Wageningen University – Department of Social Sciences

MSc Thesis Business Economics

Unconventional risks in free-range meats: legal perspectives and economic performance

September 2014

Applied Food Safety **Majed AlMuhanna**

Supervisors:

Alessandro Bonanno **Business Economics Group (WUR-BEC)**

Harry Bremmers **Law and Governance Group (WUR-LAW)**

BEC-80436

Acknowledgements

First of all, I would like to thank my supervisors Alessandro Bonanno and Harry Bremmers. Second, I would like to thank my family, friends, colleagues and roommates for their support during my master thesis.

Alessandro Bonanno was my main supervisor and was always willing to help and take time for me. Alessandro, thank you so much for your help, your critical questions, and patience. All his support and understanding have contributed with the accomplishment of this thesis.

Harry Bremmers eas was my co-supervisor and also was willing to help and take time for me. Harry, thank you so much for your encouragement and help for structuring, and for giving me new insights.

Contents

List of tables

List of figures

Abbreviations

- BMEL = Bundesministerium für Ernährung und Landwirtschaft (The German Federal Ministry of Food and Agriculture).
- CFU = Colony Forming Unit.
- EC =European Commission.
- EFSA =European Food Safety Authority.
- EMV = Expected Monetary Values.
- FADN = European Union Farm Accountancy Data Network.
- GFL= General Food Law.
- GMO = Genetically Modified Organism.
- IPR = Intellectual Property Rights.
- NV = Net Value.
- NVWA = De Nederlandse Voedsel- en Warenautoriteit (The Food and Consumer Product Safety Authority of The Netherlands).
- PUFA = Poly Unsaturated Fatty Acids.
- RSPCA = Royal Society for the Prevention of Cruelty to Animals (a leading animal welfare organisation in the United Kingdom).
- UK = United Kingdom.
- WTP = Willingness to Pay.
- YOPI = Young, Old, Pregnant and Immuno-compromised.

1 Abstract

Sustainably-produced and free-range meats are nowadays considered by consumers as 'natural' and safe alternatives to conventional meat, although this form of production is not necessarily safer, as it presents different risks than conventional production systems. Isolates from numerous types of meat show higher prevalence of *Salmonella* and *Campylobacter,* reaching contamination levels of up to two-thirds more than conventional meat products. Furthermore, a number of cases of *Toxoplasma gondii* contaminations were found in free-range chickens, which are not normally present in conventional meat products. Such cases spanned the globe and originated from Austria, Brazil, Ghana, Indonesia, Italy, Poland, Portugal, and other countries. Moreover, 'Bird Flu' (in particular, Influenza A virus, subtype H5N1) can arise and present a potential threat, since there are more chances of contact between wild birds and free-range animals.

Despite the additional risks, certifying bodies mostly adopt similar safety procedures for both free-range and conventional animal farming. From a legal standpoint, specific safety measures concerning sustainable- and free-range production processes for beef, goat, lamb and pork are lacking in Europe. In the case of poultry, local food safety authorities implement animal sampling before slaughter; if tests are positive for *Salmonella* or *Campylobacter*, affected animals will be slaughtered as the last batch before cleaning and disinfection.

The aim of this thesis is to analyse the cost and benefits resulting from free-range certification. It explicitly considers the additional risks that arise from the presence of new sources of contaminants, not yet considered by certifying agencies and/or regulators. The analysis will focus on the trade-off between the additional costs from the risk of contamination and the benefits associated with implementing free-range certification. The benefits of higher selling price, market access, increased demand and cost reductions are compared with risks that may result in an outbreak.

Information was collected from sustainable and free-range production certifiers in The Netherlands, Germany and the UK. It concerned their safety standards, annual cost, and the benefits for the business holding the certification. In addition, safety standards for this type of production were collected from relevant local food safety authorities.

Key words: free-range, unconventional contaminants, certification schemes, decision analysis.

2. Introduction

2.1 General introduction

The global meat market is shifting slowly towards the production of sustainably-produced and free-range meats, because consumers seek out natural products that are free from non-organic compounds (i.e. pesticides and herbicides)(Athanasios Krystallis et al. 2012). Products characterised as 'natural' are generally perceived to be safer (i.e. containing less pesticide- and antibiotic- residues) than those produced by conventional, industrial farming methods, in which the animals are kept indoors (Franklin 2012, Sauvegrain et al. 2012). However, this perception may not be accurate, as non-industrial production techniques can be associated with unconventional risks of higher microbial levels (i.e. higher presence of *Salmonella*, *Campylobacter*, *Toxoplasma gondii* and Influenza A subtype H5N1 ('Bird 'Flu')). When animals are allowed to move freely in their environment, they are exposed to different potential risks, which have been largely eliminated in traditional production during the 20th Century. The main risks, associated with free-range production, are the high presence of microbes, parasitic protozoa and viruses (Kijlstra, Meerburg, and Bos 2009).

Free-range certification schemes began in the 1990s. They evolved as a part of many animal welfare associations' campaigns to engage the regular consumer towards achieving their aim to increase animal welfare in the meat production industry. Moreover, their origins stem from the sustainable production methods that were born in the 1930s from an approach designed by the English Botanist, Sir Albert Howerd, in response to concerns about the increased use of industrial fertilizers and pesticides in agriculture (Kijlstra, Meerburg, and Bos 2009). Today, sustainable production includes three main categories: fair trade, organic and free-range.

2.2 Consumer perspectives

The free-range market is driven by consumers' concerns about sustainable interaction with the environment and the use of natural products. The general perspective of consumers is that sustainably-produced products are more environmentally-friendly, and contribute towards reducing ecological footprint. However, it can be argued that free-range meats are not

environmentally- friendly because large amounts of space are required, which could increase the rate of deforestation (Kijlstra, Meerburg, and Bos 2009).

In addition, free-range meats are produced 'naturally', therefore consumers associate them with quality and health (Athanasios Krystallis et al. 2012, Grunert 2006). Studies have shown that free-range meats do possess positive features compared to conventionally produced meats: positive indicators include high Poly Unsaturated Fatty Acids (PUFA) content, antioxidants and mechanical properties (such as cutting properties) (Nilzén et al. 2001, Bee, Guex, and Herzog 2004, Braghieri et al. 2013). However, free-range meats also possess negative features that are absent in conventionally-produced meats, such as lower water holding capacity. In addition, they have a normal PH value, as compared to conventionally-produced meats (Nilzén et al. 2001).

2.3 What is free-range?

According to the Oxford English Dictionary, 'free-range' refers to *'livestock or their produce kept or produced in natural conditions, where the animals have freedom of movement'* (Stevenson and Waite 2011). According to the United States Department of Agriculture (USDA), free-range '*is the production of a flock with unlimited amount to food, fresh water and outdoor access. However, the outdoor area can have a fence but not to be covered with netting-like material*.' (USDA 2014).

2.4 Free-range legislation

From the perspective of legislation, there are no specific regulations concerning the management of unconventional risks associated with free-range meats. Therefore, meat products that are labelled with free-range certification fall under the European Union's (EU's) General Food Law Article 14 on food safety requirements (EC No 178/2002)[1]. Current EU policies focus only on production methods and cover details, such as the age of the animal at slaughter, the source of animal feed, the use of veterinary drugs and the space allocated to each animal on

[1] Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 that outlines the general principles and requirements of food law, establishment of the European Food Safety Authority and procedures in matters of food safety.

the farm (EC No 543/2008[2]; EC 1234/2007). These policies are currently used as the basis of benchmarking trustworthiness in free-range meat production. The legislation does not specify any special safety measures, beyond the conventional Code of Practice ((EC) No 543/2008). In addition, the policies only apply specifically to poultry production, and laying hens used for egg production.

