the intervention were not to be implemented.
6) Targets: statement of the objectives susceptible of being measured and quantified.

These definitions allow linking each intervention with its associated target. However, depending on the level of the intervention considered, a set of interventions can be associated with the same target, e.g. all compensation measures within eradication programmes are devised to provide incentives for the reporting of diseases.

3.1.2 Indicators and outcomes

Indicators are used to analyse the performance of a policy according to its objectives and targets while informing on several dimensions of its implementation. In particular, for spending programmes in the CFF it is of interest to measure the level of implementation of each activity, i.e. how many measures were implemented, as well as the outcomes of such actions.

[8] In the present report, indicators at this level are not presented but could be developed.
[9] In order to ease the notation and terminology, any of these types of interventions will generically be referred to as `intervention' or `measure' from this point onwards.
[10] Note the EU co-funding is awarded only to some expenses related to the actions/measures.

With respect to the type of outcome, indicators can be grouped into two categories: *technical indicators* (as listed in the operational technical indicators for the AH, PH, BTSF and EURL activities) and *impact indicators*. *Technical indicators* measure the outcomes that are directly related to the interventions and can be classified as *output* and *result* indicators. *Impact indicators* allow identifying relevant indirect economic and/or social outcomes induced by the interventions.

Output indicators

Output indicators relate directly to the implementation of an intervention, i.e. they are measurable deliverables from the interventions that need to be generated in order to achieve its objectives[11].

These indicators are informative on how the funds have been spent without reference to the intended outcome of the intervention. However, in some cases the mere implementation of a given action might in itself be an important desirable outcome (e.g. having all MS running surveys to detect plant pests, or awareness campaigns).

Result indicators

Result indicators aim at monitoring and evaluating what the policy intervention intends to achieve. They represent changes over the short, medium and long term which can be directly linked to the intervention's ability to address the identified problems and their drivers.

These indicators measure the immediate positive or negative effects of the intervention. These indicators aim at assessing the direct impact of the co-funded measures and therefore link the funding with the achievements of the policy targets.

When considering the measurement of these outcomes, it is crucial to distinguish between short-term and long-term policy effects, as some interventions are implemented in a multi-annual perspective in view of the characteristics of the issues to be addressed. For instance, eradication programmes for certain animal diseases can take several years to produce results.

Despite providing valuable information to monitor the progress towards the target at any point in time, scheduling early effectiveness assessments could be misleading. This is especially the case if the minimum time necessary for the intervention to have an actual and tangible effect has not been taken into account.

Impact indicators

While *result indicators* concern the direct effects of a given intervention, *impact indicators* aim at monitoring the relevant indirect effects on economic, social and health outcomes (e.g. livestock production losses, disruptions in trade, or, in case of zoonosis, the impact on human health and the costs to the health system). They represent changes over the short, medium and long term which can be linked to the intervention, and should be closely related to the identified problems and drivers.

3.1.3 Indicators and policy cycle

Monitoring and evaluation of the EU funded food chain measures can and should be done at different stages of the policy cycle by using the appropriate set of indicators.

Depending on the stage of the policy cycle at which the indicators are computed, they can provide information on either the expected, actual or final performance of the intervention. Specifically, they might be used to: ex-ante assess the effect of the proposed actions; assess whether (and the extent to which) those actions are being taken and; evaluate the returns from those actions.

[11] As defined by the *Tool #41*, *Monitoring Arrangements and Indicators*, within the European Commission 'Better Regulation Toolbox' (https://ec.europa.eu/info/sites/info/files/file_import/better-regulation-toolbox-41_en_0.pdf)

At different stages of the policy cycle – before, during and after - the performance of the intervention requires employing the appropriate indicators.

Before the intervention

At this stage it is relevant to consider indicators that: (i) allow the computation of the expected cost of the interventions for budgetary purposes and; (ii) assess the impact of the proposed interventions in order to justify its implementation.

The first objective can be achieved through computation of the expected output indicators, while the second can be addressed by considering the expected, result or impact indicator. Both expected indicators can be computed on the basis of technical characteristics or more plausibly from previous evaluation exercises of similar programmes.

Consideration of these indicators at this stage of the policy cycle is particularly relevant where alternative interventions addressing the same target are available or where programmes are designed in a context of scarce resources or lack of priorities.

During the intervention

At this stage, given that policy choices have been made, the aim of the indicators are informative for monitoring the implementation of the intervention, comparing the actions that have been taken with the ones proposed by the intervention and possibly correcting its path. This type of activity is especially important when the implementation of the intervention is done in a multi-annual framework.

In this context it is particularly relevant to compute *output indicators* to assess how the proposed actions are being implemented and, *result indicators* able to measure the effectiveness of the intervention and to provide information on the possible need to correct its path.

After the intervention

At this final stage of the policy cycle, the main purpose of the indicators is to evaluate the interventions. *Result* and *impact indicators* are the most relevant as they are designed and computed to assess the performance of the actions taken and compare it with the prospective targets.

These indicators can also be used as benchmark to guide the policy choices to be made in the subsequent policy cycle.

3.2 Technical indicators for the CFF spending areas

This section presents the set of technical indicators for the CFF spending areas following the methodology proposed in the previous section[12]. The chosen indicators update and complement the existing set of 21 technical indicators currently defined by DG SANTE.

The choice of the indicators is motivated by providing, firstly a summary of the intervention that leads to a description of the targets it is designed to achieve. Some targets are implicitly defined by the existing CFF indicators, while new targets may be suggested from the description of the programmes.

Secondly, the existing indicators are classified in the proposed framework while new ones are suggested so that, all programmes are monitored and evaluated with both *output* and *result indicators*.

The proposed indicators can be computed at the different stages of the policy cycle as discussed in section 3.1.3.

The indicators will be assigned a code that identifies: the spending area, the hierarchical chain of programmes within the spending area, the type of indicator, the associated target, and the number of the indicator. (e.g. **AH.NV.ER.B.O1** represents output indicator number one for target B of the eradication under National veterinary programme of the animal health spending area).

Text in italics corresponds to concepts defined by DG SANTE such as already existing technical operational indicators, operational objectives etc.

3.2.1 Technical indicators for plant health

Table 1 summarises the survey programmes and emergency measures (up to the third intervention level) that lead to the targets definition.

Under the survey programmes two targets are considered: target A is implicitly defined by the already existing CFF indicator and target B aims to monitor and evaluate the programmes ability to detect the presence of HOs.

For the emergency measures the targets differ according to whether the MS submits an eradication or a containment programme.

Table 2 presents the output and result indicators for both National survey programmes and emergency measures associated with the targets defined above.

Both output and result indicators can be expressed in relative terms with respect to the appropriate quantities (e.g. by area in *ha*, by no. of farms, etc.)

The indicators definition is in most cases self-explanatory but some remarks are due to further clarify its content:

- **PH.NS.O.B**: Survey actions are the set of the activities under sampling - visual inspections, sampling or trapping - and testing used to identify specific HOs (e.g. a survey action could perform visual inspections and trapping activities to identify the presence of harmful insects)[13]. This would be a measure of how many times potential plant pests are surveyed.
- **PH.NS.R.B5**: This indicator relies on the definition of *early actions*. These are foreseen in the operational objective (ii) that suggests "… early appropriate actions against the presence of pests…" will be taken upon the detection of an

[12] The impact indicators, including the indicators regarding human health aspects will be discussed in the section 3.3

[13] At the time of application MS must supply data on the expected actions to be taken of these type (see *Annex: Guidance by MS for the preparation of SP for pests for 2015*)

HO. Depending on the nature of the actions to be taken, these *early actions* could be designed to prevent the occurrence of an outbreak.

- **PH.E.ER.R3**: Measuring the timing of eradication or containment requires a continuous updating of the plant pest status following the detection of a pest.

Computation of these indicators relies on: (i) available data from MS survey programme submissions and MS Reports and (ii) on data collected from the alert system (EUROPHYT-Outbreaks) implemented to monitor the plant pest status in the EU territory[14].

[14] Given the obligation to notify the presence of HOs (article 16 of Directive 2000/29/EC) an effort has been done to develop monitoring tools for the Notification of Harmful organism outbreaks in the EU. MS have to notify the presence of HOs and update those notifications to "… provide complementary information on a previous outbreak notification. This information can be related to spread, the successful eradication or any other development or information that was not available at the time of the notification of the harmful organism"(in Harmful Organisms in the EU: Annual Report 2014).

EUROPHYT-Outbreaks is based on Commission Implementing Decision 2014/917/EU setting out detailed rules for these notifications. It was designed and developed by the Commission with the support of a number of Member States, Switzerland, the European Plant Protection Organisation (EPPO) and the European Food Safety Agency (EFSA). It is aimed at supporting Member States in their reporting obligations while ensuring that comprehensive and harmonised data is provided and distributed to all official plant health services within the EU.

Table 1: Survey programmes and phytosanitary emergency measures

Intervention	**Survey programmes**	**Emergency measures**[(1)]	
		Eradication	**Containment**
Description	Surveys to detect the presence of HOs in plants	(Refund of) Actions taken to **timely eradicate/contain** PESTS once they have entered the EU territory	
Aim	Ensure early detection for taking immediate measures for the ERADICATION of the outbreaks or, if this is no longer feasible, at least ensure CONTAINMENT with the aim to protect the rest of the EU territory	Avoid the spread of an Outbreak: Hence identified encourage the swift implementation of actions to eradicate the presence of HOs.	Avoid the spread of an Outbreak: Hence identified if ERADICATION is not possible encourage the implementation of actions to contain the presence of HOs in a part of the Union territory.
Operational objectives (Annex 1 to the CID C(2016) 2465 final)	*i.* ***Timely identify and detect emerging risks*** *as regards non listed pests which represent an imminent or potential danger for the EU territory.*		
	ii. ***Ensure the early and appropriate action against the presence of pest*** *iii. Improve the functioning of the EU plant health* ***legislation*** *by monitoring the risks of pests listed in Directive 2000/29/EC, after interception of imported commodities infested with pests (This operational objective does not relate to any of the measures in the programmes)*		
CFF indicators	**CFFI 3.1:** *Coverage of the EU territory by surveys for PESTS in particular Not Known to Occur (NKO) and Most Dangerous (MD).*	**CFFI 3.2:** *Time and Success rate for the eradication of PESTS.*	
If no Action	Passive surveillance	Spread of outbreaks	
Targets	**A.** Guarantee Full EU Coverage[(2)] **B.** Obtain confirmation about the pest status of a pre-defined list of HOs: 1. Pests NKO in EU (listed in Directive 2000/29/EC) 2. Pests subject to EC measures (article 16(3) of Directive 2000/29/EC) 3. The potato pests subject to the measures laid down in Directives 69/464/EEC, 93/85/EEC, 98/57/EEC and 2007/33/EC 4. Pests not listed in Directive (NLD) 2000/29/EC that represent imminent danger or EU	Eradication of the pest/plant pest	Containment of the pest by preventing its further spread in the rest of the Union territory

[(1)] These are phytosanitary Emergency Measures, aimed at timely cope with emergency situations related to Plant Health (see *Note for the attention of the members States of the Management Board: Future funding of EU safety policies (beyond 2020)*). MS need to notify and there might be UPDATES of the notification that "… provide complementary information on a previous outbreak notification. This information can be related to SPREAD, the SUCCESSFUL ERADICATION or ACTIVE CONTAINMENT or any other development or information that was not available at the time of the notification of the harmful organism".(Harmful Organisms in the EU: Annual Report 2014.)

[(2)] See Commission Implementation Decision of 29.5.2015 "On the adoption of the financing decision for the years 2016 and 2017 for the implementation of veterinary programmes for animal diseases and zoonoses and for the year 2016 for the implementation of survey programmes for pests".

Table 2: Output and result indicators for plant health programmes

Intervention	Survey programmes	Emergency measures	
		Eradication	**Containment**
Output Indicator (OI):	**PH.NS.O.A1:** *(Increase) No. of MS covered (running the Surveys) for pests NKO* (**T.I. 3.1a – Category A WP 2017-2018**) **PH.NS.O.A2:** *(Increase) No. of MS covered (running the Surveys) for pests MD* **(T.I. 3.1b - Category B WP 2017-2018)** **PH.NS.O.A3:** (Increase) No. of MS covered (running the Surveys) for pests NLD **PH.NS.O.B1:** Total No. of Surveys actions implemented **PH.NS.O.B2:** Total number of survey programmes implemented	**PH.E.ER.O1:** No. of eradication measures put in place	**PH.E.C.O1:** No. of containment measures put in place
Result indicator (RI):	**PH.NS.R.B5:** No. of times **actions** were taken following the detection of a pest by a Survey **PH.NS.R.B6:** No. of outbreaks detected in regions covered by survey programmes (measured by the submission of emergency measures programmes) **PH.NS.R.B7**: No. of outbreaks of PESTS covered by EU legislation (T.I.3.2) **PH.NS.R.B8**: Number of MS free from the pest/outbreaks **PH.NS.R.B9**: Number of cases of PEST.	**PH.E.ER.R1:** No. (or %) of successful eradication measures(2) **PH.E.ER.R2:** (Average) time to eradication status of pest/outbreak	**PH.E.C.R1:** No (or %) of successful containment measures(2) **PH.E.C.R2:** (Average) time to containment **PH.E.C.R3:** (Average) time the rest of the Union territory has been kept free from the pest under containment

Plant Health **(PH)**; National Survey Programme **(NS)**; Emergency Measures **(E)**; Eradication **(ER)**; Containment **(C)**; Output indicator **(O)**; Result indicator **(R).**

(1) This can be collected from the technical reports (final and intermediate) on the implementation of the Survey Programmes (SP) that MS submit.

(2) The "HO in the EU" report (https://ec.europa.eu/food/sites/food/files/plant/docs/phb_ho_annual_report_2015-6_en.pdf) describes how MS should continuously report on the developments of the PEST outbreak. In particular they should also report when the pest is considered to be controlled, therefore it is possible to measure if and when the PEST is to be considered as eradicated/contained.

3.2.2 Technical indicators for animal health

Table 3 summarises the National veterinary programmes (up to the third intervention level) and emergency measures main features that lead to the targets definition.

Eligibility for a given programme depends on the MS disease status at the time of submission. These are currently defined in WD 10186/2017 that also identifies for each disease/country the expected results to be achieved by the interventions. This description has been used to assign the animal diseases to the appropriate National veterinary sub-programmes (eradication or control) as summarised in the last row of Table 3. If the expected result for a disease in a given country is "disease FREE" the intervention is labelled as an eradication programme, if instead it aims at achieving a given herd prevalence or incidence or any other disease parameter (different from zero) than it is assigned to a control programme.

Control programmes apply whenever the prospect of eradicating the disease in the short run is reduced. In such cases depending on the epidemiologic characteristics of the disease, current status and the time frame considered an animal disease specific disease parameter should be considered when measuring the achievement of the target.

The animal diseases eligible for emergency measures are listed in Annex I to Regulation (EU) No 652/2014.

Table 3: Veterinary programmes and emergency measures

	Veterinary programmes			Emergency measures
Intervention	**Eradication**	**Control**	**Surveillance**	
Description[(1)]	Actions taken to result in biological extinction of an animal disease or zoonosis, already present in the territory	Actions taken to obtain or maintain prevalence of an animal disease or zoonosis below a sanitary acceptable level	Actions taken to collect and record data on specific diseases in defined populations over a period of time, in order to assess epidemiological evolution of the diseases and the ability to take targeted measures for control and eradication	Actions taken as a result of confirmed occurrence of a number of listed diseases likely to constitute a threat for the EU due to their significant impact.
Aim	Free MS from diseases that might have impact on health and trade	Minimise the occurrence of outbreaks and reduce and/or control the occurrence of animal diseases	Monitor the evolution of diseases to act swiftly to avoid outbreak possibility in advance	Prevent or eradicate the occurrence of animal diseases. Avoid further spread of the animal diseases.[(3)]
Operational objectives[(2)]				
If no Action	Spread or presence of diseases	Presence or spread of diseases	Late detection of diseases	Spread of the outbreaks
Targets	Becoming free from a disease	An overall reduction of disease j parameters[(4)]	Fully detect the presence of animal diseases and avoid outbreaks	Timely become free following the occurrence of a disease.
Diseases (according to WD SANTE/2017/10186)	**TB, O&CB, , Rabies, CSF, ASF, BSE,CS**	**TB, O&CB, BB,BT, Rabies, CS, BSE, ZS,**	**AI, LSD, PPR and, S&GP**	**Annex I to Reg. (EU) No 652/2014**

Bovine Brucellosis (**BB**); Ovine and Caprine Brucellosis (**O&CB**); Bovine Tuberculosis (**TB**); Classical Swine Fever (**CSF**); Lumpy Skin Disease (**LSD**); Sheep and Goat Pox (**S&GP**); Peste des Petits Ruminants (**PPR**); African Swine Fever (**ASF**); Classical BSE (**BSE**); Classical Scrapie (**CS**); Zoonotic Salmonella in certain Poultry Populations (**ZS**); Avian Influenza (**AI)** and; Bluetongue Disease (**BT**).