2.5 Local guidelines

Local legislation in the EU Member States does not cover unconventional microbial risk aspects of free-range meat. There are also no specific guidelines on the slaughter of free-range animals. Guidelines in widespread use originate from the United Kingdom UK, The Netherlands and Germany, through their respective Food Standard Agencies, Institutes of Public Health and Environment and others. Furthermore, no specification was found on slaughtering in the national *Salmonella* program of the UK. However, if testing before slaughter produces results that are positive for *Salmonella* or *Campylobacter*, the animals are slaughtered according to logistic slaughtering guidelines; however there are no clear specific indications for free-range meat production (Cameron 2012). Besides this, the guidelines provide information on what free-range is and how it is produced, with more information on the type of labels in the market and their specifications (NVWA 2014a).

2.6 Organic food legislation

The presence of unconventional microbial risks associated with non-traditional production methods is recognised in the context of organic products, where the risks are considered similar to production of free-range products. In some cases, the prevalence of pathogens is even higher than free-range, because in organic meat production the feed must be grown organically using natural fertilizers, therefore potentially harbouring a higher content of bacteria (Rosenquist et al. 2013). However, European legislation mandates that organic- and non-organic products are maintained separately in all production stages to ensure fulfilment of

[2] Commission Regulation (EC) No 543/2008 of 16 June 2008 that outlines detailed rules for the application of Council Regulation (EC) No 1234/2007 as regards to the marketing standards for poultry meat.

the organic label requirements (Paragraph 1, Article 19 (EC) No 834/2007)[3],with a clear definition of all preparation stages in production (paragraph (I), Article 2 (EC) No 834/2007)[4]. Therefore, cross-contamination with conventional products is avoided. There are no restrictions that limit mixing free-range meats with conventional products. This has implications in the catering business in particular, because meats from free-range production can potentially contaminate conventionally-produced ones, since vegetables grown conventionally have a lower microbial level.

2.7 Certification labels

The certification label is a symbol that represents initiatives run by certain animal welfare or animal- or consumer protection organisations. The certification label usually takes the form of a trademark or goodwill. The schemes usually have their own production standards and criteria, which provide guarantees to consumers about the products they are buying (van der Meulen 2011, van der Meulen and van der Velde 2011). The certification bodies themselves must be certified. This is usually carried out by accreditation bodies that are linked into the local EU Member State Governments, which grant the legal status of certification and its compliance with relevant general food legislation (van der Meulen 2011, van der Meulen and van der Velde 2011, Luning and Marcelis 2011). In this research, focus is on three national certification schemes: Freedom Food (the RSPCA's farm assurance and labelling scheme in the UK), Beter Leven ('Better Life' –the assurance and labelling scheme of Netherlands leading Animal welfare organisation – Dierenbescherming ('Animal protection')) and Fur Mehr Tierschutz ('For More Animal Welfare', the equivalent scheme of the German Animal Welfare Association - the Deutsche Tierschutzbund).

[3] Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91.

[4] Organic preparation '*means the operations of preserving and/or processing of organic products, including slaughter and cutting for livestock products, and also packaging, labelling and/or alterations made to the labelling concerning the organic production method*'.

2.8 Microbial incidents

One of the main concerns related to microbial risks, is that of the higher levels of *Salmonella* and *Campylobacter* found in free-range meat products. Research has shown that free-range meats have contamination levels of up to two-thirds higher than conventional meats (Bailey and Cosby 2005, Esteban et al. 2008).In addition, a recent simulation study found the relative risk for *Campylobacter* contamination to be 70% lower in conventional meat product than in free-range meats (Jones, Anderson, and Guard 2012). Moreover, in recent years, there have been several cases where *Toxoplasma gondii,* an organism not normally found in conventional meats, was present in free-range meats (Kijlstra, Meerburg, and Bos 2009). A study conducted in southern Spain found that 80% of carcasses from free-range pigs tested positive for *Toxoplasma gondii* (Hernández et al. 2013).

The high prevalence of *Toxoplasma gondii* in free-range meats is of particular concern, because this microorganism can cause pregnant women to abort, rendering it the most severe risks associated with this type of production (James, Martin, and David 2005).

Additionally, several cases of similar contaminations have emerged in other countries, such as Austria, Brazil, Ghana, Indonesia, Italy, Poland and Portugal. Lastly, Bird 'Flu (Influenza A subtype H5N1) contamination has also emerged as a potential risk for free-range chicken, because of the higher chance of contact with wild birds (Goutard et al. 2011, De Krom and Oosterveer 2010).

2.9 Research objectives

The objective of this research was twofold. Firstly, to examine whether there is a lack of food safety rules in free-range production within existing legislation. Secondly, to measure the benefits and the economic impact of high unconventional microbial risks on sustainable and free-range beef and pork production in The Netherlands, Germany and the UK.

2.10 Research questions

The research explored the following questions:

1. Is there a gap in food safety rules between risks arising in production methods that satisfy free-range certification standards and food safety regulation?

2. What additional costs are incurred due to high unconventional microbial risks free-range meat production for businesses with free-range certification??
3. What are the benefits of investing in free-range certification, with regard of the incidental costs from unconventional risks?
4. How much would the incidental cost be in the eventuality of an outbreak due to those risks?

2.11 Report outline

The research is presented in the following structure:

- Chapter 2 presents a literature review of existing regulations for free-range products, certification standards, and microbial prevalence in free-range meat.
- Chapter 3 presents the materials and methods used to calculate the probability of contamination, partial budgeting and Expected Monetary Values (EMVs).
- Chapter 4 presents the results of the comparative review, partial budgeting, EMVs and analyses of an outbreak probability.
- Chapter 5 presents the discussion.
- Chapter 6 presents the conclusion and suggestions for further research.

3. Literature review

A literature review was carried out to acquire information on the prevalence of unconventional risks, current the legislation regulating food safety with respect to safety and production standards of certification bodies, and on the costs associated with obtaining free-range certification. The initial focus was to identify the probability of contamination associated with different types of contaminants that characterise unconventional risks in free-range production. A second priority was to analyse EU regulation concerning free-range production, with respect to the safety standards of free-range certification. The third analysis priority was to evaluate the costs incurred by farms in obtaining free-range certification to determine the profitability and loss associated with this type of production.

3.1 Prevalence and analyses

3.1.1 Quality

The quality aspects that consumers consider in free-range products can be categorized into three aspects: nutritional value, free of non-organic compounds and association with animal welfare. For nutritional value and quality, consumers always assume that 'natural' products contain higher amounts of nutrients and have a stronger flavour (Grunert 2006). However, free-range meats have both positive and negative quality features. Positive indicators include a high content of Poly Unsaturated Fatty Acids PUFA (e.g. Omega-3), antioxidants and desirable mechanical properties (i.e. cutting). High amounts of antioxidants slow quality deterioration (Nilzén et al. 2001, Bee, Guex, and Herzog 2004, Braghieri et al. 2013). Nonetheless, poor criteria are low water holding capacity and a normal Ph level, which leads to loss of juices in the mouth in meat, which is considered detrimental in meat taste (Nilzén et al. 2001).

One more feature regarding free-range meat quality is that it is produced without exposure to pesticides and herbicides. This perspective is strengthened by growing consumer awareness of the increased risk of chronic diseases (e.g. cancer) associated with their consumption (Franklin 2012). Although, present legislation minimises the use of pesticides and herbicides, consumers still assume that 'natural' methods guarantee more safety. They

associate ‘natural’ as safer, and because free-range is considered to be ‘naturally-produced meat’ that it has been produced without exposure to pesticides or herbicides.

One last quality attribute is the use of veterinary drugs. Many consumers assume that free=range meat production doesn’t allow their use. However, the use of veterinary drugs in free-range systems is permitted in some circumstances, with a long withdrawal period and separation of diseased animals from the rest of the herd (Tierschutz 2014b, Leven 2010, Food 2014b).

Consumers assume that by buying free-range products, they are helping to reduce their environmental footprint. One study has determined that sustainability is a preferred choice by consumers, accounting for up to 37% of all consumers’ preferences (Food 2010c). This perspective is not substantiated, due to fact that free-range animal production contributes to deforestation, through the requirement for more land to satisfy the per animal space allowance specified in certification schemes. Another factor that influences consumers’ perspectives is the high number of meat scandals and food-related disease outbreaks (i.e. most of the total food disease outbreaks are meat-related) or fraudulence, as in the recent European ‘horse meat scandal’. These incidents have shaped consumers’ perspectives, enhanced their focus on adequate labelling and making better informed choices, and has consolidated their trust in certification schemes (Grunert 2006).

3.1.2 Microbial background

One of the key concerns in this research is that higher microbial load can contribute towards a higher probability of consumers infected with food borne illnesses. To elucidate the situation, information was obtained on the symptoms that each pathogen causes and the impact of food borne outbreaks that occurred in Europe during 2012.

Salmonella

Salmonella is a rod-shaped bacteria. It is one of the most common causes of food-related illnesses in the world (James, Martin, and David 2005). In the EU, a summary report on trends

and sources of zoonosis, zoonotic agents and food borne outbreaks in 2012 published by the European Food Safety Authority (EFSA) and the European Centre for Disease Prevention and Control, reported that *Salmonella* was the main cause of food outbreaks, accounting for 28.6% of total outbreaks (1533/ total outbreaks) (EFSA and ECDC 2012).

The bacteria is gram-negative and facultative anaerobic (i.e. its preferred environment is anaerobic, but it can grow in other environments too), and grows optimally at temperatures of 5-45℃ . The infective dose for *Salmonella* food infection (Salmonellosis) is 10^5 CFU. The main clinical symptoms of Salmonellosis include abdominal cramps, diarrhoea, mild fever, nausea and vomiting, which last for two to three days, and in some cases up to one week (Adams and Moss 2010).

Campylobacter

Campylobacter is a spiral-shaped bacteria. It has one of the lowest infection doses (Bee 2004). The EU's 2012 summary report on trends and sources of zoonosis, zoonotic agents and food borne outbreaks links *Campylobacter* infection to an estimated 501 outbreaks - 9.3 % of total outbreaks (EFSA and ECDC 2012).

The pathogen is gram-negative and microaerophilic (i.e. it thrives in an aerobic environment). Its optimum temperature for growth is 30-45℃. The infection dose for *Campylobacter* is 100 CFU. Its incubation time (the time required for the bacteria to grow in intestines and manifest clinical symptoms) is one to 11 days, which makes infection difficult to predict. Clinical symptoms include bloody diarrhoea, fever, severe abdominal pain and arthritis (inflamed and painful joint problems) in a small proportion of clinical cases (two to seven percent).

Toxoplasma gondii

Toxoplasma gondii is a protozoon parasite usually linked to domestic cats and can cause abortion in pregnant women. The EU's 2012 summary report on trends and sources of zoonosis,

zoonotic agents and food borne outbreaks listed parasites in general without specification of type. Parasitic infection was attributed to 38 of total outbreaks (0.7%) (EFSA and ECDC 2012).

Infection by *Toxoplasma gondii* is called Toxoplasmosis. It can cause behavioural change and abortion; the infections affect all warm blooded animals. The parasite needs live cells to reproduce and form a zygote that matures into an oocyst which is the stage which becomes infections of dose 100 oocysts. Domestic cats act as hosts through consumption of wild rodents infected with parasitic cysts; they can then transmit active parasitic infection to humans through faecal contact (James, Martin, and David 2005).

3.1.3 YOPI

YOPI's (Young, Old, Pregnant and Immuno-compromised people) comprise a vulnerable, high-risk group. Food borne infections are more likely in these four high-risk people, because they frequently have a weakened immune system that reduces protection from microbial attacks, thus enhancing the risk that pathogens can penetrate the intestines. Usually, these groups are advised to strictly avoid consumption of food products with a high probability of contamination, even in low amounts (Adams and Moss 2010).

3.2 Regulations, legislation and guidelines

Under European food legislation, all-encompassing regulations, such as the EU's General Food Law ((EC) No 178/2002) are considered the main umbrella of food legislation in Europe. The regulations include broad measures, such as Article 14, Paragraph 1 '*food shall not be placed on the market if it is unsafe'*, as well as more specific regulations regarding certain food types, or distinguish between a variety of products, which can sometimes provide Intellectual Property Rights (IPRs). In addition to this type of legislation, third-party regulations (private food standards) provide more detailed standards for specific food production methods. These can add value to products, but must also correspond with major European food laws. The main

EU regulation that covers the production of free-range poultry is Commission Regulation (EC) No 543/2008 [5], which incorporates types of labelling and production method.

3.2.1 Regulations

3.2.1.1 Certification

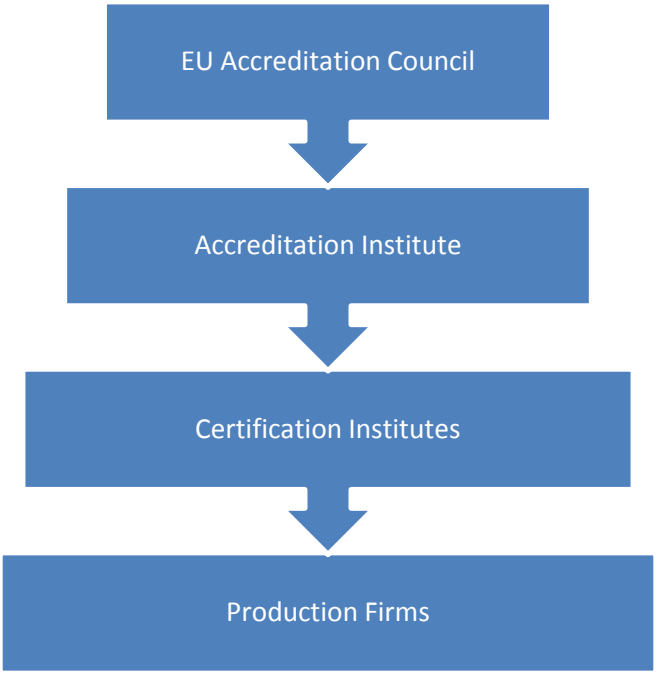
To further understand and analyse any voids in existing legislation, current regulations regarding free-range meat production and their enforcement were fully explored. Certification marks are considered private food standards that are specific to certain types of production. Each specify and apply their own specific standards and therefore represent trademarks or goodwill. All certification schemes must be audited and certified by accreditation bodies, which ensure correspondence of their standards with general EU Member State regulations. In addition, the owners of the certification schemes have the right to refuse or accept their use by other institutes, which also give them the power to impose their standards in reward for the use of their label (van der Meulen 2011).

3.2.1.2 Accreditation

In legislation, there has to be a place for public standards for the recognition of voluntary labelling, thus, accreditation bodies were established. On the basis of such standards, certifiers can request accreditation to prove to their customers that the product they deliver (e.g. proof of compliance with private standards) is aligned with EU legislation. Therefore, accreditation is the official certification of certifiers often by, or with the consent of public authorities (Figure2).

[5] Commission Regulation (EC) No 543/2008 of 16 June 2008 outlines detailed rules for the application of Council Regulation (EC) No 1234/2007 as regards the marketing standards for poultry meat.

Figure 1. Relation between accreditation bodies and certification institute.



An EU framework for marketing certification and accreditation, was established ((EC) No 765/2008)[6], effective from 1st January 2010. The regulation requires that EU Member States appoint an independent national accreditation body, which must meet the approval of the EU (Article 5, (EC) No 765/2008) (van der Meulen and van der Velde 2011).