(1) Operational objectives are defined in WD SANCO/1081/2014Rev consistent with the priorities set in the more recent version WD SANTE/2017/10186

(2) As defined in https://ec.europa.eu/food/funding/animal-health/national-veterinary-programmes_en

(3) As defined in article 1 of CID C(2016) 4840 final of 29.7.2016 (objectives and results).

(4) Expected results are listed in the WD 10186/2017

Table 4: Output and result indicators for animal health programmes

	Veterinary programmes							**Emergency measures**
Intervention	**Eradication**	**Control**					**Surveillance**		
Output Indicator (OI):	**AH.NV.ER.O1:** No. of eradication programmes implemented (by disease).	**AH.NV.CR.O1:** No. of control programmes implemented (by disease)					**AH.NV.S.O1:** No. of surveillance programmes implemented (by disease).		**AH.EM.O1:** No. emergency measures implemented by MS (by disease**)**
Result indicator (RI):									
(according to Disease Parameters in WD SANTE/2017/10186)	**No. of non-affected/free MSs**	**Herd Incidence/Prevalence (%)**	**No. of non-affected/free MS**	**No. of Cases** (at the EU level only)	**No. MS with negligible risk[(1)]**	**MS in all PP below EU targets[(2)]**	**% of Secondary outbreaks in domestic birds**	**No of outbreaks**	**AH.EM.R1:** No. (%) of Successful Emergency measures **AH.EM.R2:** No. secondary outbreaks
Diseases	**TB, O&CB, Rabies, CSF, ASF, BSE,CS**	**TBO & CBBB, BT and ZS**	**CS BT**	***Rabies, BSE, BT***	**BSE**	**ZS**	**AI**	**LSD, PPR and, S&GP**	
	AH.NV.ER.R1: *(An increase in the) No. of MS or their regions free from disease* (**T.I. 2.1a,d**) **AH.NV.ER.R2:** No. (%) of MS/regions that became free from a disease	**j= TB, O&CB, BB,BT, Rabies, CS, BSE, ZS,**					**j= AI, LSD, PPR and, S&GP**		
		AH.NV.C.R1.j*:* *Distance to the disease parameter as defined in WD SANTE/2017/10186* **AH.NV.C.R2.j:** No.(%) of times target (in the WD SANTE/2017/10186) for <u>disease j</u> was achieved **AH.NV.C.R3:** No. of times target (in the WD SANTE/2017/10186) for <u>all diseases</u> was achieved (results from aggregating **AH.NV.C.R1.j**)					**AH.NV.S.R1.j:** *Distance to the disease parameter as defined in WD SANTE/2017/10186* **AH.NV.S.R2.j** No.(%) of times target for <u>disease j</u> was achieved **AH.NV.S.R3:** No. of times target for <u>all diseases</u> was achieved (results from aggregating **AH.NV.S.R2.j**) **AH.NV.S.R4.j:** No. of times early actions taken following the detection of <u>disease j</u> through a Surveillance Programme (by disease) **AH.NV.S.R5.j:** No. of <u>diseases j</u> outbreaks in regions covered by Surveillance Programmes		
Animal Health **(AH)**; National Veterinary Programme **(NV)**; Control & Eradication **(C)**; Eradication **(ER)**; Emergency Measures **(EM);** Surveillance **(C)**; Output indicator **(O)**; Result indicator **(R);**									

Table 4 presents the output and result indicators for both Veterinary programmes and emergency measures associated with the targets defined in Table 3.

Again, both output and result indicators can be expressed in relative terms with respect to the appropriate relevant quantities (e.g. by no. of animals or holdings at risk, etc.)

The current list of operational technical indicators for animal health in the WD SANTE/2017/10186 does not cover all diseases for which expected results and therefore targets are defined. As such, indicators based on those parameters are proposed to cover all animal diseases under the Control and Surveillance Programmes:

- **AH.NV.C.R1.J** and **AH.NV.S.R1.J**: These set of result indicators (R1) are disease (j index) and country specific and depend on to the definition of the relevant disease parameter in the WD SANTE/2017/10186.
- **AH.NV.C.R2.J**, **AH.NV.C.R3** and **AH.NV.S.R2.J**, **AH.NV.S.R3**: These indicators are unit free to allow for comparisons on the monitoring and evaluation of the different diseases (R2) and, the computation of an aggregated indicator (R3) able to monitor the evolution of all diseases.

The additional indicators for surveillance programmes assume the availability to continuously monitor the disease status:

- **AH.NV.S.R4.J** and **AH.NV.S.R5.J**: These indicators rely on both the identification of early actions taken to prevent the outbreak of the disease after it has been detected by a surveillance measure (R4) and on the effective reporting of the disease outbreaks (R5)[15]

3.2.3 Technical indicators for official controls

The EU co-funding of the EURL covers two main areas: (i) the costs incurred by the laboratories of implementing the work programmes approved by the EC and; (ii) training activities for the staff of the competent authorities responsible for official controls.

Despite both types of activities contribute to the specific objective set for this spending area, namely "… to improve the effectiveness, efficiency and reliability of official controls…", the set of indicators already existent and the proposed ones focus on the monitoring and evaluation of the training measures, since the qualification of the official controllers is the crucial condition for its achievement.

Under training two main activities are co-funded in the CFF: Better Training for Safer Food, where three types of interventions are considered - Workshops, *e*-learning and, Sustained Training Missions (STM) - and Proficiency Tests (PT) administered and workshops provided to the national EU Reference Laboratories[16].

Table 5 summarises both the interventions under BTSF and EURL and its associated targets.

The targets assume that participation in all training activities is compulsory and that the attendees are assessed both before and after the courses. This is needed in order to allow measuring the effectiveness of these interventions. In particular the targets assume that the officials attending the workshop will be responsible for teaching (directly

[15] The existence of a notification system where information on measures taken to address the presence of a disease is reported should provide such data. (e.g. some diseases like AI are notifiable to the OIE and must therefore be reported).

[16] While in the current framework enrolment by the National Laboratories for the PTs is voluntary here compulsory participation will be assumed since harmonisation of the control procedures and increased coordination is a goal to be achieved by this funding area.

or indirectly) the same contents to the National experts. The National experts would then be subject to an assessment by the EU.

Table 6 presents the output and result indicators for both BTSF and EURL interventions associated with the targets defined in Table 5.

- The consideration of the second result indicator for target A (**xxx.R.A.2**) allows measuring the effective contribution of the training to the increase in the technical skills of participants.
- The computation of the success and satisfaction rates of all result indicators can conducted as follows:
    - Define an individual/laboratories target for the test score. The target should be a minimum score greater than 50%.
    - The success and satisfaction rates are measured by the percentage of individuals/laboratories above the target. This rate could be computed at the national and/or EU level.

Table 5: Activities of official controls

	Better Training for Safer Food[1]			EU reference laboratories	
Intervention	**Workshops**	***e*-learning**	**Sustained training missions**	**Proficiency tests (PT)**	**EURLs Workshops**
Description	EC organised training courses in host countries for the staff of the competent MS authorities responsible for the official controls: case studies, discussions, site visits and practical work and tests with assessment	EC organised e-learning training sessions	Complement to workshops to help countries in areas where deficiencies have been found	Administration of Proficiency testing (PT) amongst National Reference Laboratories (NRL's) and other international laboratories, allowing a laboratory to assess its performance against, through testing its ability to detect various (bacteriological) disease parameters	EC organised workshops addressing current practice and future directions of PT, which may include lectures or training courses and discussions in working groups
Aim	To keep MS competent authorities up-to-date with all aspects of Union law in the areas specified above and ensure that controls are carried out in a more uniform, objective and adequate manner in all Member States			To ensure high-quality, uniform testing in the EU and support Commission activities on risk management and risk assessment in the area of laboratory analysis	To improve the organisation and promote best practice of proficiency testing, providing organisers and users of PT a forum for issues and activities related to PT.
Operational objectives	The main objective of the initiative "Better Training for Safer Food"[1] is the organisation and development of a Community training strategy with a view to: • Ensuring and maintaining a high level of consumer protection and of animal health, animal welfare and plant health; • Promoting a harmonised approach to the operation of Community and national control systems; • Creating an equal level playing field for all food businesses; • Enhancing trade of safe food; • Ensuring fair trade with third countries and in particular developing countries			Reference Laboratories [2] are tasked to: •Provide National Reference Laboratories (NRLs) with analytical methods and diagnostic technics, and coordinate their application •Train staff from National Reference Laboratories •Provide the Commission with scientific and technical expertise in relation to laboratory analysis (e.g. assist actively in the diagnosis of animal disease outbreaks) •Collaborate with the competent laboratories in non-EU countries	The organisation of international workshops on PT provides for: • Enabling interactive participation and cross-fertilisation of ideas among participants • Preparing discussion documents, guides and information leaflets on topics related to PT • Collaborating with other international groups with regards to PT
If no Action	Lack of harmonisation of control procedures and lower rate of updating of control skills				
Targets	**A.** High scores in the tests performed after the training **B.** Satisfaction of participants **C.** High scores of national experts attending training administered by participants in EC workshop	**A.** High scores in the tests performed after the training **B.** Satisfaction of *e*-participants	**A.** High scores in the tests performed after the STM **B.** Participants satisfaction	**A.** High scores of proficiency test **B.** Efficient learning **C.** Satisfaction of participants	**A.** High scores in the tests performed after the training **B.** Satisfaction of participants
(1) As defined in http://ec.europa.eu/chafea/food/about.html (2) As defined in https://ec.europa.eu/food/safety/official_controls/legislation/ref-labs_en					

Table 6: Output and Result Indicators for official control activities

	Better Training for Safer Food[(1)]			**EU Reference Laboratories**	
Intervention	**Workshops**	***e*-learning**	**Sustained Training Missions**	**Proficiency Tests (PT)**	**EURLs Workshops**
Output Indicator (OI):	**OC.W.O.A.1:** No. of workshop participants **OC.W.O.A.2:** No. of workshops **OC.W.O.C.1:** No. of national experts attending workshop related training **OC.W.O.C.2:** No. of national workshops related trainings	**OC.*e*-l.O.A.1:** No. of *e*-learning training participants **OC.*e*-l.O.A.2:** No. *e*-learning training courses	**OC.STM.O.A.1:** No. of STM participants **OC.STM.O.A.2:** No. of STM	**OC.PT.O.A.1:** No. of PTs (by lab type)	**OC.LW.O.A.1:** No. of workshop participants **OC.LW.O.A.2:** No. of workshops **OC.LW.O.A.1:** No. of international experts attending workshop related training **OC.LW.O.A.2:** No. of international workshops related trainings
Result Indicator (RI):	**OC.W.R.A.1:** *Success rate of the tests performed* **OC.W.R.A.2:** Improvement rate compared to initial score **OC.W.R.B:** *Overall satisfaction rate of workshop participants* **OC.W.R.C1.1** Success rate of the tests performed on national experts **OC.W.R.C2.2** Improvement rate compared to initial score **OC.W.R.C:** *Overall satisfaction rate of participants attending the training*	**OC.*e*-l.R.A.1:** Success rate of the tests performed **OC.*e*-l.R.A.2:** Improvement rate compared to initial score **OC.*e*-l.R.B:** Overall satisfaction rate of participants attending the *e*-learning	**OC.STM.R.A.1:** Success rate of the tests performed **OC.STM.R.A.2:** Improvement rate compared to initial score **OC.STM.R.B:** Overall satisfaction rate of participants attending the training	**OC.PT.R.A.1:** *Success rate of proficiency test, including the correct follow-up in cases of underperformance (for each lab)* **OC.PT.R.A.2:** Improvement rate compared to initial score **OC.PT.R.B:** Number of PT retakes	**OC.LW.R.A.1:** *Success rate of the tests performed* **OC.LW.R.A.2:** Improvement rate compared to initial score **OC.LW.R.B:** *Overall satisfaction rate of workshop participants*
Official Controls **(OC);** Workshops **(W);** *e*-learning **(*e*-l);** Sustained Training Missions **(STM);** Proficiency Tests **(PT);** EURLs Workshops **(LW);** Output indicator **(O);** Result indicator **(R)**					

3.3 Impact indicators

The evaluation of the effect of the EU interventions should also be conducted on outcome indicators that reflect their impact from an economic and health perspective. In particular, three broad themes have been considered: production, trade and human health.

3.3.1 Production: productivity and production losses

First the potential *impact indicators* from the point of view of the producers are discussed. Specifically, it might be relevant considering indicators that pertain to productivity, production losses and investments. All these outcomes might be evaluated at different levels, namely at the firm, sector or regional level. The choice of the most appropriate level is strictly intertwined with the specific features and assumptions of the impact evaluation method employed[17].

The effect of plant pests and animal diseases in a given production system is a reduction in the efficiency with which inputs and resources are converted into outputs and products. In other words, pests and diseases decrease productivity within the farm[18].

Animal health

Indicators to monitor production from the livestock resources usually consider the following commodities: meat, milk, eggs and wool produced by animal species. Possible indicators to measure commodity-specific productivity are:

AH.I.PD.J - Production density (for commodity j): density of total production for each commodity produced (meat/milk/eggs and wool). This is the quantity (volume/value) produced divided by total (agricultural) land. Since the denominator is not affected by the possible mortality this measure is relevant if the impact of diseases on the productive chain is to be accounted for.

AH.I.P1.J - Production by animal (for commodity j): average production for each commodity (meat/milk/eggs). This is the quantity (volume/value) produced divided by the total no. of animals. If measured in value, it could be measured as total livestock output/Livestock Unit (LU) (as defined in the FADN data base)[19].

When measured in value, these indicators may incorporate price changes due to potentially reduced quality of the output. Hence, if both input and output are measured in monetary terms, the indicators would constitute a measure of the economic value of output.

Another advantage of considering monetary output instead of physical output is that a production system (farm/holding) uses many different kinds of input and produces several kinds of output, especially in the case of livestock systems. A productivity indicator that takes that into account is:

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[17] Data on production, input cost, and investment is available at the Farm Accountancy Data Network (FADN) collected at farm level.

[18] Throughout this section the following codes represent: Impact indicator (**I**); Production Density (**PD**); Production (**P**); Production Losses (**PL**); Private Investment (**PI**); Exports (**X**); Net Exports (**NX**); Quantity (**Q**); Value (**V**); Food Safety (**FS**); Human Health (**HH**);

[19] The livestock unit, abbreviated as LSU (or sometimes as LU), is a reference unit which facilitates the aggregation of livestock from various species and age as per convention, via the use of specific coefficients established initially on the basis of the nutritional or feed requirement of each type of animal (see http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Livestock_unit_(LSU)).

AH.I.P2.J - Total output divided by total input (for commodity j): both are measured in monetary units and can be collected at farm, regional or country level (through aggregation).

Additionally, it is of interest to measure how EU funding impact on animal health. Indicators to monitor livestock health should describe not only the disease status of a region but should also include information on slaughtered or destroyed animals by animal disease. An indicator to measure production (livestock) losses is:

AH.I.PL.J Production (livestock) losses: total no. of animals affected by disease (sick animals + animals that died from the disease) by specie in volume or value.

Plant Health

Possible indicators to measure commodity-specific productivity in plants and plant products potentially affected by diseases or pests funded by the EU are:

PH.I.PD.J - Production density: density of total production for each type of plants (product). This is the quantity (expressed in volume or value) produced divided by total (agricultural) land (ha)[20].

As measured in the case of animal health, if output and input are measured in value, the productivity indicator would then be:

PH.I.P1.J - Total output divided by total input: both are measured in monetary units and can be collected at farm (relevant), regional or country level (through aggregation).

3.3.2 Private investment

The use of farmer's private investment as an indicator is relevant to evaluate the impact of the intervention on their capability to keep up with the innovation in technology in the sector.

Private investments encompass operations that aim at renovating and/or expanding the farms physical assets such as buying new farm equipment and machinery, constructing farm buildings, improving the land, etc., or at enhancements in human capital (e.g. undergoing specific training). These operations, in turn, often translate into increased health of plants and animals, better quality of the products, higher farm productivity and reduced waste and emissions into the environment[21].