3.2.1.3 General Food Law (GFL)

The General Food Law (GFL) ((EC) No 178/ 2002) is the main food safety regulation that governs national-, communal- and public standards, therefore acting as the general framework for governance of the safety of food and feed in the EU. Its purpose is to provide widespread food safety assurance for the protection of consumers' health, across the wide diversity of foods, production methods and stakeholders within the EU. The main article of the GFL regarding safety is Article 14, Chapter 2 which states that '*Food shall not be placed on the*

[6] ((EC) No 765/2008 of the European Parliament and of the Council of 9 July 2008 sets out the requirements for accreditation and market surveillance related to the marketing of products)

market if it is unsafe. Food shall be deemed to be unsafe if it is considered to be: (a) injurious to health; (b) unfit for human consumption' ((EC) No 178/ 2002). Consequently, any food that is proven to be unfit for human consumption must not be placed in the market, and if so, will be withdrawn. This can be seen in Diagram 1 (van der Meulen and van der Velde 2011). In the absence of regulating laws that might govern any lack in free-range production, whether legislation or legal limits, in private standards or national laws, the GFL is the main source of regulation, regarding the safety of food being placed on the market - Chapter 1 Article 1 ((EC) No 178/ 2002) (van der Meulen and van der Velde 2011). For this reason, if there is an absence of detailed legislation for safety criteria in free-range the GFL will be implemented (van der Meulen and van der Velde 2011).

Diagram1. Principles of food law P264 (van der Meulen and van der Velde 2011). (Chapter 2 (EC) No 178/ 2002).

Principle	Content Details
General principles (section 1)	
General objectives (or focus)(Art.5)	Protection of: • Human life and health. • Consumers' interests. • Fair trade. • Animal health and welfare, plant health, environment. • Free movement of feed and food products. • Application of international standards.
Science-based (Art.6)	Based on risk analysis. Risk assessment based on all scientific evidence, independent, objective and transparent manner. Risk management takes into account results of risk. Assessment, other legitimate factors, precautionary principle.
Precautionary principle (Art.7)	If the possibility of harmful effects on health are identified, but scientific uncertainty persists: • Provisional risk management measures may be taken. • Pending further research. • Proportionate. • No more restrictive to trade than required. • With regard to technical and economic feasibility and other legitimate factors. • Measures shall be reviewed within a reasonable time.
General requirements (Section 4)	

Food safety (Art.14)	• No unsafe food placed on the market. • Applies to entire batch, unless proven safe.	Food is unsafe, if: • Injurious to health. • Unfit for consumption (contamination, putrefaction, deterioration, decay). Regarding: • normal use. • Information. Regarding: • Long-term effects; including future generations. • Cumulative toxic effects. • Sensitive categories of consumers. Food complying with food law is deemed safe for the aspects covered: • Compliance dose not bar authorities from taking measures.
Feed safety (Art.15)	• No unsafe food to be placed on the market. • No unsafe feed to be fed to food-producing animals.	
Presentation (Art.16)	• No misleading consumers.	
Responsibilities (Art.17)	• Business operators from farm-to-fork, following food legislation. • Member States for enforcements from farm-to-fork (controls, communication and penalties).	
Traceability (Art.18)	• From farm-to-fork. • One step up, one step down. • Operators have systems in place. • Information available for authorities. • Adequate identification and labelling.	
Responsibilities for food (Art.19)	• An operator who has reason to doubt safety must withdraw food. • If food has reached consumer, inform consumers, and if necessary, recall. • Inform and cooperate with competent authorities.	
Liability (Art.21)	• General provisions on product liability apply.	

3.2.1.4 Free- range labelling

The main EU regulation that governs the legal labelling of free-range poultry products is (EC) No 543/2008. It identifies three types of grazing system within the classification of free-range: free-range, traditional free-range and free-range total freedom ((EC) No 543/2008).In addition, within ANNEX 4, the classifications are provided in each language of the EU Member States. For a producer to legally name their product as one of the three categories of free-range, the minimum requirements specified in Article 11 and Annex 5 must be achieved, which requires fulfilment of certain criteria in age of slaughter, space for housing and type of feed. The age at slaughter is mostly unified for all types of production according to each animal type (e.g. turkeys at 70 days and chickens at 56 days). Regarding space allowance, space is specified in minimum square metres allocated according to a number of chickens and weight (e.g. for free-range, the amount of chickens in housing space is 13, but not more than 27,5 kg live weight per square metre, and an outdoor space of one square metre per head). However, in traditional free-range the space allowance is much bigger (e.g. chickens: 12 but not more than 25 kg live weight per one metre square of space). Likewise, the specification for feed must be 70% of cereals, applied to all types of production. Concerning free-range total freedom, the main requirements are the same as the other types of free-range (e.g. the space alone is the same as traditional free-range). Though, most prominent feature of this production method is that poultry has free access at all times to outdoor space. All criteria mentioned above are intended for the labelling of free-range poultry only. Moreover, the criteria do not include measures that might reduce exposure to high microbial load within an environment, or through encounters with wild animals or domestic pets ((EC) No 543/2008).

3.2.1.5 Free-range regulations

Within the literature reviewed, several articles indicated that free-range production is mentioned in four types of regulations in the official website EUR-Lex. These specific regulations are: labelling, sampling, contaminants and geographical indicators. As previously mentioned[7], the main regulation for free-range labelling is contained within ((EC) No 543/2008). However,

[7] Check section 3.2.1.4 Free-range labelling.

one other regulation ((EU) No 1308/2013)[8] that had made optional reserved terms for poultry meat production only, that mentions the three types of free-range grazing ((EU) No 1308/2013).

Moreover, sampling plans for turkeys farms is mentioned in the ((EU) No 1190/2012 of 12)[9] that specifies detailed methods to monitor *Salmonella*. In Annex 1, Paragraph 2, the regulation emphasises specific instructions for sampling certain types of farming, including free-range. The text focused on free-range turkey production states: '*For free range flocks of turkeys, samples shall only be collected inside the house*'. In the event that access to the turkeys' housing is not possible, because of limited space, the use of hand fabric swabs is permitted ((EU) No 1190/2012).

Furthermore, contamination in free-range products is referred to in EU legislation for non-organic[10] contaminants only (2013/711/EU)[11]. These contaminants were not the focus of this research, however, they are closely related to free-range production (2013/711/EU).

Geographic indication is a label indicator that is used to identify goods with a specific geographical origin that possess specific quality and production criteria, and have a reputation linked to that origin. In the review of regulations regarding free-range production, two geographical indications were found: *Abbacchio Romano* and *Taureau de Camargue*. The first is Abbacchio Romano in Italy which produces lamb meat that must be grazed free-range in order to qualify for Abbacchio Romano labelling ((EU) No 1174/2012)[12]. The second is Taureau de

[8] (EU) No 1308/2013 OF the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products and repealing Council Regulations (EEC) No 922/72, (EEC) No 234/79, (EC) No 1037/2001 and (EC) No 1234/2007

[9] December 2012 concerning the defining a target for the reduction of *Salmonella Enteritidis* and *Salmonella Typhimurium* in flocks of turkeys, as provided for in Regulation (EC) No 2160/2003 of the European Parliament and of the Council.

[10] High exposure levels of dioxins.

[11] Commission Recommendation of 3 December 2013 on the reduction of the presence of dioxins, furans and PCBs in feed and food (Text with EEA relevance) (2013/711/EU).

[12] ((EU) No 1174/2012 of 5 December 2012 approving a minor amendment to the specification for a name entered in the register of protected designations of origin and protected geographical indications (Abbacchio Romano (PGI)) ((EU) No 1174/2012).

Camargue in the south of France. This is a local cattle meat variety, which must be bred according to free-range methods ((EU) No 1054/2012)[13].

3.2.2 Guidelines

3.2.2.1 Free-range guidelines

Guidelines on free-range production in the Netherlands, Germany and the UK all include some information on free-range production and labelling criteria with indications to specify the difference between levels of outdoor access for animals (Voedingscentrum 2014, Landwirtschaft 2014).However, safety criteria are not included, or any indication that these types of products can harbour a high microbial load.

3.2.2.2 Limits

Legal limits of microbial contaminants are listed in ((EC) No 2073/2005)[14]. This article illustrates sampling plans, and legal limit in food according to each pathogen, along with appropriate preserving and processing methods. The limit for both *Salmonella* and *Campylobacter* is absolute zero in 25g - all samples of 25 g must be free of pathogenic cells. These limits determine the maximum allowed amount of *Salmonella* and *Campylobacter* CFU[15] in foods, when inspected in production and customs. However, there is no specification for *Toxoplasma gondii* in the regulation ((EC) No 2073/2005). Furthermore, the Federal Ministry of Food, Agriculture and Consumer Protection in Germany (Bundesministerium für Ernährung und Landwirtschaft (BMEL)) categorized *Toxoplasma gondii* in their microbial risk classification as a second-class risk, whereas *Salmonella* and *Campylobacter* are considered a first-class risk. Thus, BMEL did not prioritize the need for further legal limits (BMEL 2013). Also, according to the Dutch Food and Consumer Product Safety Authority (Nederlandse Voedsel- en Warenautoriteit (NVWA)), there are no legal limits or rules for *Toxoplasma gondii* (NVWA 2014b). However, the

[13] ((EU) No 1054/2012 of 7 November 2012 approving minor amendments to the specification for a name entered in the register of protected designations of origin and protected geographical indications [Taureau de Camargue (PDO)) ((EU) No 1054/2012).
[14] (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs.
[15] Colony forming unit.

GFL regulation ((EC) No 178/ 2002 (Article 14)) states that products cannot be put into the market if unsafe, unhealthy or unfit for human consumption, and this can be applied to food that is proven to be contaminated with *Toxoplasma gondii* (NVWA 2014b).

3.2.2.3 Logistic slaughtering

Slaughterhouses are the main source for cross-contamination (i.e. carcasses with high microbial loads can transmit bacteria to carcasses with lower loads) in the meat production chain. Therefore, logistic slaughtering puts high risk animals or those positive in sampling for bacteria in the last batch to slaughter. This method helps reduce the chance of cross-contamination, since there is no mention of free-range in logistic slaughtering standards it still applies if sampling proves positive to *Salmonella* or *Campylobacter* (Cameron 2012).

3.2.2.4 Fines

According to the EU GFL ((EC) No 178/2002), the penalties (fines) for not complying with this regulation are determined by the EU Member State. To establish the exact value of the fines, the websites of the food safety bodies in the Netherlands, Germany and the UK were consulted ((EC) No 178/2002). For the UK, the fine for not keeping records is £5000 and £750, and £750 for supplying animals with higher level of contamination, also some cases the penalty reaches £1,000 (Shah 2009, Lewsey 2002). In the Netherlands, NVWA will fine up to €10,000 for trading contaminated live animals (NVWA 2014a). Whereas, in Germany, according to the Federal Office Report of 2007/2008 BVL, the fine for not complying with the legal contamination and hygiene requirements is €10,000, with the likely production license withdrawal (BVL 2008, Lebensmittelsicherheit 2009).

3.2.3 Certification

Three certification schemes from the UK –'Freedom Food'; The Netherlands – 'Beter Leven' and Germany – 'Für Mehr Tierschutz' were the main focus of the research. Most free-

range certification schemes are developed by major animal protection societies in these countries, whose ultimate aim is to further increase the animal welfare conditions in meat production.

3.2.3.1 Certification background

Freedom Food

This is an animal welfare free-range certification, established in 1994. This makes it the oldest scheme studied. It was developed by the Royal Society for the Prevention of Cruelty to Animals (RSPCA) (Food 2010b). The scheme covers all types of animal meat production, including two varieties of fish, which makes it, from an institutional perspective, more advanced than the two other schemes (Food 2010c).

Beter Leven

Beter Leven is a Dutch animal welfare certification that aims to increase free-range and organic production. The scheme supports free-range, but has a three-level star-rating system. When a product is awarded three stars, it is considered organic[16] under the Beter Leven classification. The certification was established in 2007, and it was developed by the Dierenbescherming (Dutch Society for Animal Protection) (Bescherming 2014).

[16] The scheme is designed to gradually evolve the meat industry into organic production.

Für Mehr Tierschutz

Für Mehr Tierschutz means 'for more animal welfare´. It is a free range certification established in 2011. It is the youngest scheme in this research. The certification was developed by the German Animal Welfare Association. It covers only chickens and pigs and features a two star-rating: Entry Level (one star) and Premium Level (two stars) (Tierschutz 2014a).

3.2.3.2 Star system

In the schemes from Beter Leven and Für Mehr Tierschutz the star system is designed as ascending ladder to guide farmers and producers step-by-step towards implementing higher levels of animal welfare. It also gives insight to the evaluation of the standards set by certification schemes to facilitate producers transition from conventional to free-range. Furthermore, producers are given solid encouragement to further invest in changing their facilities, as the higher the star-rating the greater the returns. Moreover, from the consumers' perspective the star system provides a better range of options to choose from. In addition, it takes into account consumers' financial budgets, as the lower the star-rating, the cheaper the product. This helps the consumer to adapt to the changes in the further increasing percentage of free-range meats available on the market.

3.2.3.3 Standards

The production standards obtain and monitor free range certification for cattle and pork are mostly similar in all three schemes (Table 1). However, there are some differences in details (e.g. the space allowance is different in each scheme). Some schemes offer more detailed information to supplement certifications. The similarities between all schemes are mainly in housing design, which includes: flooring, ventilation, lighting and separation of sick or injured animals. Additional standards include transport time and slaughter, which also includes age, waiting time, killing method, and presence of a qualified animal welfare officer. Also, all schemes agree on the ban of veterinary drugs, which should be used only in severe

circumstances. Furthermore, during the annual visit by the certification inspector, blood samples are taken to assess the amount of iron, as the serum iron level indicates if the animals have been provided adequate outdoor access (Tierschutz 2014b, Food 2014a, Tierschutz 2014c, Leven 2011, 2014, Food 2014b).

The main differences are in space allocations for each animal, which not only differ from one scheme to another, but within each scheme that has different star-rating levels, so the more stars a farm has the more space[17] per head (Tierschutz 2014b, Food 2014b). Moreover, most of the certification schemes prohibit the use of Genetically Modified Organisms (GMOs), except Für Mehr Tierschutz which prohibits this only in its Premium Level (two star) (Tierschutz 2014c).

All free-range certifications separate free-range meat from conventional meats during processing and packaging (Leven 2014). Of significant importance, all certifications, except Freedom Food, omit the ban of domestic animals (cats and dogs) from accessing the farms outdoor and animal housing areas. This is very important, as mentioned in the microbial background, since domestic cats act as hosts for *Toxoplasma gondii* (Food 2014b, 2010b).

[17] As farms acquire more stars animals will be given more outdoor time, this will increase the exposure to environmental contaminants.

Table 1. Free- range certification bodies production standards.

Standard		Freedom Food	Beter Leven			Fur Mehr Tierschutz	
			*	**	***	*	**
Space	Cattle	$6.5/m^2$	$1.8/m^2$	$2/m^2$	$2.5/m^2$		
	Pigs	$1.5/m^2$	$1/m^2$	$1.2/m^2$	$1.3/m^2$	$1/m^2$	$1.6/m^2$
Housing		✓		✓			✓
Transport		✓		✓			✓
Slaughter		✓		✓			✓
Veterinary drugs		✓		✓			✓
Serum iron level monitoring		✓		✓			✓
GMO		✓		✓			-
Conventional meats		✓		✓			✓
Domestic animals		✓		-			-

* space for one star, ** space for two stars, ***space for three stars, Housing includes flooring, air ventilation, light fixers and separation of sick or injured animals, Slaughter includes also age, waiting time, and killing method, GMO Genetically Modified Organisms, Für Mehr Tierschutz prohibits in premium level (two star), Conventional meats separate the free range meat from conventional meats during acts of processing and packaging, Domestic animals ban from accessing farms outdoor and animal housing areas. (Tierschutz 2014b, c, Beter-Leven 2013, Leven 2010, 2011, Food 2014b, 2010b, c).