The following measures are good candidates to be used to proxy changes in private investments in the agricultural sector (both livestock and plants):

PH/AH.I.PI1 - Number of machinery owned by the farm (exclusively or used by several holdings) by size of farm;

PH/AH.I.PI2 - Physical and/or economic size of the agricultural holdings;

PH/AH.I.PI2 - Gross fixed capital formation in agriculture (investments in assets which are used repeatedly or continuously over a number of years to produce goods in agriculture);

PH/AH.I.PI2 - Number of farm managers who underwent full agricultural training.

[20] If the output is measured in monetary terms, this indicator would coincide with the measure suggested by FADN (total crops output / ha).

[21] Potential sources of information about private investments in farms are found within the Farm Structure Surveys (http://ec.europa.eu/eurostat/web/agriculture/farm-structure) and the Monitoring and Evaluation Framework for the CAP 2014-2020 (source: common context indicators for rural development programs, CAP context indicators, https://ec.europa.eu/agriculture/cap-indicators/context_en).

3.3.3 Trade

The spread of animal diseases and plant pests can have an effect on trade even in the short run, through changes in both supply and demand[22]. The export indicators show how each country manages to sell its product to other countries. A country's trade balance position (net exporter or net importer) is an important indicator of food security and stability of a country. The trade balance can be estimated as the difference between exports and imports both in monetary and quantity terms.

Possible indicators to measure trade are:[23]

PH/AH.I.X.Q – Export in volume quantity: collected by country, both for animals (dairy products/eggs/meat and livestock) and for crops (where the categories are defined by DG SANTE).

PH/AH.I.NX.Q – Net export in volume quantity: collected by country, both for animals and animal products and for crops.

When measured in value, these indicators need also to incorporate price changes.

PH/AH.I.X.V – Export in monetary value: collected by country, both for animals and animal products and for crops.

PH/AH.I.NX.V – Net export in monetary value: collected by country, both for animals and animal products and for crops.

3.3.4 Human health

According to the last report on the global burden of foodborne diseases by the World Health Organisation in 2015, 23 million people are affected by foodborne diseases every year, including 5000 deaths in the WHO European region.[24] Clearly, this makes food safety a public health priority for any country and any cross-national institution.

Possible indicators to measure human health:

FS.I.HH.J - Number of confirmed cases of zoonosis from disease j *(j=Salmonella, Brucellosis, …).*

In addition to this, a measure of quality of life can also be included, such as:

FS.I.QALY - QALY (Quality Adjusted Life Years): this is a measure of health outcome (morbidity) that considers the reduction in quality of life due to illnesses. It is a composite indicator that can be computed for all kind of illnesses and can be used to compare different levels of health quality in different countries.

FS.I.DALY - DALY (Disability Adjusted Life Years): this is computed as the sum of the years of potential life lost due to premature mortality and the years of productive life lost due to disability.

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[22] On the one hand, supply might change due to fluctuations in the exchange rates, temporary trade restrictions or changes in input prices. On the other hand, demand might be affected by changes in tastes and preferences, population growth, responses to food safety issues, income growth, changes in the price of other substitution goods.

[23] The potential sources of information on trade are the following. 1) Trade Market Access data and Statistics (EU Commission) that contains detailed trade information between EU and non-EU countries such as the monetary value and the quantity of export and import of live animal, animal products and vegetable products. 2) EUROSTAT COMEXT within EU trade dataset that contains detailed information about within-EU trade such as the monetary value and the quantity of export and import of live animal, animal products and vegetable products. 3) DG AGRI dataset contains detailed product data by country (e.g. dairy herds and yields, milk production).

24 World Health Organisation (2015) WHO estimates of the global burden of foodborne diseases: foodborne diseases burden epidemiology, reference group 2007-2015 (http://www.who.int/foodsafety/publications/foodborne_disease/fergreport/en/).

Box 3: Indicators to measure effectiveness in plant and animal health, and official controls

Three types of effectiveness indicators can be used in the evaluation:

— *Output* and *result* indicators that measure the outcomes that are directly related to the interventions

— *Impact* indicators are relevant indirect economic and/or social outcomes induced by the interventions

Which indicators to use depend on:

— the study question

— the stage of the policy cycle that needs to be evaluated; before, during or after the implementation of the intervention

4 Cost-effectiveness analysis without experimental setting: Identifying the causal impact of the intervention

4.1 The Evaluation Framework: definitions

4.1.1 Types of cost-effectiveness ratios based on the intervention design

CEA is a methodology that performs a comparative analysis between two or more types of interventions, in which both costs (cost evaluation) and impacts (impact evaluation) are compared. In the context of the CFF spending the impacts, i.e. effectiveness of the interventions are measured either by the *output*, *result or impact* indicators discussed in section 3.1. As discussed, the indicators should be positioning in the policy cycle. The cost measures depend on the perspective of the analysis as discussed in section 2.1.

In section 1.4.3 the basic notions on CEA were presented in a general set up. This section discusses how to conduct CEA analysis in the context of the evaluation of the spending on the food chain area. In particular different types of Cost Effectiveness Ratios are suggested that are specific to the context of the intervention or to the type of evaluation to be performed. These can be interpreted as special cases of the ICER and vary according to the nature of the alternative intervention.

In this context, the term alternative intervention must in this context be given a broader interpretation beyond the typical set-up where there are two or more mutually exclusive interventions. In the context of the CFF spending it will be of interest to consider three types of alternatives interventions: (i) inexistent –arising whenever a new type of intervention is implemented with a new set of targets; (ii) qualitatively different but with the same target or; (iii) qualitatively similar but with a different degree of (spending) intensity.

The choice of the relevant CER will depend on the nature of the alternative intervention but also on the policy evaluation question of interest. A CER could be computed to simply address the (average) cost performance of a single intervention, assess the effectiveness of varying the intensity of a given intervention, or to evaluate how new policy instruments are cost effective to complement existent interventions. These approaches are not mutually exclusive and for some spending areas it might be relevant to compute more than one type of CER.

Given relevant measures of the cost and effectiveness of an intervention the following cost-effectiveness ratios (CER) can be computed.

4.1.1.1 Incremental cost-effectiveness ratio (ICER)

As discussed in section 1.4.3, the ICER is computed as the ratio of the difference in the cost of the two interventions and in their effects.

$$Incremental\ cost\ effectiveness\ ratio\ (ICER) = \frac{cost\ of\ intervention\ B - cost\ of\ intervention\ A}{effect\ of\ intervention\ B - effect\ of\ intervention\ A}$$

The ICER gives the extra cost per extra unit of effect and can be used as a decision rule in resource allocation. When compared to a pre-determined threshold for the willingness to pay (WTP) (for intervention B) it allows deciding if choosing the new intervention is an efficient use of resources. If for a given intervention the ICER is above this threshold it will be deemed too expensive and thus should not be funded, whereas if the ICER lies below the threshold the intervention can be judged cost-effective.

4.1.1.2 Marginal cost-effectiveness ratio (MCER)

The Marginal Cost-Effectiveness Ratio (MCER) is the appropriate CER whenever the alternative intervention only differs with respect to its intensity, i.e. as the intervention expands or reduces. It is therefore computed as special case of the ICER since the interventions only differ with respect to its cost.

$$Marginal\ cost\ effectiveness\ ratio\ (MCER) = \frac{change\ in\ cost\ of\ intervention}{change\ in\ effect\ of\ intervention}$$

While the MCER can assesses the cost-effectiveness of the same intervention with different intensity, the ICER compares two interventions with the same target. Therefore the MCER can provide guidance when the aim is to assess the optimal level of implementation, i.e., the level of intensity of the intervention where most effects are reached at lowest cost.

4.1.1.3 Average cost-effectiveness ratio (ACER)

The Average cost-effectiveness ratio (ACER) is the ratio of the cost to the effectiveness of an intervention without reference to a comparator[25]. If an output indicator is used as an effectiveness measure the ACER is just the average cost of the intervention. The ACER corresponds to the ICER when the alternative intervention is inexistent:

$$Average\ cost\ effectiveness\ ratio\ (ACER) = \frac{total\ cost\ of\ intervention}{effect\ of\ intervention}$$

Computing the ACER is therefore the appropriate measure of CE upon the introduction of an intervention with respect to which there are not and there have been no interventions with the same target.

From the policy decision making point of view the ACER can be used to devise a decision rule based on a fixed budget in order to maximise total effectiveness.

4.1.2 Causation and the identification problem

In order for an evaluation to be accurate and to allow solid policy indications, one needs to identify a causal relationship between the explanatory variables and the outcomes under examination. For instance, in the case of the evaluation of a programme for the eradication of Bovine Tuberculosis, the causal effect of the explanatory variable "money invested in the programme" on the outcome "eradication rate" would identify to what extent the occurrence of the programme determines an increase in the eradication rate.

The first challenge in identifying **causality**, is its distinction from correlation. Correlation is a measure that describes the direction and the size of a relationship between two or more variables. In other words, when two or more variables are correlated they can display a similar (or opposite) behaviour. If the variables increase or decrease altogether, the variables are said to be positively correlated. Vice versa, if one increases and the other one decreases the correlation is negative. In both cases, however, the correlation between two variables does not imply a causal relationship between them, i.e. that the change in one variable causes a change in the other variable.

In practice, it is possible to pinpoint a causal relationship between two variables by solving the so-called **identification problem**. This consists in determining the best estimate of the value of a given parameter in a regression, net of all possible confounding factors (contextual indicators that may influence the effect under analysis in

[25] In section 1.4.3 the ACER was referred to as "cost effectiveness description".

such a way that the estimated results do not reflect the true relationship). For example, the incidence of Salmonellosis infections in animals and in humans are positively correlated (i.e. the more infections in animals, the higher the incidence among humans). Nevertheless, the causal effect of a high incidence rate of Salmonellosis in animals on the number of infections in humans can be identified only if one takes into account confounding factors that are known to be related to the incidence of the disease, such as hygienic conditions, eating behaviours and average temperatures.

The identification problem is often generated by the lack of **(good-quality) data**. This may be due to small sample size and/or to the complete or partial absence of certain measures that are thought to have a role in the process under scrutiny. In fact, sometimes even relatively little absent information on some variables can yield a substantial reduction in the sample size. Given that most statistical methods rely on the assumption of having a sufficiently large number of observations, this may result in a loss of precision in the estimated parameters of interest. Furthermore, when all or some information on specific variables which are thought to be relevant for the analysis are missing, it may become impossible to disentangle the causal effect of the intervention. It may be the case, for instance, that one wants to evaluate the causal effect of an emergency measure aimed at eradicating an outbreak of *Xylella fastidiosa* and that, at the same time, private investments are thought to be confounding this relationship. If there is lack of information on the investments made by farmers, then the identification of the effect of the measure on the outbreak of *Xylella* becomes arduous. These issues are amplified when the confounders that are thought to affect the relationship between the exposure to intervention and outcome are hardly measurable, like in the case of **unobservable characteristics** (e.g. effort put by the farmer).

4.1.3 Counterfactual impact evaluation (CIE)

In this specific context, impact evaluation is useful for finding evidence on whether a specific EU policy induced the intended changes in the target group's outcome (for instance, the effect of National veterinary programmes on eradication outcomes), or whether it had no impact, or even had unintended positive or negative consequences.

In practice, impact evaluation aims at answering the following counterfactual question: what would have happened to the target group affected by a given policy in case the policy had not been implemented? The average difference in the outcome (result, impact) indicator induced by the intervention is called the Average Treatment Effect (ATE). Impact evaluations that analyse counterfactual questions are called Counterfactual Impact Evaluations (CIE). They embody the standard methodologies in policy evaluation where the contribution of a given programme to the outcome variables is assessed by an ex-post impact evaluation analysis. Typically, this requires statistical handling of micro-data, or individual-level data. This is intended to be collected at the level of the unit (individual) that is targeted by the policy, e.g. animals, farms or regions/municipalities, so that the more detailed, complete and disaggregated the data, the more accurate is the analysis.

The characteristics of the target group that are relevant for a policy impact evaluation are called outcome variables (result and impact indicators). These may consist in either intended or unintended effects of the policy. Examples of outcome variables include: incidence rate, number of outbreaks, number of successful eradications of pests, production losses, value of live animals traded, and price of meat. Moreover, any evaluation should take into account all potential external elements (i.e. confounding factors) that might have an effect on the selected outcome variables. This is crucial to ensure a reliable evaluation that accurately isolates the effect of a policy, which, in turn, allows determining the EU's added value correctly.

At first glance, in fact, the solution to the counterfactual questions might rely on the so-called naïve before-after comparison. This consists in computing the difference between

the selected outcome variables before and after the policy implementation. As an example, one could consider comparing the number of positive test results before and after some specific veterinary programmes are introduced in a given country. Hence, a decrease in the average number of positive test results, say by 3 percentage points, might lead to the conclusion that such a decrease is entirely due to the EU National veterinary programme. However, such conclusions might be imprecise (hence, the name "naïve") because they do not account for other factors that might have contributed to the difference in the said outcomes, such as other measures funded by the local government or the natural decreasing trend of the disease due to biological or weather factors. Therefore, a more appropriate methodology should be chosen in order to achieve a better estimation of the effects of an intervention.

The main challenge in the counterfactual evaluation setting is that only one state of the world is actually observed. In other words, when evaluating the effects of an intervention, typically one can directly observe its consequences but not their counterfactual (what would have happened in the absence of the intervention). Since the impact of the intervention is assessed by comparing the two settings, it is necessary to find an approximation of the counterfactual. Most CIE methods rely on the existence of two comparable groups of individuals or units of observation (e.g. animals, farms, etc.): the treated group, which is the one receiving the intervention and the untreated or control or placebo group, which is made of individuals who do not receive the treatment. In principle, for counterfactual analysis to be valid, the two groups should be perfectly identical except for the application of the intervention (i.e. the treatment). Hence, for each evaluation analysis it is essential to be able to define and identify the appropriate control group.

A thorough description of the indicators is provided in section 3, while an account of the challenges related to data acquisition and to the identification of the control group can be found in the next section. What follows provides a brief description of the most common CIE methods. A priori, no method is superior to another in absolute terms. The optimal evaluation method must be chosen on the basis of the type and structure of the available data and the specific characteristics of the policy intervention that needs to be assessed. In all cases, the final goal is to identify the causal effect of a specific intervention with accuracy and precision.

4.1.3.1 Randomised control trials (RCT)

Randomised control trials (RCT) consist in experimental settings where two groups of individuals or units of observation (e.g. animals, farms, etc.) are defined: the treated and the control. The main feature of the RCT setting is that all individuals are randomly allocated to either group. The randomisation should be such that it generates two identical groups which differ only in the fact of receiving the treatment. This strategy is crucial for the identification of the causal effect of the treatment, which is found by simply comparing the average outcome of the two groups. This could be used in cases where, for instance, farms that can benefit from an intervention (treatment) in a given area are chosen through a random draft. In such a setting, however, it is important to rule out any potential externality effect, that is the possibility that the presence of a treated farm has a positive influence on the outcome of the neighbouring (untreated) holdings and vice versa.

While it is frequently used in medicine, RTC is not easily implementable in policy evaluation because, by nature, it requires the existence of a very specific setting. Yet, when properly designed, this method is extremely convenient in terms of computation of the results because it yields a clear identification of the effect under analysis: any difference between the treatment and the control group must be due to the treatment. Unfortunately, in many instances, the results of a RTC analysis have little external validity, i.e. they cannot be generalised outside of the context where they are generated. Nevertheless, to a certain extent, predictions can be usually made about what the effects of related programs in similar contexts could be.

4.1.3.2 Difference-in-differences (DiD)

The identification of a causal relationship can be reached with the implementation of the Difference-in-differences (DiD) method. Again, this requires the definition of two groups of individuals or units of observation: the treated group and the untreated or control group. The existence of the control group ensures to isolate the counterfactual situation of what would have happened to the treated group in the absence of the policy. Because of this, the control group should be as similar as possible to the treated group. A plausible setting in which the DiD method can be applied is one where all farms in a region are exposed to an intervention (treated group) and none of the farms in a similar region receive the said intervention (control group).

The DiD consists in taking the difference in the outcomes between the two groups after the policy implementation (say period t+1), the difference before the policy implementation (say period t), and finally the difference between the two differences (difference-in-differences). The DiD method can also be implemented in regression form, including potential confounders in the regression.

The advantage of this method crucially hinges on the assumption that the control group is a good counterfactual of what would have happened to the treated group in the absence of the policy. This can be checked by verifying that the two groups were behaving similarly before the implementation of the intervention (sometimes called the "parallel trends" assumption). Specifically, in the absence of the treatment, both treated and control groups would have experienced over time the same trend in the outcome variable. Therefore, any deviation from the trend observed in the treated group can be interpreted as the effect of the treatment. In order to verify the parallel trends assumption it is important to have information on the two groups in the periods before the implementation of the intervention.

4.1.3.3 Regression discontinuity design (RDD)

Similarly to the DiD, the regression discontinuity design (RDD) method requires the identification of a treated and a control group. In this case the eligibility to the policy has to be defined according to a quantitative variable for which a threshold is set. This could be, for instance, the case in which additional funds are given to farms to replace the animals that have been slaughtered following an epidemic and that such funds are granted only to farms that have lost at least a given percentage of their animal livestock (say, 50%).

The RDD consists in focusing solely on the two groups that are close to the eligibility threshold. In the previous example, one would evaluate the replacement intervention around the 50% level, by comparing the farms that are just above and just below the threshold (e.g. above 45 and below 55), under the assumption that the two groups of farms are identical in all aspects but receiving the intervention.

The RDD method can be implemented in regression form. The main issue with this methodology is that it only allows estimating the causal effect of a policy on the outcome for the groups around the threshold but it makes it difficult to infer the results to other groups further away from the same threshold, i.e. the analysis has internal validity but may lack of external validity. In the previous example, this may happen if, e.g., as soon as the ratio of sick animals over the total livestock reaches a certain level (say 70%), farmers find it more profitable to shut down their activity or to switch to other types of farming.

4.1.3.4 Matching

Matching is also a method that requires the definition of treatment and control groups and where the effect of the treatment is computed by comparing the individuals across the two groups. Specifically, each individual in the treated group is "matched" to one or more counterparts in the control group on the basis of all observable characteristics. Then, a comparison between the outcomes of the treated and the non-treated yields an

estimation of the effect of the treatment, where the bias due to the confounders is reduced thanks to the matching process. Clearly, the accuracy of the matching is strictly dependent on the richness of information on the observable characteristics: the more exhaustive the list of variables, the better the matching, and the more precise the computation of the effect.

4.2 Specific evaluation challenges in non-experimental settings

Impact evaluation and measuring the cost-effectiveness of an intervention require the existence of a clear evaluation plan and precise measurements. In order to achieve this, it is important to deal with the following potential issues which might threaten the validity of the analysis.

4.2.1 Informative harmonised database

With respect to measurements, it is essential to ensure the existence of a complete, detailed and harmonised database. This should include information on all observable characteristics of the unit of analysis and of the environment in which the said unit stands. For instance, if one uses farms or holdings as unit of analysis, then it becomes necessary to have information on the features of the farm: its size (number and type of plants or animals farmed, number of employees, whether there is uninterrupted access to clean water, etc.), the type of farming techniques and the level of technology employed (e.g. the value of the machinery), whether the farmer has access to public or private funding and the amount of each transfer, history of diseases and pests detected and/or treated by the farmer. Furthermore, in order to account for external confounding factors, it is also important to have information about the geographical area in which the farm is located, including average GDP, whether the area belongs to any special funding intervention (e.g. "Objective One" regions), prevalence of farming types, type, incidence and timing of diseases and pests in the area, etc. One aspect that is especially relevant in this context consists of clearly isolating the effects of a given EU-funded intervention from those of other interventions that might be funded by the single Member States or co-funded with the EU itself. Hence, a clear distinction between the various sources of funding is essential.

As reported in previous documents by the European Commission, the epidemiological data provided by the individual operators and the Member States appear to be reliable and consistent with data from other sources.[26] Nevertheless, access to micro-data is sometimes problematic, especially at the most disaggregated geographical level, such as farm orholding level. Hence, all efforts should be made to guarantee access to administrative data in order be able to evaluate the impact and the effectiveness of the interventions in the food chain area.

4.2.2 Identification

As regards the identification of a clear setting, in many cases this is the most challenging task of all. As stressed in the previous sections, in fact, counterfactual evaluation analysis aims at assessing the effects of a given treatment (the implementation of a given intervention) on the treated unit of observation and, by definition; it requires the existence of a control unit or group. The control stands for an equivalent situation to the one under study (treated) such that the only difference between them is the treatment itself. An inappropriate choice of the control can seriously jeopardize the validity of the

[26] "Evaluation of the Eradication, Monitoring and Control Programmes for Animal Diseases, Final Report 2013." Directorate-General for Health and Consumers and ICF GHK.

analysis. Hence, the identification of the control must be tailored on the specific setting that is under study and only general issues can be addressed at this stage.

4.2.3 Confounding factors

Within the counterfactual evaluation framework, the following issues are likely to occur and must be dealt with. First, as mentioned, external confounding factors can have an impact on both the exposure to the intervention and the outcomes, so they might alter the estimated effect of an intervention. The same occurs in the case of selection. Here, the exposure to the intervention depends on unobserved features which, in turn, affect the outcome. A very common example pertains to individuals or communities that are chosen to participate to a policy intervention because they are more likely to benefit from it. In this case, the `true' estimated effect of the intervention should be taking into account the selection bias, i.e. that the treated group has a higher propensity to benefit from it compared to any other group, regardless of the intervention itself. Then, spillovers and contamination might also arise. In the first case, the control group is also affected by the intervention, making it hard to isolate the exact causal effect of the intervention. In the latter, the treated and/or the control groups have access to another intervention that has an effect on the outcome, so that a clear distinction between the effects of the two different interventions should be made.

4.2.4 Selection bias

Generally speaking, any analysis aimed at identifying the causal effect of an intervention on the outcome should account for all the potential sources of bias generated by these circumstances. In the specific context of eradication, monitoring and control programmes in the food chain area, some additional issues appear to be potentially relevant.

First of all, some programmes, such as the survey programmes for plant health, are bound to reach full coverage of the EU territories and lead to universal implementation. The same happens in the case of emergency measures for eradication and containment, which are put into place as soon as an eligible pest or disease is detected within any EU MS. In terms of counterfactual analysis, this implies that all areas would be defined as treated and identifying the control group in this setting can become problematic.

One solution to this relies on geographical comparisons and might be found in the use of non-EU units of observation as control group. They may be either extra-EU territories or pre-EU accession regions, provided that they are similar to the treated units under analysis in terms of economic and environmental features (i.e. they are comparable).

Another variation that can be used refers to timing. Specifically, the control group can be identified in those instances in which the application of the intervention is not contemporaneous in all areas. If country A implements the intervention in year t and country B complies in year t+2, then this difference in timing can be exploited such that one can identify a control group within the two years in which country B was not implementing the intervention but country A was.

A third option could be a comparison across harmful organisms that have similar epidemiological characteristics but of which one is covered by the EU funded intervention and the other one is not. This would be the case of, e.g., disease A and disease B, both of which have similar contagion patterns and similar symptoms on animals and/or plants but only disease A enters the eligibility criteria for a given eradication and control programme to be funded. Hence, the question of "what would have happened in the absence of the programme" can be addresses by comparing the outbreaks of the two diseases.

4.2.5 Heterogeneity across MS

Moreover, when it comes to the implementation of eradication, monitoring and control programmes, some evidence of both structural and organisational difficulties for the MS

arises. These lead to a sub-optimal implementation of the interventions and lower effectiveness in terms of outcomes.

Structural issues relate mainly to the nature of some farming practices (e.g. the widespread existence of backyard holdings in some countries makes it hard to identify the holdings themselves and to count animals and plants therein), to the fact that diseases may pass into a country from a neighbouring one, particularly in areas that act as the EU's external border, and to the presence of wildlife reservoirs, which might foment the transmission of diseases by re-infection or even by spreading them in areas that had not been previously affected.

Organisational issues, on the other hand, may be due to various reasons. One of them is the low-quality co-ordination between and within Member States. On the one hand, poor or absent co-operation *between* neighbouring countries is detrimental because it causes an increase in the costs of the intervention. This is particularly important in countries that experience high incidence of diseases that are spread by the wildlife, such as the recent cases of rabies in Bulgaria and Romania, and even more so in areas that are at the EU's external border. On the other hand, the lack of co-ordination and co-operation *within* a single country can also be a problem because it leads to increases in costs and loss in operational efficiency.

Other reasons may be linked to the lack of systematic gathering of information (databases) or to differences in standards across countries. For instance, differently from the rest of the EU, in Ireland and the UK by law a holding does not need to encompass only contiguous land, but it can include all the land that is managed by the same keeper, regardless of its specific location. Such lack of distinction between contiguous and non-contiguous land, as a consequence, has caused delays and difficulties in the implementation of disease eradication programmes.

Other organisational issues may be related to delays in payment or in the delivery of the appropriate equipment, which might, in turn, compromise previous efforts to achieve the desired outcome and lead to a failure of the intervention. Finally, in some cases, the design of the programme did not take into account an appropriate set of incentives for farmers, whose co-operation in transmitting accurate and detailed information and in complying with the procedures set by the competent authorities is crucial for the effective implementation of measures.

Box 4: Identification of the causal impact of the intervention

The main challenge for identifying the causal impact of an intervention is to be able to measure what would have happen in the absence of the intervention under evaluation. This counterfactual situation is by definition not observable as regions or MS are either receiving the interventions or not. The aim of policy evaluation methods (or CIE methods) is to find the best proxy possible to measure the counterfactual situation i.e. to find a so-called "control group".

5 Measuring Cost-effectiveness in the Food chain area

Based on the concepts introduced in the previous chapters regarding the measurement of costs and effectiveness, and what would have happened in the absence of the intervention, this section presents the three main methodological points to consider in order to perform a cost-effectiveness analysis in the food chain area; (i) which identification strategy(ies) to implement, (ii) which estimation method(s) to run and (iii) which cost-effectiveness indicators to use.

5.1 Identification strategies

This section discusses the appropriate strategy to identify the effectiveness of the EU co-funding in the food chain area. Two possible solutions are envisaged depending on whether a control group can be identified with which a counterfactual analysis can be performed..

5.1.1 The existence of a control group

The possibilities of finding a control group within the food chain area are discussed in the following subsections differentiating planned programmes from emergency measures.

5.1.1.1 Planned programmes

Planned programmes such as eradication, control or surveillance programmes in animal health or survey programmes in plant health are in general tailored fitted to Member States' needs (via working programmes).

In this case, possible control groups could be:

1. EU regions receiving no funding either because; (i) MS that applied for funding but their submitted programme was rejected or; (ii) MS that did not apply while being at risk.
2. Regions in other countries such as EU candidates may also be used as control groups.
3. Regions which implement the policy later than the treated region.

If potential control groups exist they need to be similar to the treatment group that is the population or the region receiving the intervention under evaluation.

5.1.1.2 Emergency measures

In the case of emergency measures, identifying a good control group to evaluate what would have happen if the MS would not receive EU funding is even harder because all MS are required by the EU legislation to take measures in the presence of an outbreak.

5.1.2 The entire target population receives the intervention

One can assume that the entire target population receives the intervention when the risk assessment is properly done for each population/region so that the entire target

population is defined and the funds are awarded to all risk groups previously defined which is the population of interest (As defined under the CFF regulation)[27].

In this case, it is relevant to note that there is no selection bias as all the target population receives the intervention. However, measuring the cost-effectiveness of an intervention compared to no intervention is not feasible.

Nevertheless, a cost-effectiveness analysis can be performed to evaluate the marginal (increase in funding over time) and/or the incremental (change in the intervention measure) cost effectiveness of an intervention compared to the same intervention before the qualitative or quantitative change in the intervention.

5.2 Econometric based analysis[28]

This section describes a general econometric methodology to perform CEA. Given the availability of data at the region/MS level over time regression methods are the appropriate methodologies to perform economic evaluation. Regression methods allow addressing the important issue of confounding factors and selection issues in order to correctly assess the impact of EU co-funding on the outcomes of interest. In particular in the context of cost-effectiveness analysis the Net Benefit Regression approach provides a solution for the challenges posed by the computation of CER and namely the ICER.

To compute the ICER, one can then estimate the following regressions:

$Cost_{it} = \alpha_0 + \alpha_1 T_{it} + X_{it}\beta + \epsilon_{it}$,

$Effectiveness_{it} = \gamma_0 + \gamma_1 T_{it} + X_{it}\beta + \epsilon_{it}$,

using data on the units *i* over a period of time *t*=1, …, T where

$Cost_{it}$ and $Effectiveness_{it}$ are the chosen measures of cost and effectiveness for each unit i and t.

T_{it} =1 for a *new intervention at time t in unit i,* T_{it} = 0 otherwise;

ϵ_{it} = the random error term for unit *i* in period *t;*

X_{it} = the set of regressors for unit *i* in period *t;*

The treatment variable T_{it} embeds the nature of the intervention. It incorporates all changes in the intervention that occurred in the time interval considered for observation unit *i*[29]. It can be associated with the introduction of a new measure or just with a change in the intensity of an existing intervention.[30]

These equations can be computed by a difference in group means under each treatment. However, since simple average does not allow considering other factors that influence the effectiveness of the intervention that may differ across units (regions/MS) nor the potential selection bias when the entire target population does not receive the intervention, a regression approach provides a way to estimate directly the average difference in cost and the average difference in effectiveness while controlling for

[27] However, as mentioned in section 5.1, one could only identify a control group if MSs would not have applied or the risk assessment was not correctly or if the EU did not recognized the MS at risks.

[28] An application of this econometric method is provided in Box 7 of Chapter 7.

[29] This would be the case when different region or MS start implementing a co-funding intervention in different years.

[30] Here two alternatives are compared but the method could be extended to more than two measures/activities/programmes to be compared.

confounding factors (X_{it}) and potential selection bias using CIE methods as discussed in chapter 4.

The ICER is then of the form:

$$\text{ICER} = \frac{\Delta C}{\Delta E} = \frac{\alpha_1}{\gamma_1}$$

As discussed in chapter 1, the ICER needs to be compared to the WTP. An appropriate way of estimating the cost-effectiveness is to use the Net Monetary Benefit as follows:

$$\text{NB}_\text{A} = \text{WTP} * \text{E}_\text{A} - \text{C}_\text{A}$$

The WTP can be viewed as the conversion factor allowing cost and effect to be valued in the same units.

As the ICER which is a ratio that allows comparison of two interventions, the Incremental Net Benefit (INB) is defined as the monetary difference between the net benefits:

$$INB \quad = WTP * E_B - C_B - (WTP * E_A - C_A) = WTP * \Delta E \quad - \Delta C$$

The second equality makes evident the relation between the ICER, the WTP and the INB.

The net benefit regression (NBR) using data on the units *i* over a period of time *t*=1, …, T and assuming a choice for the value of WTP is of the form:

$$nb_{\text{it}} = \delta_0 + \delta_1 T_{it} + X_{it}\beta + \epsilon_{ti}$$

nb_{it} = the net benefit for observation unit *i* in period *t*;

The estimate of the expected INB in the population is the coefficient δ_1. If $\delta_1 > 0$, the new intervention is cost-effective for the given value of WTP. The procedure relies on estimating the net benefit regression for several values of the WTP.

Using the NBR to estimate the cost-effectiveness has several advantages over computing the cost-effectiveness ratio; first it is possible to test the sensitivity of the cost-effectiveness conclusion to the value of the WTP computing the probability of the new intervention to be cost-effective for different values of WTP and displays the cost-effectiveness acceptability curve (CEAC).

This equation is a general form including only confounding factors and the interventions to be evaluated (T). This form is valid only when the entire target population receives the intervention as in this context no selection issues arise.

When not the entire target population receives the treatment this equation needs to be extended with one suitable CIE method presented in chapter 4 to account for potential selection bias and to allow for identifying the causal effect of the intervention.

5.3 Cost-effectiveness indicators for the Food Chain Area

This section provides a set of cost-effectiveness indicators (CEI) based on the indicators proposed in chapter 3 to measure the effectiveness of the interventions. In principle, CEI can be computed on the basis of all Effectiveness Indicators. Also they can be based on Output, Result and Impact depending at which stage of implementation of the intervention one wants to measure the cost-effectiveness.

- Output CEI are a measure of average costs that might be relevant in terms of ex-post analysis of the CFF budget allocation without looking at the results. They can be used as monitoring indicators to assess how well the implementation of the intervention is going. They can be computed as Average Cost-Effectiveness Ratios.

For instance, the average cost per survey actions implemented (Survey programme in Plant Health) can be computed as:

$$Average\ cost\ effectiveness\ ratio\ (ACER) = \frac{Total\ cost\ of\ survey\ actions\ implemented}{Number\ of\ survey\ actions\ implemented}$$

- CEI based on Result and Impact Indicators are used to measure the ex-post cost-effectiveness of the intervention. They are computed thanks to the identification strategies presented in section 5.1 and the estimation method described in section 5.2.

The Result and Impact CEIs in addition to their link to the objectives of the programme were chosen based on[31]:

- **Their degree of applicability in different settings**. This criterion means that the same indicator can be collected and computed for all MS and regions in a uniform way. But also its ability to be computed at different levels of aggregation (in terms of geographical information, time or type of diseases.)
- **Data availability.** Use of data already collected in the food chain area also through other sources. Potential sources of data are discussed in chapter 6.
- **Burden of data collection:** This criterion should be assessed when planning the evaluation and will be covered in chapter 6.