3.2.3.4 Costs

The cost for obtaining (initial cost) and maintaining (annual cost) free-range certification vary from one scheme to another. All of them have different criteria that contribute to varying initial costs as shown in Table 1 (Ressourcenschutz 2011, Leven 2014, Food 2012). With the exception of the Freedom Food scheme, in which annual costs are the same as initial costs, they require a license fee of 0.3% of all profits. The license fee grants the producing company the right to use the Freedom Food logo on their packaged meat. However, this is not the case in Beter Leven or 'Für Mehr Tierschutz', which issue these rights when the company is approved for certification (Food 2010a). Also, Beter Leven has the same cost for large and small farms in different stages of production. Although, Beter Leven support farmers to change to free-range production by not obligating them to pay any costs for the certification scheme (Leven 2014). In addition, the costs at retail level in the Beter Leven scheme are higher at all stages of production, even if from the same company (Leven 2014).

Table 2. Initial and annual costs for obtaining free range certification (Leven 2014, Food 2010a, 2012, Ressourcenschutz 2011).

Certification	type	size	Initial	Annual	Fee	Extra	reference
Freedom Food	Cattle	Up to 200 animals	£119	The initial costs are equivalent to the annual cost.	RETURNS MUST BE FORWARDED MONTHLY (Quarterly if < £15/ month); 0.3% of wholesale value	Costs cover one inspection per year.	(Freedom Food 2012A; Freedom Food 2012B)
		For 201 animals and over	£176				
	Pigs	Breeder or Rearer or Finisher	£119				
		Breeder, Rearer (Rearer, Finisher)	£176				
Beter Leven	Cattle	small	€ 79	€ 318	Additional costs for slaughter house	Price of certification for all stages of production, except : -primary (€0). -retail (annual cost) Small € 2,497 Medium € 3,121 Large € 4,015.	(Beter Leven 2014F)
		large	€780	€ 3,121	€ 0,2583/ head for		
	Pigs	small	€79	€ 318	€0,0716/ head		
		large	€780	€ 3,121			
Für Mehr Tierschutz	Pigs	One star	€ 0	€ 184	-	No specific fee - depends on several variables.	(Leistungskatalog 2007)
		Two stars	€ 0	€ 322	-		

3.2.3.5 Benefits

The main benefit from free-range certification is a higher return, as meats labelled with certification logos are usually sold at higher prices than conventionally produced meats (Athanasios Krystallis et al. 2012). Also, free-range certification gives access to new markets with less competition, providing an advantage to producers, since this is a growing market with high consumer demand (Food 2014b). Furthermore, some certification schemes, such as Freedom Food and Beter Leven, incorporate retailers, caterers, restaurants and processors as part of the internal network within the certification group (Food 2014a). In addition, they promote that by obtaining the certification, the company will contribute towards achieving better animal welfare, which is considered by many companies as a way of 'giving back' to the environment and driving the industry further towards sustainability.

4. Material and methods

4. 1. Comparative review

A comparison of the existing food safety regulations with private (internal) safety standards imposed by third-party certification bodies was performed to understand the gaps in legal measures that control the high unconventional microbial risks associated with free-range production. Additionally, the standards of processing and packaging free-range meats were compared with organic meat (another form of sustainably-produced meat).

4. 2. Simulation case study

An analysis of the initial, operational and incidental costs was performed using a business simulation of cattle and pig farms to provide guidance for those considering whether or not to invest in free-range certification. The business simulation consisted of representative farms of various sizes in The Netherlands, Germany and the UK. The simulation included a fixed amount of outputs (animals) to compare the costs of obtaining (initial costs) and maintaining (annual costs) a certificate, plus the amount of benefits. The simulation study consisted of small farms (100 heads of livestock) and large farms (200 heads of livestock) and a comparison of cattle and pigs with regard to star-ratings in certification schemes. The initial costs for acquiring certifications were acquired from the detailed outlines of the certification schemes (Table 2).

The simulation was supported by partial budgeting to analyse the Net Value (NV) of the additional revenue and extra operational costs. These are the main costs that farms would incur for implementing changes on their farm to achieve certification standards.

The results of this were used to perform a decision tree analysis - a tool to assess the Expected Monetary Values (EMV)[18]. This was done to clarify the high microbial levels associated with free-range production, by taking into account the incidental costs that could arise based on the probability of different types of contamination in different kinds of meat.

[18] the Expected Monetary Values (EMV): is the total payoffs associated with the decision of implementing change or new investment, with consideration of the incidental events that's may occur from this decision (Blumsack 2014).

4. 2.1 Description of data

To provide guidance for businesses on the costs associated with different types of contaminants, financial data for obtaining free-range certification (initial costs to obtain certification and the annual costs to maintain it) was acquired from certifying bodies.

The data collected from literature review includes the following indicators: willingness to pay (WTP), animal purchase costs, conventional meat prices, the cost of iron blood monitoring, operating costs (Table 3), fines for exceeding microbial limits (Table 4) and the prevalence of the three pathogens (*Salmonella, Campylobacter* and *Toxoplasma gondii)* (Table 5). Table 3 Shows the WTP collected from one study for each country, the WTP are for animal welfare and free-range. The figures presented for animal welfare are related to free-range as they are interrelated. Moreover, the figures for WTP collected from the literature are for one star for the Netherlands and Germany, and the regular WTP for the UK. However in the case of multiple star-rating certification schemes in The Netherlands and Germany, there are no specifications for WTP. Therefore, the exact extra prices per kilogram between the stars were acquired by analysing the existing free-range meat star-rating prices in The Netherlands and Germany and comparing those with one star. The regular prices of conventional products were derived from the market to calculate the revenue foregone in the partial budgeting. For the animal purchase and operating costs, the data was derived from the EU Farm Accountancy Data Network (FADN) report of 2010, except for pig production. Iron blood monitoring costs were obtained from four veterinary clinics, two of them from the Netherlands. For bacterial prevalence, the data was derived from literature in each country per specific pathogen. However, some of them are taken from free range chicken cases and two were taken from nearby countries, Spain and Switzerland, as there were no relevant existing studies on them. Finally, some of the costs are in Euro and Pounds Sterling and some were US Dollars, therefore Currency Converter rates that were used as of the 17th of February 2014.

Table 3. Data used in partial budgeting.

Type	Amount	Reference
WTP UK	£0.8	(Dickinson and Bailey 2003)
WTP NL *	€2.27	(Meuwissen, Van Der Lans, and Huirne 2007)
WTP NL **	€3.27	€1 compared with market
WTP NL ***	€4.47	€1.2 compared with market
WTP GR *	€2.14	(Lusk, Roosen, and Fox 2003)
WTP GR **	€3.14	€1 compared with market
Animal purchase Cattle UK	£387.85	(Development 2013)
Animal purchase pig UK	£38.54	(Development 2009)
Animal purchase Cattle NL	€537	(Development 2013)
Animal purchase Pig NL	€46	(Development 2009)
Animal purchase Pig GR	€46	(Development 2009)
Conventional cattle meat price/kg UK	£6	Taken from retail outlets' websites
conventional pig meat price/kg UK	£3.61	Taken from retail outlets' websites
conventional cattle meat price/kg NL	€5.58	Taken from retail outlets' websites
conventional pig meat price/kg NL	€3.61	Taken from retail outlets' websites
conventional pig meat price/kg GR	€3.6	Taken from retail outlets' websites
Iron blood monitoring UK	£5/ 10 animals	(Clinic 2014b)
Iron blood monitoring NL	€10.1 /animal	(clinic 2014a, Horst. 2014)
Iron blood monitoring GR	€10.6 /animal	(Tierklinik 2014)
Operating cost UK	£1539 for cattle	(Development 2013)
Operating cost NL	€2185 for cattle	(Development 2013)
Operating cost GR	€101	(Development 2009)

UK United Kingdom - NL the Netherlands – GR Germany - WTP willingness to pay - * amount of stars.