For each intervention in the three spending areas i.e. Plant Health, Animal Health, and Official Controls; one Output, two to three Result and Impact CEIs for use in CEA in the Food chain area (Tables 7, 8, and 9) are proposed.

The feature of the selected CEIs is that they can be computed at different level of aggregation (local areas, regions, MS, by disease or types of disease, for a whole programme, by lab in the area of official controls)

The impact will always be with respect to the impact indicator that measures reduction in production losses both in volume and value because it is relevant in all activities under animal and plant health. Other impact indicators could be suggested such as the reduction in net exports or investment but may be only applicable to a class of activities where export matters and investment is continuous.

[31] Those criteria are based on some of the criteria for selection of indicators developed for instance by EvaluATE http://www.evalu-ate.org/authors/goldie-macdonald/ in a Checklist to Inform Monitoring and Evaluation. http://www.wmich.edu/sites/default/files/attachments/u350/2014/Indicator_checklist.pdf

Table 7: Selected cost-effectiveness indicators in Plant health

	Survey programmes	Emergency measures	
		Eradication	**Containment**
CEI 1 (OI)	Cost per survey actions implemented	Cost per eradication measure put in place	Cost per containment measure put in place
CEI 2 (RI)	Cost per HO/pest detected	Cost per successful eradication measure	Cost per successful containment measure
CEI 3 (RI)	Cost per early action taken	Cost per reduction of time to eradicate pest/outbreak	Cost per reduction of time to contain pest/outbreak
CEI 4 (RI)	Cost per outbreak of pests covered by EU legislation avoided Cost per outbreak of pests covered by EU legislation avoided due to early action taken		
CEI 5 (II)	Cost per production loss due to pest detected / outbreak	Cost per production loss due to pest detected/outbreak	Cost per production loss due to pest detected / outbreak
CEI 6 (II)	Cost per unit of gain/reduction in (net) export	Cost per unit of gain/reduction in (net) export	Cost per unit of gain/reduction in (net) export

Cost-Effectiveness Indicator **(CEI)**, Output Indicator **(OI)**, Result Indicator **(RI)**, Impact Indicator **(II)**

Table 8: Selected cost-effectiveness indicators in Animal health

	Veterinary programmes			Emergency measures
	Eradication	**Control**	**Surveillance**	
CEI 1 (OI)	Cost per eradication programme	Cost per control programme	Cost per surveillance programme	Cost per emergency measure
CEI 2 (RI)	Cost per MS/region free from disease	Cost per target achieved (for disease j)	Cost per target achieved (for disease j)	Cost per successful emergency measure
CEI 3 (RI)		Cost per target achieved (aggregated for all disease)	Cost per target achieved (aggregated for all disease) Cost per outbreak avoided	Cost per secondary outbreak avoided
CEI 4 (II)	Cost per gain/reduction in production/productivity	Cost per gain/reduction in production/productivity	Cost per gain/reduction in production/productivity	Cost per gain/reduction in production/productivity
CEI 5 (II)	Cost per unit of gain/reduction in (net) export	Cost per unit of gain/reduction in (net) export	Cost per unit of gain/reduction in (net) export	Cost per unit of gain/reduction in (net) export
CEI 6 (II)	Cost per case of zoonosis avoided	Cost per case of zoonosis avoided	Cost per case of zoonosis avoided	Cost per case of zoonosis avoided

Cost-Effectiveness Indicator **(CEI)**, Output Indicator **(OI)**, Result Indicator **(RI)**, Impact Indicator **(II)**

Table 9: Selected cost-effectiveness indicators in Official controls

	Better Training for Safer Food			**EU reference laboratories**	
	Workshops	**e-learning**	**Sustained training missions (STM)**	**Proficiency tests (PT)**	**EURL Workshops**
CEI 1 (OI)	Cost per workshop participant	Cost per e-learning training participant	Cost per STM participant	Cost per PT (by lab type)	Cost per workshop participant
CEI 2 (RI)	Cost per increase in test score	Cost per increase in test score	Cost per increase in test score	Cost per increase in successful PT	Cost per increase in test score
CEI 3 (RI)	Cost per increase in percentage point of satisfaction rate	Cost per increase in percentage point of satisfaction rate	Cost per increase in percentage point of satisfaction rate	Cost per increase in percentage point of satisfaction rate	Cost per increase in percentage point of satisfaction rate
Cost-Effectiveness Indicator **(CEI)**, Output Indicator **(OI)**, Result Indicator **(RI)**.					

Box 5: Cost-effectiveness estimation strategy

When setting the estimation strategy to perform a cost-effectiveness analysis in the food chain area, the following points needs to be discussed:

— The identification strategy

— The estimation methods

— The cost-effectiveness indicators

6 Implementation requirements

The methodology described in this report to measure the impact and the cost-effectiveness of the interventions funded under the food chain area is an in-depth-data-driven technique. This technique is grounded on micro data and provides robust ex-post evidence on the impact and the efficiency of interventions. The method requires careful planning of the monitoring and evaluation of the interventions.

This chapter provides guidance on data collection and requirements, and evaluation planning which are key for applying this methodology.

6.1 Planning the evaluation

6.1.1 Legal deadline for the ex-post evaluation of the interventions implemented within the Food chain area

In September 2017 the Commission established and presented (to the European Parliament and to the Council) a mid-term evaluation report on whether, in terms of their results and impacts, the interventions funded under the common financial framework of the food chain area (CFF, Regulation (EU) No 652/2014) achieve their objectives.

Under article 42 ("Evaluation") of the CCF Regulation itself, the Commission shall carry out an ex-post evaluation of the measures referred to in paragraph 1 of this Article in close cooperation with the Member States by 30 June 2022. This ex-post evaluation shall examine the effectiveness and efficiency of the funded interventions and their impacts.

The main objective of this report is to serve as a guidance document to help the responsible authorities to carry out the ex-post evaluation referred above. It also provides the MS with the tools tailored to their needs to prepare the annual technical and financial report that each MS receiving funding shall submit by 30 April each year at the latest (Art. 14 of Regulation (EU) No 652/2014).

6.1.2 Evaluation plan

Good evaluation planning is a critical step to ensure the availability of the evaluation results on time. It is fundamental to have sufficient internal and/or external staff able to deal with the process and communicate effectively with the beneficiaries, together with a detailed planning of the implementation of the evaluation to allow supervision and troubleshooting.

In this regard, it is recommended that the responsible authorities prepare thorough evaluation plans, which should identify at least the following:

- the resources needed to carry out the evaluation;
- the work plan with a timeline and clear deadlines to allow follow-up and review of the progress;
- the procedures to check and validate the results of the evaluation.

If the evaluation is carried out by an external consultant, the work plan should allow sufficient time for contracting (including for preparation of the terms of reference, launch of the call for tenders, selection of the contractor and signature of the contract).

In addition, the time margin necessary for carrying out the quality assessment of the deliverables needs to be taken into account in the end of the contract.

Finally, in their evaluation plan, responsible authorities should also foresee the strategy and approach in disseminating the results of the evaluation of the interventions funded within the food chain area.

6.1.3 Selecting the evaluation experts: Terms of Reference (ToR)

It is vital that the evaluation is carried out by experts who are functionally independent from the responsible authorities, the audit authorities and the delegated authorities. This implies that the Commission or the Member States have the choice to entrust the evaluation to external experts (contractors), or to an internal but functionally independent body. Under the second option, these experts may be affiliated to an autonomous public institution responsible for the monitoring, evaluation and audit of the administration. The hierarchical independence of the evaluators should be ensured through an appropriate assessment of the situation[32].

Depending on the option selected, procurement may be necessary. or not.It is recommended to set up a detailed plan and to write precise Terms of Reference (hereafter referred to as the ToR).

Preparing Terms of Reference (ToR)[33]

The ToR presents an overview of the evaluation manager's requirements and expectations related to the evaluation study, providing a brief and concise description of the main scope and purpose of the evaluation, the roles and responsibilities of the actors involved, the methodology, the selection criteria, the timeline, and the amount of resources available for the evaluation (if applicable).

The ToR discusses the logical connection between several elements: the rationale for the evaluation, the objectives of the fund, the purpose of the evaluation, and the evaluation questions. The ToR should be structured to include the following key elements:

1. Background introduction and description of the intervention providing context information and the objectives of the fund.

2. Specific purpose and scope of the evaluation, explaining what will be evaluated and why, complemented by the main evaluation questions.

3. Intervention logic with the expected broad methodological approach, wide enough to ensure room for the evaluators to assess the quality of the proposed methodologies and if appropriate suggest additional/alternative ones.

4. Evaluation questions encouraging critical analysis. The evaluation questions selected by the Commission should be worded in a way that forces the evaluator to go beyond providing a yes/no answer based on simple description, and to look at what the links were between the changes observed and the EU interventions.

[32] For more information one can check the Better Regulation Guidelines https://ec.europa.eu/info/sites/info/files/better-regulation-guidelines.pdf

[33] A set of supporting material to write a Terms of Reference including suggestions is available on the Competence Centre on Microeconomic Evaluation website: https://crie.jrc.ec.europa.eu/?q=content/tor Advice on the on the qualifications of the evaluation team is provided in the 5. Selection and Award criteria of the guideline: https://crie.jrc.ec.europa.eu/sites/default/files/GuideTermsReference.pdf .

5. Availability of relevant data (e.g. outcome measures, covariates) on the target population directly provided by the commissioning authority or publicly available.

6. Availability of data on the control group if Counterfactual Impact Evaluation methods are being used.

7. Description of the required professional competences and qualifications of the evaluators (according to the scope and methodology of the evaluation) as well as of the selection and award criteria.

The ToR should indicate the minimum requirements on size and experience profile of the evaluation team, the qualifications of the principal investigator, the necessary human and technical resources, and the distribution of responsibilities among team members to perform the proposed work and demonstrated specific experience usually from relevant evaluations performed in the past.

For an impact evaluation and cost-effectiveness analysis in the Food chain area such as a case study described in chapter 7, one would need at least one expert in econometrics and counterfactual impact evaluation methods and one (Public Health) expert in the relevant field of the evaluation (animal health, plant health, food safety).

8. Expected tasks and deliverables (inception, intermediate and final reports, presentations, other documents expected from the evaluators), the time schedule of the study and the available budget.

In order to provide an additional safety net, ensuring a high editorial quality of the contractors' final report, it is recommended to consider including the following clause in the ToR: "In view of its publication, the final report by the contractors must be of high editorial quality. In cases where the contractor does not manage to produce a final report of high editorial quality within the timeframe defined by the contract, the contracting authority can decide to have the final report professionally edited at the expense of the contractor (e.g. deduction of these costs from the final payment)."

Finally, the ToR should contain detailed information on the methodology that it is advisable to adopt for the evaluation. Different methodologies can be used depending on the data at hand. Responsible Authorities can choose to be very prescriptive and to describe in the ToR which data collection tools and analytical methods shall be used, or request the evaluation experts to propose their approach and methodology, and use these as one of the criteria for the selection of the experts. However, the ToR should specify that triangulation of methods is required.

The contractors should be asked to explain in their bid the advantages, the limitations and the risks involved in using the proposed tools and techniques.

To make this step smooth it is important that the Responsible Authorities are in touch with the beneficiaries of the funds in terms of data availability and collection. During the inception phase of the evaluation, the evaluators may be asked to refine the methodology proposed in the tender bid and to provide further details on the data collection tools, sources, analysis methods, data limitations and back-up solutions.

6.2 Data requirements

6.2.1 Types of data needed

Performing cost-effectiveness analysis requires collecting information on:

- The entire population under evaluation that is not only the regions/holdings, individuals receiving the intervention but also the existing control groups.
- The follow-up time period of the evaluation; before and after the introduction of the intervention or/and until the effects are expected to occur.
- The chosen effectiveness indicators; output, result or impact indicators for each observation unit and time period.
- The costs in relation with the view point followed in the evaluation, EU funding, but also the part of the interventions funded by the MS or privately.
- A set of "control variables" which are all potential confounding factors or contextual indicators of the effect under evaluation, such as qualification levels of official controllers, their age and gender, etc. when evaluating the BTSF programme.
- The level of observation unit could be the region, the holdings, and the individuals depending on the study question and of the data availability.

6.2.2 Data provisions

To ensure that the necessary data are available in time the evaluation needs to be performed, this section lists guiding questions specific to data planning and collection.

- **Plan:** How will data be collected or accessed?

  Whenever possible, data collection and data organization should be (a) no (or only a limited) burden to beneficiaries and (b) centralised (for simplification and uniformity). One should assess when sufficient data will be available and ready to perform the evaluation. One would also need a plan to enhance collection and management of data.

- **Data sources:** Are there data already collected that could be used for evaluation?

  A. Outcome, output and impact indicators, and contextual indicators:

Valuable data are already collected by the EC that could be used for evaluation within the Food chain area, such as:

- Web based notification system for Harmful organisms, EUROPHYT-Outbreaks https://ec.europa.eu/food/plant/plant_health_biosecurity/europhyt/network_en
- EUROSTAT: http://epp.eurostat.ec.europa.eu/newxtweb/
- FADN, Farm Accountancy Data Network: https://ec.europa.eu/agriculture/fadn_en
- MADB, Market Access database: http://madb.europa.eu/madb/indexPubli.htm

- The new platform: "Electronic Official Controls of Food and Plant Products"
- TRACES, TRAde Control and Expert System: https://ec.europa.eu/food/animals/traces_en
- RASFF, Food and Feed Safety Alerts: https://webgate.ec.europa.eu/rasff-window/portal/?event=SearchForm&cleanSearch=1

B. Cost and financial data

Cost information is collected through **online templates** that MS are requested to fill in to receive financial support each year:

- Record information on output and (result) indicators (number of tests, visual inspection, vaccination, number of farms tested, type of farms, number of infection detected, number of outbreaks, etc.)
- Record geographical information: region, local areas in the MS in which the measures were implemented. This information is important and need to be link with the corresponding cost and type of activities funded per geographical unit at the most disaggregated level.
- The co-funding rate, source of funding: public or private.

Data collection: what information and how data should be collected?

The data for the analysis should be prepared in a format that can be read by the software used for the evaluation. This can be either Excel or delimited text file (see an example of a set of data in Annex 2). If the data required for analysis, - financial and technical - are not part of a harmonized data system but are stored in separate datasets, it is crucial that a common identifier is included in each dataset to allow linkage.

For an evaluation at the EU level of the interventions funded within the Animal health spending area, one common identifier could be the NUTS or regional unit to link the financial data with other sources of data such as EUROSTAT or data collected via the Animal Disease Notification System (ADNS).

When individual data are required as for the evaluation of the training activities within the Official controls spending area, the datasets would require an anonymised common identifier to guarantee the non-identification of training participants.

To facilitate high quality and reliable impact evaluation it is advised to preparedata as granular as possible.

It is also crucial that the legal text clarifies what data shall be collected and what data can be shared within DGs and with external contractors.

It would be relevant to keep information on non-successful applicants also to be used for later ex-post evaluations as counterfactual group.

Box 6: Implementation requirements

The methodology described in this report to measure the impact and the cost-effectiveness of the interventions funded under the food chain area is an in-depth-data-driven technique. This technique is grounded on micro data and provides robust ex-post evidence on the impact and the efficiency of interventions.

This method then requires:

— careful planning of the evaluation of the interventions, and

— in particular on data requirements:

— use of data already collected also for other purposes (cost information, effectiveness indicators, contextual indicators)

— use of data at the least aggregated level

— plan harmonised data collection

— ensure the legal arrangements for data collection and sharing

7 Case studies

Given the different nature of the indicators to evaluate the effectiveness of EU co-funding in the food chain area and the different perspectives in which the interventions, a CEA must provide an answer for a particular policy question. In this section, examples of cost-effectiveness analyses in the context of interventions co-funded in the CFF are provided which could be performed in collaboration with JRC.

The presented cases are not exhaustive with respect to the CEA that can be conducted but provide examples of relevant policy questions and how the methodologies considered in this report can be used to address them.

They are presented by discussing the: policy question, the motivation, the intervention under evaluations, the outcome variable, the CER implicit in the NBR, the scope of the analysis, the suggested time frame for the analysis, the outcome variable, the control variables, the cost perspective, and possible selection problems.

Case study 2 is described in more details. In particular, an example of estimation of the cost-effectiveness indicator based on simulated data is reported in Box 7.

7.1 Case study 1

Policy question: what is the cost-effectiveness of the introduction of *e*-learning compared to workshops in the programme BTSF?

Motivation: e-learning is a training tool that reaches more people at lower cost; however the learning approach is different from workshops since those allow a bigger interaction between trainer and trainees and lecturing is complemented by field work and case studies. However assuming that acquired knowledge can in both cases be assessed and comparable, the aim is to evaluate how cost effective is the introduction of *e*-learning.

Interventions: Spending in workshop *versus* spending in workshop + *e*-learning.

CER method: The Incremental CER, as two types of trainings are compared.

Scope: The observational units are the individual participants in the training sessions.

Follow-up time: at least one year before and one year after the introduction of e-learning modules

Outcome variable: Test score (result indicator). The Cost-effectiveness will be measured as the cost per additional point in the test score.

Control variables: individual qualifications and experience, MS identifier, participation in previous training sessions.

Cost perspective: It matters to consider the analysis not only at the EU level, but also MS and participants' private costs.

Selection issue: CIE might have to be used as participation in the training sessions is not compulsory.

7.2 Case study 2: Economic evaluation of the veterinary programmes for O&CB, ASF, rabies, CBSE, ZS, CSF

7.2.1 Description and objective of the programme

EU co-funding in veterinary programmes builds up on the results achieved in the recent past on eradicating and controlling the prevalence of different diseases that have an impact also on human health, trade and farmers. Since veterinary programmes may have a multiannual nature, their implementation needs to be continuously evaluated. New measures have been implemented in MS and EU funded such as vaccination in particular as prevention measures. These new measures increased the EU funding spent in veterinary programmes.

7.2.2 Policy question

Tracing the different intensities of veterinary programmes in EU regions over time and measure what is the effectiveness of an increase/reduction in the EU spending on eradication and control interventions within veterinary programmes for the following diseases: O&CB, ASF, rabies, CBSE, ZS and CSF.

The cost perspective will be the one of the EC. What is the effectiveness of EU funding on reaching the target set by the Commission for each disease?

7.2.3 Identification of a control group and scope of the analysis

Veterinary programmes are awarded to regions where a disease is present. It is not reasonable to assume that there are regions infected (with the same risk) that do not apply for co-funding. In this case, the entire target population receives funding and there is no selection issue (as explained in sections 4.1.2 and 5.1.2).

Given the policy question, the cost-effectiveness indicator used is the marginal cost-effectiveness ratio (MCER) to measure the impact of an increase of EU funding using variation of EU funding over time across regions and diseases.

The observational units are the regions[34] targeted by veterinary programmes.

As the estimation of the MCER relies on variation over time and given that the impact of veterinary programmes on the presence of the analysed diseases (O&CB, ASF, rabies, CBSE, ZS and CSF) can occur also a number of years after the implementation of the measures, the more data on previous funding periods and presence of the diseases are available (backward in years) the better.

7.2.4 Data

Measuring the costs

EU funding: it is crucial to have access to precise and detailed information on the amount of EU funding that each region receives for each disease within the veterinary programmes. Moreover, it is essential that a measure of national co-funding (total amounts of the payments by each MS or, if missing, the co-funding rate) is provided at the same regional level at which the analysis is conducted. This information should be made available every year by MS that receive EU funding in the annual technical and financial report (Art. 14 of Regulation (EU) No 652/2014).

[34] The regions targeted by the EC i.e. regions in which the disease is present or regions in which there is a risk of disease

National Funding: in addition to the co-payments to EU funding, it is necessary to retrieve information on any other financial contribution pertaining to veterinary programmes that each MS supplies at the NUTS2 regional level.

Measuring the effectiveness

The effectiveness of the eradication and control programmes can be measured in a given region, a given year and for a given disease as the distance from the target set by the Commission. Hence, the effectiveness increases when the distance decreases. This can be expressed either (i) as a continuous measure of distance from the target that is normalised across diseases, or (ii) as a dummy variable for whether the target was reached (i.e. equal to 1 if the target was achieved, and 0 otherwise). The choice of the type of variable used (continuous or dichotomous) depends on the quality of data available. Yet, in both cases, to be able to compute the distance from the target it is necessary to have information on the number of cases/outbreaks[35] and the actual targets for each disease (Result Indicator).

Contextual indicators

A set of contextual indicators including: GDP, farms indicators such as the number of farms, the number of livestock and the standard output are available on EUROSTAT.

Other relevant contextual indicators to include are the year of first outbreak; the number of secondary outbreaks and other risk indicators to assess the epidemiological situation in the region, the existence (or/and amount) of national funded actions to eradicate, control and survey these diseases complementary to the EU-funding.

7.2.5 Cost-effectiveness indicators and interpretation

The cost-effectiveness indicator used to estimate the impact of EU funding in veterinary programmes on the distance to the target at the regional level is the cost per percentage point decrease in the distance from the target. Box 7 provides an illustration of the potential estimation results.

In this case, the cost-effectiveness indicator does not measure the impact of the veterinary programme compared to the counterfactual situation of no veterinary programme but measures the marginal (increase/decrease in funding over time) cost effectiveness of the veterinary programme compared to the same programme before the quantitative/qualitative change in the funding/programme. As the policy question is not about knowing and measuring whether the EU should fund veterinary programme or not but rather how much money should be given to MS, the most relevant cost-effectiveness indicator is the marginal cost effectiveness indicator.

We estimate the MCER for all the listed diseases combined; hence, the estimated MCER can be interpreted as the average marginal effect of funding for these specific diseases.

The identification of the cost-effectiveness of the veterinary programmes on the distance to the target relies on the quality of the data/information on contextual factors collected and introduced in the estimation. The panel nature of the evaluation (region, disease and time variations) allows introducing time, disease and country fixed effects to control for any unobservable heterogeneity.

[35] The EC defines the target as a number of cases or outbreaks depending on the disease as defined in WD SANTE/2017/10186.

Box 7: Estimation results of case study 2 using simulated data

PLEASE NOTE THAT THE RESULTS HEREIN PRESENTED DO NOT REFLECT REALITY AND ARE USED FOR ILLUSTRATION PURPOSES ONLY.

The analysis considers the econometric methodology as proposed in section 5.3, which is reported below for the reader's convenience.

To compute the MCER of case study 2, the following equations are estimated:

$$Cost_{ijt} = \alpha_0 + \alpha_1 T_{ijt} + X_{ijt}\beta + \epsilon_{ijt},$$

$$Effectiveness_{ijt} = \gamma_0 + \gamma_1 T_{ijt} + X_{ijt}\beta + \epsilon_{ijt},$$

The net benefit regression (NBR) to be estimated for region *i*, disease *j* and year *t* is:

$$nb_{\mathrm{ijt}} = \delta_0 + \delta_1 T_{ijt} + X_{it}\beta + \epsilon_{ijt},$$

In this specific setting, each term of the regression equation is defined as follows.

where $Cost_{ijt}$ is defined as the total funding received by each region in a given year for a given disease and the $Effectiveness_{ijt}$ is measured as the distance from the target for each disease. In the general case we consider a dummy variable that takes value 1 if the target was reached in a given region, a given year and for a given disease, and 0 otherwise.

T_{it} is a variable that takes value 1 if the NUTS region has received funding for the veterinary programme in a given year for a given disease and value 0 otherwise.

X_{it} is a set that contains the following variables:

— Standard output (agricultural sector) for each NUTS region and each year,

— GDP for each NUTS region and each year,

— Number of farms for each NUTS region and each year,

— Number of outbreaks in the previous year for each NUTS region, each disease and each year,

— National funding that is not related to EU funding for each country and each year,

— Whether the region has received funding for the National veterinary programme in the previous year for each NUTS region, each disease and each year,

— A country fixed effect,

— A disease fixed effect,

— A year fixed effect.

nb_{ijt} is a measure that encompasses the Net Monetary Benefit of the control programme and corresponds to the general formula described in section 1.3:

$$WTP * \Delta E - \Delta C$$

This is computed as the difference between the willingness to pay (WTP) parameter multiplied by the effectiveness of the veterinary programmes measured as the distance from the target set by the Commission (as defined in WD SANTE/2017/10186) in a given region and a given year for each disease and the cost of the intervention in terms of EU funding spent on the veterinary programme.

Based on the simulated data (from which an extract is presented in Annex 2), the marginal effectiveness ratio (MCER) is:

$$\text{MCER} = \frac{\Delta C}{\Delta E} = \frac{\alpha_1}{\gamma_1} = \frac{40166}{10} = 4\,016.60$$

The additional cost of a ten percentage point increase in effectiveness measured as the reduction in the distance from the target is 40 166 EUR on average per year, region and disease.

Figure 2 displays the cost-effectiveness plane to represent the uncertainty of this MCER using bootstrapping with 1,000 iterations. Figure 2 shows the points are located in the quadrant I (cf. Chapter 1), indicating that the increase in EU Funding produces an increase in effectiveness (i.e. a reduction in the distance to the target).

In this area there is a trade-off between effect and cost: a reduction of the number of cases can be obtained but at higher cost. The question which then arises is whether or not the trade-off is acceptable, i.e. whether the effectiveness gain is worth the additional cost. This decision is based on the MCER and what the decision-makers are willing to pay for the additional effectiveness, i.e. the Willingness to Pay (WTP).

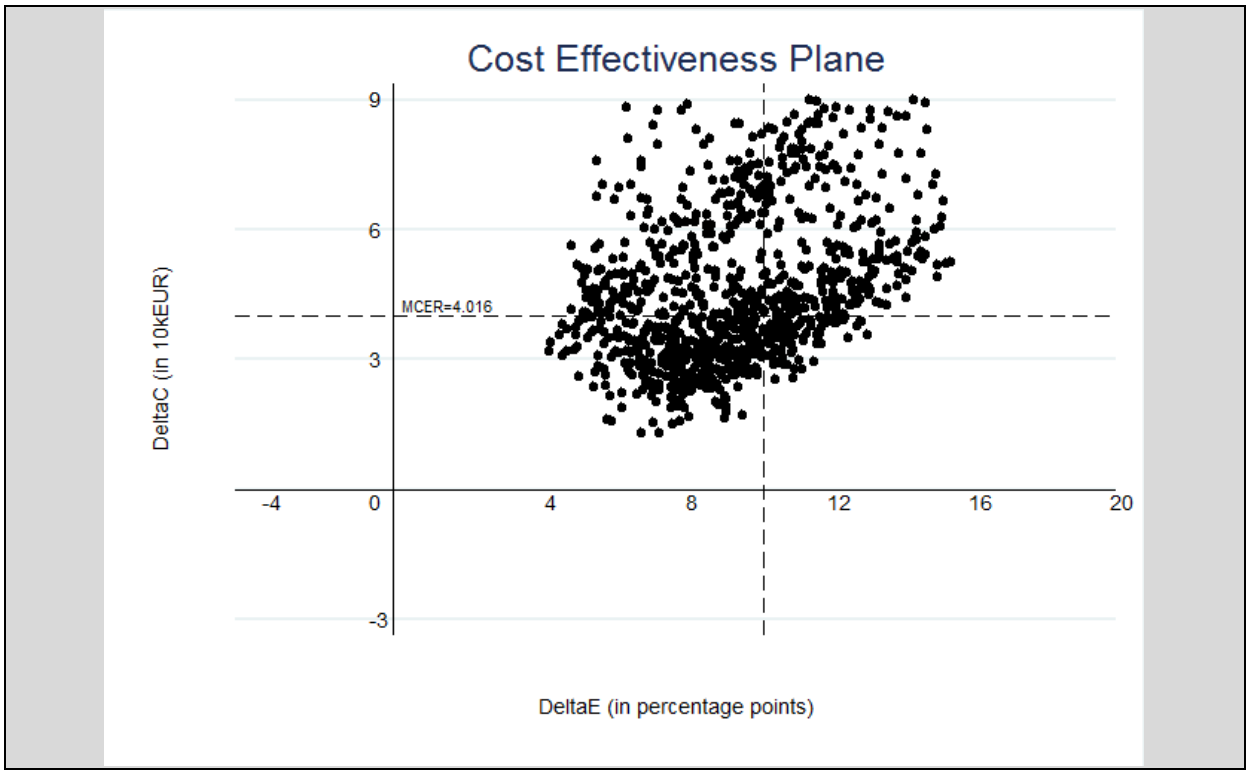
Figure 3 reports the estimates of the Net Benefit Regression showing the increase in effectiveness for different values of WTP.

The above ratio measures an overall MCER for all the listed diseases combined. Nonetheless, one can also run similar regressions separately for each disease (i.e. on a sub-sample of the one considered above) to calculate the MCER for each disease. Note that this is only feasible provided that there is a reasonable number of an observation.

For example, in the case of a single disease (e.g. ASF), the marginal effectiveness ratio is $\text{MCER} = \frac{\Delta C}{\Delta E} = \frac{\alpha_1}{\gamma_1} = \frac{31292}{10} = 3129.20$

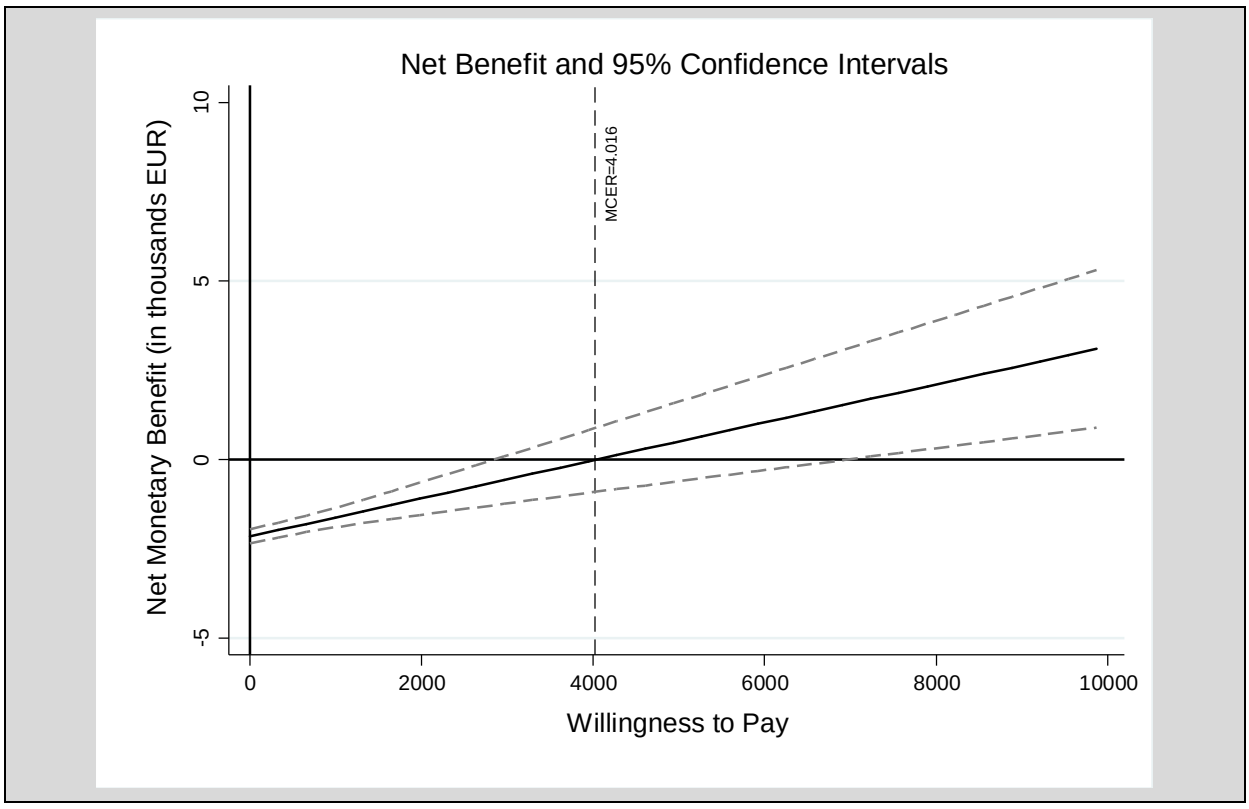
In this case, the additional cost of a ten-percentage point reduction in the distance from the target set by the Commission for ASF is 31292 EUR per year per region.

Figure 3 – The cost-effectiveness plane for the veterinary programme in Animal Health



Source: Average marginal cost-effectiveness estimates for O&CB, ASF, rabies, CBSE, ZS, CSF. Authors' own estimations based on simulated data

Figure 4 – Net Benefit for the National veterinary programme in Animal Health



Source: Authors' own estimations based on simulated data

7.3 Case study 3

Study question: what is the cost-effectiveness of the spending in plant health emergency measures?

Motivation: Plant pest outbreaks are a constant threat in the EU territory. There are many possible sources including exposure to infected neighbouring third countries. Cost-effectiveness of emergency measures for pests occurring in the EU territory is relevant when assessing its efficacy but also when evaluating relevant indirect impacts for farmers in Europe.