In Table 3, animal purchase is the cost of buying the animals. Conventional meat prices were added with WTP to calculate the selling price of free-range meat. Iron blood monitoring costs were included because these indicate compliance with certification standards. Operating costs included the costs of transportation, feed, slaughter and veterinary services.

Table 4. Data used in decision tree.

Type	Amount	Reference
Fine UK	€10,000	(Shah 2009)
Fine NL	€10,000	(NVWA 2014a)
Fine GR	€10,000	(BVL 2008, Lebensmittelsicherheit 2009)

Table 5. Data used for probability of contamination.

Prevalence (%)						
	Sal	**Reference**	**Cam**	**Reference**	**Tox**	**Reference**
NL	44.6	(Van der Wolf et al. 2001)	80.6	(Colles et al. 2010)	5.62	(van der Giessen et al. 2007)
UK	31	(Davies and Breslin 2003)	50.2	(Esteban 2008)	5	(Kijlstra et al. 2004)
GR	41	(Hernández et al. 2013)	76.7	(Colles et al. 2008)	4.7	(Berger-Schoch et al. 2011)
Constant				Contact (kg)		
	a	**N50**	**Reference**	NL	89.3	(Brown 2009)
Sal	0.21	4910	(McCullough and Elsele 1951)	UK	79.6	
Cam	0.144	890	(Black et al. 1988)	GR	82.1	
Tox	k=	0.0263	(Ware et al. 2010)			

Sal *Salmonella,* Cam *Campylobacter,* Tox *Toxoplasma gondii*, Prevalence percentage of positive samples in carcasses taken from study cases in literature, Constant is constant used in dose response models to mimic the probability and severity of microbial pathogens and taken from the literature, N50 is a dose that will affect 50% of population, α and k is a the probability of pathogen survival. Contact is the total consumed amount of meat per person per year.

The Table 4 indicates the fines incurred should farms exceed legal microbial limits. Table 5 data was used to calculate the probability of contamination for free-range products. The outcome was used to determine the risks associated with the decision to convert to free-range farming.

4.3.2. Partial budgeting

To further assess the additional costs involved in free-range production, partial budgeting was applied to predict the total additional revenue and total additional costs farm to convert from conventional production to free-range. The total additional revenue was calculated from the amount of additional revenue, plus the reduced costs, whilst total costs included the revenue foregone plus additional costs (Figure 2). This could be a useful tool that provides budgeting of only added cost and revenue from adopting certain change or addition to the business. The outcome of the partial budgeting is the NV calculated from the total additional revenue minus the total costs (Figure 3). If the NV outcome is higher than it is profitable for business to engage in the new methods for the first year. The data used for the additional revenues was WTP, outdoor area standard, animal purchase cost and operating costs (reduced costs). The data used for total costs included animal yield foregone (revenues foregone), initial and annual certification costs, iron blood monitoring and flooring costs. The farm partial budgeting was applied for the first year of the change to free range.

Figure 2. Partial budgeting attributes (Ehui and Rey 1992).

1. Additional income: List the items of income from the alternative plan that will not be received from the base plan.

2. Reduced expenses: List the items of expense for the base plan that will be avoided with the alternative plan.

3. Subtotal: 1 + 2.

4. Reduced Income: List the items of income from the base plan that will not be received from the alternative.

5. Additional expenses: List the items of expense from the alternative plan that are not require with the base plan.

6. Subtotal: 4 + 5.

7. Difference: 3 - 6: A positive (negative) difference indicates that the net income of the alternative exceeds (is less than) the net income of the base plan by the amount shown.

The design of the partial budgeting is a table divided into four sections the two on left are the additional revenues and reduced costs, the two on the right are revenues foregone and additional costs. An example of the partial budgeting table from Beter Leven two stars for a small cattle farm is shown in Figure 3.

Figure 3. Example of the design for small cattle farm in UK partial budgeting.

Cattle			
Small 100 heads			
Additional revenue		Revenues foregone	
Amount of heads	100	Total animal yield foregone *£6	£114,666.67
WTP /£	£0.80		
Meat yield/kg	430		
Meat price/ carcass =	£344.00		
Total extra revenue	£34,400.00		
Certification space/ m2	6.5		
Total space area/m2	650		
Conventional space/ m2	4.5		
Total animals foregone	44.44444444		
Animal purchase cost/£	£387.85		
Cost of livestock foregone £	£17,237.78		
Total revenue=	**£51,637.78**	Total revenues foregone	£114,666.67
Reduced costs		Additional cost	
operating cost*1539	£68,400.00	Certification initial cost	£119.00
		Certification annual cost	£154.91
		Iron level check(5£/10animal)	£7.50
		Floors (650m2)*(£11.40)	£7,410.00
Total additional revenue	**£120,037.78**	**Total cost**	**£122,358.08**
		Net value=additional revenue-total cost=	-£2,320.30

Additional revenue

Amount of heads for simulation size small 100 big 200 heads, Meat yield/kg = 430 kg from one cattle carcass, Meat price/ carcass = WTP * Meat yield, Total extra revenue = amount of heads * meat price/ carcass, Certification space = 6.5 m^2, Total space area = amount of heads * certification space, Conventional farming space = 4.5m^2, Total animals foregone = (conventional space / total space) – 100, Animal purchase cost = the original cost for buying a cattle, cost of previous heads = Total animals foregone * Animal purchase cost.

Reduced costs

Operating cost*1539 = 1539 $ operating cost * Total previous animals.

Revenues foregone

Total animal yield foregone *6£ = Total animals foregone* meat yield * the price conventional meat/ kg.

Additional cost

Certification initial cost = £119.00, Certification annual cost = £154.91, Iron level monitoring (5£/10animal) = amount depends on sampling plan (this case it is 15 animals), Floors (650m2)*(11.40£) = £7,410.00.

4. 3.3. Probability of contamination

The probability of contamination was used to calculate the risk of exceeding the legal microbial limits of different contaminants (*Salmonella, Campylobacter* and *Toxoplasma gondii*) in conversion to free-range production. The probability was taken from the probability of infection and calculated by applying a dose-response model. This model represents a simple derivation of the actually complex correlation of dose and the adverse effects caused by microbial organisms. There are several dose-response models, each with their own attributes (Browen and Stringer 2000). For the purpose of this research, two models were used - the Beta-Poisson Model and the Exponential Model. The Beta- Poisson Model was used for *Salmonella, Campylobacter* and the Exponential Model was used for *Toxoplasma gondii*. Both models are commonly used in microbial risk assessment as part of the hazard characterisation

.

(1) Beta- Poisson model $\mathbf{P = 1 - \left[1 + dose \left(\frac{\left(\frac{2*1}{\alpha}\right)-1}{N50}\right)\right]^{-a}}$

- **dose** = $\boldsymbol{infection\ dose * contact\ rate}$
- **contact rate** = $\frac{\mathbf{(contact * prevalence)}}{\mathbf{100}}$

The Beta- Poisson model (1) was applied for *Salmonella* and *Campylobacter* using data collected from the literature review (Table 5). In the model, P is the probability of contamination, α and N50 are constants derived from the literature, where N50 is a dose that will affect 50% of the population, and α is the probability of pathogen survival. Dose was calculated by multiplying the infection dose with contact rate, where the contact rate is the total consumed amount of meat per person per year multiplied with the prevalence percentage of positive samples in carcasses.

(2) Exponential model **P = 1 – exp (-k x dose)**

- **dose** = $\boldsymbol{infection\ dose * contact\ rate}$
- **contact rate** = $\frac{\mathbf{(contact * prevalence)}}{\mathbf{100}}$

The Exponential Model (2) was applied for *Toxoplasma gondii* using data collected from literature review (Table 5). In this model, P is probability of contamination, K is a constant derived from the literature, where K is the probability of pathogen survival. For the dose, the same calculation as the Beta- Poisson Model was used.