Interventions: Tracing the different intensities of emergency measures in EU regions over time.

CER method: Marginal CER interpretation of the ICER as the intervention is the same overtime.

Scope: The observational units are the regions under emergency measures.

Follow-up time: will depend on the disease characteristics, but control for past outbreaks, two CFF funding periods should be covered.

Outcome variable:

a. Indicator variable of whether the eradication programme was successful (Result Indicator).

b. Productivity indicator (Impact indicator)

Control variables:

a. Type of disease; year of first outbreak; number of secondary outbreaks; MS identifier; existence (or/and amount) of national funded actions to eradicate diseases complementary to the EU-funding;

b. Average size farm, capital intensity, MS identifier etc.

Cost perspective: It matters to consider the analysis not only at the EU level, but also MS and farmer

Selection issue: Emergency measures co-fund measures once an outbreak as occurred and timely action has been taken. It is not reasonable to assume that regions infected do not apply for co-funding.

List of abbreviations

ACER	Average Cost-Effectiveness Ratio
AH	Animal Health
AI	Avian Influenza
ASF	African Swine Fever
BD	Bluetongue Disease
BSE	Bovine Spongiform Encephalopathy
BT	Bovine Tuberculosis
BTSF	Better Training for Safer Food
BTV	Bluetongue Virus
BTV8	Bluetongue Virus Serotype 8
CBA	Cost Benefit Analysis
CBSE	Classical BSE
CEA	Cost Effectiveness Analysis
CFF	Common Financial Framework
CIE	Counterfactual Impact Evaluation
CS	Classical Scrapie
CSF	Classical Swine Fever
DALY	Disability Adjusted Life Years
DiD	Difference in Difference
EURL	European Union Reference Laboratory
FADN	Farm Accountancy Data Network
FCA	Food Chain Area
FMD	Foot-and-Mouth Disease
HO	Harmful Organism
HPAI	Highly Pathogenic Avian Influenza
ICER	Incremental Cost-Effectiveness Ratio
LSD	Lumpy Skin Disease
MCER	Marginal Cost-Effectiveness Ratio
MS	Member State
NKO	Not Known to Occur
NLD	Not Listed in Directive
NMB	Net Monetary Benefit
NRL	National Reference Laboratory
O&CB	Ovine and Caprine Brucellosis
OC	Official Controls
OIE	World Organisation for Animal Health

OOP	Out-of-pocket
PH	Plant Health
PPR	Peste des Petits Ruminants
PT	Proficiency Tests
QALY	Quality Adjusted Life Years
RCT	Randomised Control Trials
RDD	Regression Discontinuity Design
S&GP	Sheep and Goat Pox
SP	Survey Programme
STM	Sustained Training Missions
BB	Bovine Brucellosis
WD	Working Document
WP	Working Programme
WTO	World Trade Organisation
WTP	Willingness to Pay
ZS	Zoonotic Salmonella

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Annexes

Annex 1. Literature Review on the cost of outbreaks

Introduction

In many countries, agricultural and livestock sectors play a fundamental role in the national economy as food production is a source of valuable income, employment and international trade. Outbreaks of diseases affecting animals and plants are therefore a source of considerable concern due to the magnitude and variety of economic impacts that they could entail.

Cases of Bovine spongiform encephalopathy have been detected, for example, in the United Kingdom in 1996/1997 when a total of 6,271 animals have been slaughtered as well as in Germany with a total of 413 BSE cases confirmed from November 2000 onwards. The Netherlands has been hit by Classical Swine Fever (CSF) in 1997/1998 for a period of eighteen months and a total of 11 million animals slaughtered. Foot and Mouth Disease (FMD) has infected over 0.7 million animals in United Kingdom in 2001 and 6.24 million have been slaughtered (FAO, 2002). In August 2006, North-Western Europe's first Bluetongue virus serotype 8 (BTV8) outbreak was detected in the Netherlands. Finally, according to FAO (2008), the year 2006 was identified as the 'peak' of the highly pathogenic avian influenza (HPAI) H5N1 with 60 countries reporting outbreaks. The total number of confirmed human cases was 115 of which 79 were fatal (WHO, 2015). For what concerns plant pests, since October 2013 Xylella Fastidiosa has caused large economic damages to the olive oil industry in Apulia (Italy).

Large scale outbreaks of animal diseases and plant pests can be extremely costly. As stated by Bennett (2003), the consequences of diseases are not limited to the direct economic losses but extend also to indirect impacts. The former category should include the reduction in the level of marketable outputs, a reduction in output quality, a waste of inputs and resource costs associated with disease prevention and control. The latter category accounts for human health costs associated with diseases or disease control, negative animal welfare impacts and international trade restrictions due to disease and its control. Furthermore, diseases outbreaks may have economic consequences even in other sectors of the economic system. For example, the outbreak of Foot and Mouth Disease in the UK in 2001 affected not only residents of rural areas but also other UK residents who could not visit rural areas because of the implementation of a temporary policy that limited access to them. Moreover, the touristic sector was affected as well because foreign tourists who considered the UK as a potential destination were prevented from visiting rural areas.

This chapter aims at providing a review of the literature about the economic costs of diseases outbreaks. The literature on the costs of outbreaks in the food chain area is rather scant. Pritchett et al. (2005) reviewed the literature on the economic impacts of animal diseases by distinguishing the studies according to the level of analysis, ranging from the individual producer level to the national level. Morgan and Prakash (2006) reviewed the factors and trends underpinning the growth in meat trade over the past decade and assess the impact of animal diseases on international markets. Rushton and Lyons (2015) described the most relevant contributions in the extant literature on production related losses due to Bluetongue. By focusing on methodological approaches, Gethmann et al. (2015) presented a brief overview of the methods used to retrospectively analyse the economic impact of two particular relevant diseases in Germany in the last few years: Bluetongue disease and Bovine Spongiform Encephalopathy. Finally, Ward (2016) reviews some past pest outbreaks by focusing on the variation in the costs depending on the timing of the intervention. According to the authors, visible symptoms lag behind the arrival of a pest in a new area and noticeable damage lags behind early symptoms. Hence, diagnosis and awareness tend to appear

sometime after the damage. Furthermore, the less evident the damage, the lower the willingness of the stakeholder to spend on measures. The progression may take several years during the course of which the actual benefit to cost ratio of any action is likely to decline. As a pest spreads the cost of measures tends to increase in proportion to the area infected, and the likelihood of successful eradication or containment falls rapidly. Political willingness to commit resources therefore increases just as the cost effectiveness of doing so becomes more doubtful.

Our review differs from previous reviews in a number of ways: first, it focuses on both direct and indirect costs; second, it is not limited to a specific type of plant or animal disease; third, it covers a long period of time (from 1997 to 2017); fourth, it does not consider outbreaks in a single country but extends to the whole Europe, North America and Australia. Reviewed studies have been categorised according to: the kind of disease, the typology of economic costs involved in the analysis and the methodological approach used to estimate economic impacts, i.e. deterministic or simulation approach.

The rest of the chapter is organized as follows. The next section describes the methodology used for the identification of relevant studies. Then, the results of the literature review are presented and discussed on the basis of the typology of the costs, the factors determining the magnitude of the impacts and the methodological approach. Finally, the last section concludes.

Methodology

a. Search Strategy

The literature search aimed at identifying studies dealing with the evaluation of economic costs of plant and animal disease outbreaks. The following databases have been searched in July 2017 from their inception dates to present: Scopus, Google Scholar, and Pubsy.

Searches are designed to identify studies on costs of plant and animal diseases outbreaks in Europe, North America and Australia from 1997 onwards. The search has been conducted by combining the concepts of 'animal disease' or 'plant pest' and 'outbreak' or 'crisis' with the concepts of 'cost analysis', 'cost evaluation', 'economic impact'. Full details of the search strategy for Scopus database is presented in the Additional Material and full search strategies for all databases are available from the authors upon request. Bibliographies of included studies were also searched for relevant studies.

b. Inclusion Criteria

To be eligible for inclusion studies had to evaluate economic costs of either food or veterinary or phytosanitary crisis. Only studies where the impact of an outbreak was measured in terms of economic costs were selected for full review.

Studies that reported qualitative data, literature reviews, studies that lacked quantitative data, studies in countries different from Europe, North America and Australia as well as studies written in a language other than English were excluded.

Moreover, studies that evaluated the cost-effectiveness of alternative control strategies for the eradication of the disease were excluded, as the main focus of the review was to analyse the direct and indirect costs of outbreaks.

The focus is on specific diseases for which outbreaks have been observed in recent decades across the countries of interest (e.g. Avian Influenza, Bovine Spongiform encephalopathy, Foot-and Mouth Disease, Classical Swine Fever, Bluetongue and Foot and Mouth Disease).

Finally, only studies referred to outbreaks that occurred in the period 1997-2017 were considered.

c. Data collection and analysis

To select studies for the review, titles and abstracts were screened using the above inclusion criteria and this process was managed using the Mendeley software. When the decision to include or exclude a study was not straightforward, a second reviewer was consulted to resolve uncertainty. The detailed process of articles selection is presented in a PRISMA chart in the Additional Material (Liberati et al., 2009).

Once the included studies were identified, data were extracted using a data extraction form developed for this purpose. For each study the following information have been selected: type of disease, analysed country, and methodological approach of the paper, description of either the outbreak or the simulated scenarios, type of costs considered in the analysis and main results. Due to the substantial differences in interventions, setting, disease area, and sample, a meta-analysis was not conducted. Instead, a narrative summary of the included studies is presented below.

Results

a. Methodological approaches

From a methodological point of view, papers estimating economic costs of diseases outbreaks may be divided into those dealing with real outbreaks and simulation studies. The former category encompasses those studies looking at the economic costs of outbreaks that took place between 1997 and 2007 either in North America or Europe or Australia. On the contrary, the latter group of papers simulate the occurrence of an outbreak and estimate its potential consequences. The results show that 21 studies focus on real outbreaks while the remaining 14 are simulation analysis.

Specific outbreaks that have received more attention are the Foot-and-Mouth Disease in the United Kingdom in 2001 (3 studies) and the 1999 Xylella Fastidiosa epidemic in California (2 studies). The diseases with the highest number of reviewed outbreaks are the Bovine Spongiforme Encephalophaty and the Salmonella while the country where the highest number of reviewed outbreaks occurred is the United Kingdom, with the 2001 Foot-and-Mouth Disease, the 1996/1997 and 2000 Bovine Spongiforme Encephalophaty, the 1998 Bovine Tuberculosis, the 2010-2015 Avian Influenza and the 1999 Salmonella outbreaks.

For what concerns simulation studies, five out of fourteen deal with human influenza pandemic potentially caused by avian influenza while other two assess its economic costs without assuming human contagion. Simulation studies then concentrate on potential African and Classical Swine Fever (CSF) outbreaks as well as on hypothetical Foot-and-Mouth Disease episodes. Papers adopting this methodological framework are well distributed over geographical areas of interest and one of them provides worldwide estimates.

b. Typology of costs

Outbreaks of animal diseases are likely to have negative consequences on the economic system. Generally speaking, total economic costs may be calculated as the sum of direct and indirect costs. The former category represents the loss of profitability of the production system while the latter encompasses both the costs associated to disease controls as well as the impact on sectors other than the agricultural one (Rushton, 2009 and Dijkhuizen and Morris, 1996).

Direct costs may be evaluated at the farm level. According to Bennet (2003), direct costs consist of two components: losses and expenditures. On the one hand, the value of the

loss in expected output accounts for both the visible effect of the disease on livestock outputs as well as for the invisible production losses. The former includes, among the others, milk yields reduction, wool production decrease, animals' infertility and mortality; the latter refers, for example, to the delay in the sale of animals. On the other hand, the presence of an outbreak may increase expenditures on non-veterinary sources, such as feed and farm labour, and may require a larger amount of resources to be spent on disease treatment (to mitigate the consequences of disease after infection) as well as on prevention measures (to prevent further occurrence of the infection). Hence, direct costs represent the variation in gross margins following the outbreak. The difference between change in output and change in variable costs (in both cases with respect to "business as usual") indicates the response in terms of profitability to a shock to the production system (Gethmann et al., 2015).

The assessment of the economic importance of diseases usually follows the works by Bennet et al. (1999) and Bennet (2003). The authors focus only on direct costs associated with a disease, defined as the value of the loss in expected output and/or of resource wastage due to the disease, together with the treatment costs incurred in trying to mitigate the effects of disease on production and the costs associated with specific disease prevention. A standardized methodology is applied to the estimation of the direct costs associated with each disease and a spreadsheet model is used to enable a transparent financial estimation of the direct costs whilst still providing a realistic representation of the impact of each disease on production.

According to Bennet et al. (1999) and Bennet (2003), direct costs (C) are defined as:

$$C = L + T + P,$$

where L is the value of the loss in expected output and/or of resource wastage due to the disease, T are the treatment costs incurred in trying to mitigate the effects of disease on production and P are the costs associated with specific disease prevention.

The methodology to estimate direct disease cost involves:

1. Identification of the livestock populations at risk and the production systems affected and estimation of the incidence or prevalence of each disease in these populations.
2. Identification of the range and incidence of physical effects of each disease on the production systems affected (i.e. compared to what might be expected without the disease being present).
3. Valuation of the physical effects of each disease on production.
4. Estimation of the value of the direct disease losses to livestock production due to the disease.
5. Identification of the treatment measures undertaken for each disease and estimation of treatment costs incurred due to the disease.
6. Identification of specific prophylactic measures for each disease and estimation of the costs incurred in undertaking those measures.

Using this approach, a simple spreadsheet model was constructed for each disease which estimated the components of the direct cost measure defined above where:

$L = p\, i_d i_e e\, v_i$	for each disease effect
$T = p\, i_t v_t$	for each type of disease treatment
$P = p\, i_p v_p$	for each type of disease prevention

Here, p is the size of the livestock population at risk, i_d the annual incidence of disease as a proportion of the population at risk, i_e the incidence of disease effects as a proportion of

the affected population, e the magnitude of physical disease effects, v_i the unit value of lost output or resource wastage, i_t the proportion of the population at risk treated, v_t the cost of treatment per animal, i_p the proportion of the population at risk where prevention measure is taken, and v_p the cost of prevention measure per animal.

Disease outbreaks may also have indirect costs that accrue at the regional, country or EU level. On the one hand, indirect costs are related to the set of measures taken to prevent, diagnose and control the disease through compulsory vaccination programmes, insecticide treatment, epidemiological investigations, culling, monitoring/surveillance and removal of specified risk materials. On the other hand, indirect costs may refer to the economic impact of the outbreak on national markets due to change in domestic consumer perception as well as to export losses due to international trade restrictions. In particular, the international market of a specific good may experience change in price, shift of market shares between exporters and a variation in consumption from that good to a substitute. Moreover, other sectors of the economic system may be affected by disease outbreaks. The 2001 Foot-and-Mouth disease outbreak in the United Kingdom has shown how tourism and recreational activities are the most prone to suffer economic losses mainly because of restrictions access to the countryside (Blake et al., 2014). Finally, other indirect costs include human health costs associated with diseases or disease control, negative animal welfare impacts associated with the disease and increase need for research.

Direct economic costs have been evaluated by a high number of papers: nine out of twenty-one among the studies analysing the economic consequences of a real outbreak and six out of nine among the studies evaluating the potential impact of simulated animal or plants diseases. Two studies look only at eradication programmes costs.

Indirect economic costs may be differentiated into a variety of sub-categories. First of all, animals or plants diseases outbreaks may have an impact on the overall GDP, which accounts for both direct economic costs and for the costs to the other sectors of the economy. Three papers out of the twenty-one analysing the economic consequences of a real outbreak estimate the overall GDP impact while all the papers simulating an influenza pandemic report the figure. Similarly, two studies among those dealing with simulated outbreaks of animals or plants diseases evaluate the variation in total welfare calculated as total discounted economic gains and losses and cost to producer, consumer and government over a certain period of time following the outbreak.

Secondly, outbreaks may affect international markets. On the one hand, animals or plants diseases outbreak are likely to decrease product's demand because consumer confidence decreases; on the other hand, export bans are usually applied to those countries experiencing the outbreak. Reduction in demand for exports and fall in export prices have been analysed by nine papers in total.

Finally, indirect costs may be disease specific. For example, all the three papers dealing with the 2001 FMD outbreak in the UK provide estimates on reduction of tourism expenditures. The reduction in this kind of recreational activity may happen because of access restrictions to affected areas and because people themselves prefer not to visit regions where the disease is spreading. Other types of diseases, e.g. salmonella and rabies, may entail health costs, which have been estimated by three papers among those selected for the review.

c. Cost estimates

In the table that follows (Table A), a summary of the selected papers is presented, which are classified by typology of costs analysed. The information in the table includes the estimated costs and whether the study is based on a real or simulated scenario.

Table A: Classification of studies by typology of costs and results

	Outbreak / Scenario	Real / Simulated Outbreak	Direct Impacts	GDP	Welfare	International Mkts	Tourism	Eradication	Health
Thompson et al. (2002)	FMD, UK in 2001	Real	£3.1 billion				£2.7-£3.2 billion		
Blake et al. (2014)	FMD, UK in 2001	Real		£2.1-£2.6 billion			£6.7-£8.8 billion		
Royal Society of Edinburgh (2002)	FMD, Scotland in 2001	Real		£2.4 billion			£200-£250 million (Scotland)		
Atkinson (1999)	BSE, UK in 1996/1997	Real		£1 billion		£1.5 billion			
Mathews et al. (2003)	BSE, UK in 2000	Real				Exports decline: 30%-40%			
Park et al. (2006)	BSE, US in 2003	Real				Demand loss: $4.6 million			
Velthius et al. (2015)	BTV, Netherlands in 2006/2007	Real	107€-134€ million						
Gethmann et al. (2015)	BTV, Germany in 2006-2011	Real	200€ million						
Bennett and Cooke (2006)	BT, UK in 1998-2000	Real	£18,000 per farm						
Caminiti et al. (2016)	BT, Italy in 2007-2011	Real						19€ million	
Mazzocchi et al. (2007)	AI, various countries in 2005	Real				Imports decline: 10%			
Siettou (2016)	AI, UK in 2010-2015	Real				No variation			
Meuwissen et al. (1999)	CSF, Netherlands in 1997/1998	Real	2.4 billion						

Damaso and Rushton (2017)	Salmonella, Wales in 1999/2001	Real	£19,000 per farm						
Ailes et al. (2013)	Salmonella, City of Alamosa, Colorado in 2008	Real							$2.6 million
Suijkerbuijk et al. (2016)	Salmonella, Netherlands in 2012/2013	Real							€ 1.9 million
Shwiff et al. (2007)	Rabies, California in 1998-2002	Real							$3.7 thousand per case
Sartore et al. (2017)	Rabies, Italy in 2009/2016	Real						€4.7 million	
Siebert (2001)	PD, California in 1999	Real	$37.9 million						
Tumber et al. (2014)	PD, California in 1999-2010	Real	$104.4 million						
Sardaro et al. (2015)	PD, Italy (Puglia) in 2013	Real	€104 per tree (medium firm)						
CBO (2005)	Influenza Pandemic, US	Simulated		-1.5%					
James & Sargent (2006)	Influenza Pandemic, CAN	Simulated		-0.4%					
McKibbin & Sidorenko (2006)	Influenza Pandemic, World	Simulated		-1.5%					
Kennedy et al. (2006)	Influenza Pandemic, AUS	Simulated		-9.3%					
Jonung & Röger (2006)	Influenza Pandemic, EU	Simulated		-1.6%					
Morgan and Prakash (2006)	AI, EU	Simulated				Price: +10%			

Djunaidi & Djunaidi (2007)	AI, US	Simulated				Price: +10%			
Halasa et al. (2016a)	ASF, Denmark	Simulated	€12 million			€350 million			
Garner et al. (2001)	CSF, AUS	Simulated	€15-25 million			$35 million			
Scottish Government (2008)	BTV, Scotland	Simulated	£30 million			£70 million			
Tozer et al. (2015)	FMD, CAN	Simulated			$26.4 billion in 30 years				
Paarlberg et al. (2002)	FMD, US	Simulated	$14 billion						
Brown & Spreen (2000)	Citrus Tristeza Virus, US	Simulated	Production reduction: 30%			Price increase: 80%-90%			
Soliman et al. (2012)	Pine Wood Nematode, EU	Simulated	€22 billion		€218 million in 2030				

Discussion

Comparison of estimates per typology of costs turns out to be a complex task due to the fact that numerous diseases have been considered and different countries have been involved in the analysis. Hence, the discussion will be limited to those studies for which it exists a term of comparison.

Direct economic impacts of 2006 BTV outbreak seem to have been consistently estimated by Velthius et al. (2015) and Gethmann et al. (2015) for Netherlands and Germany, respectively. As a matter of fact, costs are around 130€ million in the first case and 200€ million in the second case with the difference accounting for the spread of the disease. Lower estimates, i.e. £30 million, are reported for a simulated outbreak in Scotland by the Scottish Government (2008) report. For what concerns the spread of Pierce's disease in California in 1999, Siebert (2001) indicates a total loss of $37.9 million while Tumber et al. (2014) estimates are about $104.4 million. The higher figure provided by the latter is due to the fact that the authors consider the costs of vine losses, industry assessments, compliance costs, and expenditures by government entities while Siebert (2001) only accounts for replanting entire vineyards and vineyard management.

For what concerns GDP impact of the 2001 FMD outbreak in the UK, both Blake et al. (2014) and the Royal Society of Edinburgh (2002) report a reduction in GDP in the range of £2.1-£2.6 billion. Consistent estimates of GDP decrease are provided by those studies simulating an influenza pandemic. CBO (2005) for the US, James & Sargent (2006) for Canada, Jonung & Röger (2006) for EU and McKibbin & Sidorenko (2006) for the world argue that the drop in GDP may vary between 0.5% and 1.5%. Higher values are reported by Kennedy et al. (2006) for a possible pandemic in Australia.

By looking at those studies evaluating the impact of diseases outbreaks on international markets, both Morgan and Prakash (2006) and Djunaidi & Djunaidi (2007) estimate an increase in poultry price of about 10% for EU and US, respectively. In general, the only study that seems not to be in line with all the others is the paper by Siettou (2016) who finds no association between poultry consumption and AI occurrence both within the UK territory and elsewhere in the world. The author himself suggests that the figures may in part be due to the fact that the studied outbreak was very small in magnitude and rapidly confined. Therefore, the result should be further tested, and outcomes of the paper must be taken with caution.

For what concerns tourism expenditures, Thompson et al. (2002) and Blake et al. (2014) estimates a reduction of about £2.7-£3.2 billion and £6.7-£8.8 billion, respectively. The study of Thompson et al. (2002) has been subjected to serious data limitations; therefore, the analysis draws heavily on attitudinal data and a series of assumptions. On the other hand, Blake et al. (2014) adopt a Computable General Equilibrium model to estimate the effect on tourism. The reduction in international tourism receipts by region is calculated in the model by multiplying the international tourism receipts in each region for the "without-FMD" case by the percentage change in international receipts attributed to FMD in the UK as a whole.

Finally, health costs of a Salmonella outbreak are similar for Ailes et al. (2013) and for Suijkerbuijk et al. (2016). The former estimates a cost of $2.6 million for the City of Alamosa, Colorado while the latter argue that health costs of the 2012/2013 Salmonella outbreak in the Netherlands is about €1.9 million.

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Additional materials

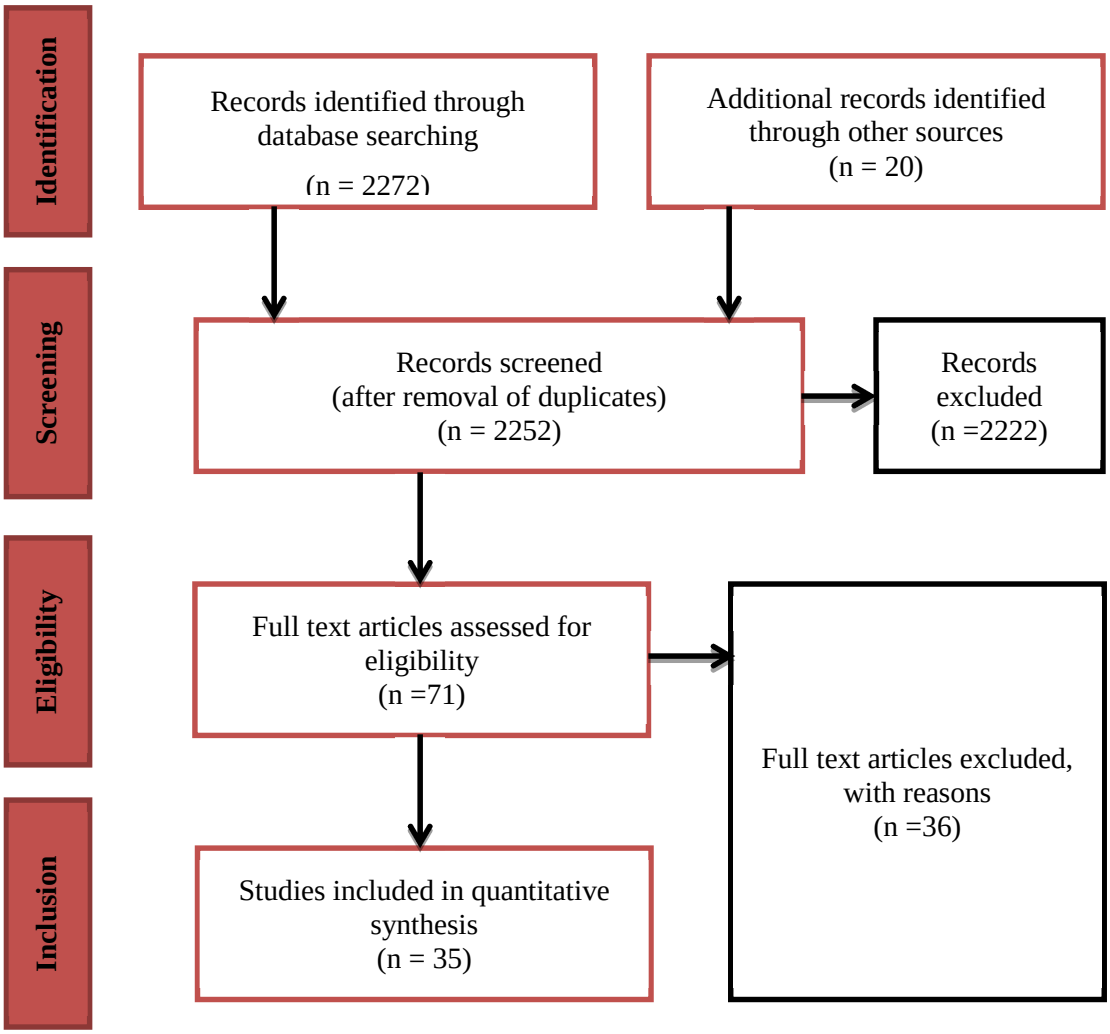
Search Strategy for Scopus (Keywords)

Cost analysis; Cost evaluation; Cost study; Cost of non-action; Indirect costs; Direct costs; Trade losses; Trade costs; Price; Farm productivity; Exports; Revenue farmers; Income farmers; Market losses; Economic Impact; Impact evaluation; Impact assessment.

AND

Outbreak; Crisis; Eradication; Zoonoses; Emergency measures; Pests; Prevention; Outer rest regions; Food crises; Veterinary crises; Phytosanitary crises; Rinderpest cattle plague; Sheep and goat plague; Swine vesicular disease; Bluetongue; Teschen disease; Sheep pox or goat pox; Rift Valley fever; Lumpy skin disease; African horse sickness; Vesicular stomatitis; Venezuelan equine viral encephalomyelitis; Haemorrhagic disease of deer; Classical swine fever; Rabies; Transmissible Spongiform Encephalopathies; African swine fever; Contagious bovine pleuropneumonia; Avian influenza; Newcastle disease; Foot-and-mouth disease; Epizootic haematopoietic necrosis in fish (EHN); Epizootic ulcerative syndrome in fish (EUS); Infection with Bonamia exitiosa; Infection with Perkinsus marinus; Infection with Microcytos mackini; Taura syndrome in crustaceans; Yellowhead disease in crustaceans; Plant pests; Bursaphelenchus xylophilus; Anoplophora chinensis; Anoplophora glabripennis; Pomacea insularum; Pomacea maculata; Ralstonia Solanacearum; Xylella fastidiosa; Citrus Tristeza virus; giant applesnail; island applesnail; applesnail; pine wood nematode; pine wilt nematode; pine wilt; citrus long-horned beetle; long-horned beetle; Asian long-horned beetle; starry sky; sky beetle; olive quick decline syndrome; phoney peach disease; bacterial leaf scorch; oleander leaf scorch; Pierce's disease; citrus variegated chlorosis disease.

Flow diagram of excluded and included studies



Annex 2. Example of dataset

countrycode	regcode	year	diseasecode	Treated	status	EUFund	GDP	NLiveStock	NFarm	Farm_area	Agr_area	NOutBreaks
1	10	2012	4	1	1	6997.92	372538.8	4254	13	515	513	2
1	10	2012	5	1	1	3463	372538.8	4254	13	515	513	2
1	10	2012	6	1	1	3446.41	372538.8	4254	13	515	513	2
1	11	2007	1	1	0	4199.46	360715.1	4340	20	310	300	3
1	11	2007	2	1	0	855.567	360715.1	4340	20	310	300	3
1	11	2007	3	1	1	10880.7	360715.1	4340	20	310	300	1
1	11	2007	4	1	0	8261.77	360715.1	4340	20	310	300	3
1	11	2007	5	1	0	4088.43	360715.1	4340	20	310	300	3
1	11	2007	6	1	0	4068.84	360715.1	4340	20	310	300	3
1	11	2008	1	1	0	4159.53	363540.2	4972	20	428	418	2
1	11	2008	2	1	0	847.432	363540.2	4972	20	428	418	2
1	11	2008	3	1	1	10777.3	363540.2	4972	20	428	418	1
1	11	2008	4	1	0	8183.22	363540.2	4972	20	428	418	2
1	11	2008	5	1	0	4049.56	363540.2	4972	20	428	418	2
1	11	2008	6	1	0	4030.15	363540.2	4972	20	428	418	2
1	11	2009	1	1	0	4094.72	355349	5295	20	488	478	2
1	11	2009	2	1	0	834.228	355349	5295	20	488	478	2
1	11	2009	3	1	1	10609.3	355349	5295	20	488	478	1
1	11	2009	4	1	0	8055.71	355349	5295	20	488	478	2
1	11	2009	5	1	1	3986.46	355349	5295	20	488	478	1
1	11	2009	6	1	0	3967.36	355349	5295	20	488	478	2
1	11	2010	1	1	0	3989.5	365100.5	5570	20	540	530	2
1	11	2010	2	1	0	812.792	365100.5	5570	20	540	530	2
1	11	2010	3	1	1	10336.7	365100.5	5570	20	540	530	1
1	11	2010	4	1	0	7848.71	365100.5	5570	20	540	530	2
1	11	2010	5	1	1	3884.03	365100.5	5570	20	540	530	1
1	11	2010	6	1	0	3865.41	365100.5	5570	20	540	530	2
1	11	2011	1	1	1	3742.12	371666.1	4723	15	581	539	2
1	11	2011	2	1	1	762.391	371666.1	4723	15	581	539	2
1	11	2011	3	1	1	9695.75	371666.1	4723	15	581	539	1
1	11	2011	4	1	1	7362.02	371666.1	4723	15	581	539	2
1	11	2011	5	1	1	3643.18	371666.1	4723	15	581	539	1
1	11	2011	6	1	1	3625.72	371666.1	4723	15	581	539	2
2	1	2007	1	0	0	5678.58	36911.6	30370	8850	3240	2370	5
2	1	2007	2	0	0	1156.91	36911.6	30370	8850	3240	2370	5
2	1	2007	3	0	0	14713.1	36911.6	30370	8850	3240	2370	5
2	1	2007	4	0	0	11171.7	36911.6	30370	8850	3240	2370	5
2	1	2007	5	0	0	5528.45	36911.6	30370	8850	3240	2370	5
2	1	2007	6	0	0	5501.96	36911.6	30370	8850	3240	2370	5
2	1	2008	1	0	0	5590.85	39134.3	29388	5766	2293	1627	4
2	1	2008	2	0	0	1139.04	39134.3	29388	5766	2293	1627	4
2	1	2008	3	0	0	14485.8	39134.3	29388	5766	2293	1627	4

Description of the variables in the dataset:

- countrycode — Country identifier
- regcode — NUTS2 region identifier
- diseasecode — disease identifier
- Treated — Receives EU funding
- status — Disease Status (1=not free, 0=free)
- EUFund — EU Funding received
- GDP — National GDP (in 2010 mln EUR)
- NLiveStock — Livestock units in farms
- NFarm — Number of farms
- Farm_area — Farm Area (in hectares)
- Agr_area — Agricultural Area (in hectares)
- NOutBreaks — Number of Secondary Outbreaks

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