Table 6. Calculated attributes for probability of contamination.

Infection dose (CFU/ocet)			
Salmonella	1000		
Campylobacter	10		
Toxoplasma	10		
Contact rate			
	Salmonella	*Campylobacter*	*Toxoplasma*
NL	39.8278	68.4931	5.01866
UK	24.676	39.9592	3.98
GR	33.661	62.9707	3.8587
Dose			
	Salmonella	*Campylobacter*	*Toxoplasma*
NL	39827.8	684.931	50.1866
UK	24676	399.592	39.8
GR	33661	629.707	38.587

Table 7. Results from dose-response models.

Probability			
	Salmonella	*Campylobacter*	*Toxoplasma*
NL	0.59	0.29	0.73
UK	0.55	0.24	0.66
GR	0.57	0.28	0.63

Probability of free-range meat being contaminated.

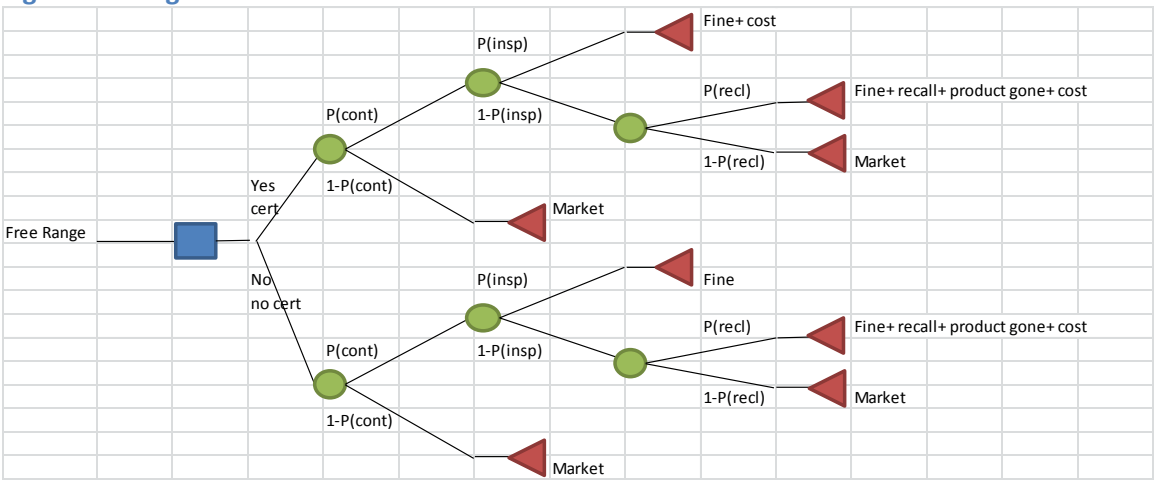
4. 3.4. Decision tree and EMV

As part of the simulation study, a decision tree was developed to identify the Expected Monetary Value (EMV) of investing in free-range meats. Decision trees are tools that provide insight into the EMV of stochastic events, which, in this case, can help producers to understand the risk and profit of investing in free-range meat. In the decision tree, the EMV was calculated

from the probability of contamination for *Salmonella, Campylobacter* and *Toxoplasma gondii*, and then compared to that associated with conventional farming.

The tree consists of decision nodes and their outcomes with separated results, depending on the occurrence probability of each node. Therefore, there are sub-trees from each decision and probability with different results for cost or revenue Figure 4. The EMV was calculated from the results of partial budgeting, which were multiplied by the probability of each decision (Figure 4) (Table 8). Additional costs or revenue of EMV 'yes' (free-range) was compared with 'no' (conventional) to arrive at an appropriate decision.

Figure 4. Design of the EMV decision tree.



Cert certification, P probability of occurrence, 1-P probability of not occurring, (cont) contamination, (insp) inspection, (recl) product withdrawal or recall.

Table 8. Attributes used in EMV.

NL								
Probability table			Pay-off table (catlle)			Pay-off table (pork)		
Salmonella			*Small			*Small		
	no certifa	invest in certificatio	no cert	cert			no cert	cert
1-P(cont)	0.71	0.41	cost	0	-574	cost	0	-11866
P(cont)	0.29	0.59	P(insp)	-10000	-10000	P(insp)	-10000	-10000
Campylobacter			P(recal)	-11000	-53811	P(recal)	-11000	-27499
	no certifa	invest in c	1-P(cont)	0	43811	1-P(cont)	0	16499
1-P(cont)	0.85	0.71	*Large			*Large		
P(cont)	0.15	0.29		no cert	cert		no cert	cert
Toxoplasma gondii			cost	0	-4104	cost	0	-26697
	no certifa	invest in c	P(insp)	-10000	-10000	P(insp)	-10000	-10000
1-P(cont)	0.76	0.27	P(recal)	-11000	-89622	P(recal)	-11000	-34998
P(cont)	0.24	0.73	1-P(cont)	0	87622	1-P(cont)	0	32998

Cert certification, P probability of occurrence, 1-P probability of not occurring, (cont) contamination, (insp) inspection, (recl) product withdrawal or recall.

Table 8 represents the figures used in the EMV for the Netherlands Beter Leven certification. The figures were calculated using the same order shown in decision tree (Figure 4). The data used was derived from literature review (Table 4), partial budgeting (Table 3) and probability of contamination (Table 5).

The probability decision nodes implemented in the tree included probability contamination, inspection and recall. In the probability of contamination a calculation was made from prevalence of each pathogen in free-range meats. The initial node ('yes'/'no') represented the decision on whether to convert farm production method to free-range or not. The probability of contamination was added to assess the effect of market sales of non-contaminated products. If product contamination occurred, inspection would be required. If the outcome of this inspection was positive (contamination confirmed) a fine would be incurred by the producer. Finally, if the contaminated product was not detected in the inspection, it would enter the market. Thus, the last probability would be the chance of recall. If not recalled, the product would enter the market (Figure 5). The difference in criteria is set for each certification and country depending on cost of investment in free-range meat production.

4.4 Evolution of an outbreak

A calculation of the direct costs and benefits helps to assess the economic impact of an outbreak due to unconventional contaminants. Direct costs of an outbreak are acquired by the sum of loss in expected contaminated products, cost of treatments and cost of preventive measures (BENNETT, CHRISTIANSEN, and CLIFTON-HADLEY 1999, McInerney, Howe, and Schepers 1992).

The attributes used to assess the direct costs in this research were derived from the partial budgeting. The measurement included additional costs and the costs for withdrawing the products from the market. In addition, the outcome would depend on any fine on exceeding legal limits. Lastly, the impact of public perception towards free-range meat outbreaks and the effect on the certification acceptance were considered.

5 Results

5.1. Results from comparative review

In the comparative review, a gap in legislation can be identified between the EU food laws and private standards imposed by the free-range certification schemes. According to the literature review, the laws regulating free-range production mainly cover labelling ((EC) No 543/2008). This supports certain free-range production methods that are focused on space and slaughter age criteria, but do not take into account the specific microbial risks associated with free-range production. There are only four types of EU regulations mentioned, namely labelling in each of the EU Member States, non-organic contaminates, sampling plan for *Campylobacter* and two products with geographical indication ((EU) No 1308/2013; (EU) No 1190/2012; (EU) No 711/2013; (EU) No 1174/2012; (EU) No 1054/2012). All the regulations mentioned in European food law are intended for free-range poultry production.

When comparing local guidelines in EU Member States with EU regulations, they did not provide any additional information. However, they did provide extended information on each of the EU Member State certification schemes. Moreover, the local guidelines provided more information on the differences between star-rating systems. However, the logistic slaughtering

guidelines generally prevent cross-contamination as a preventive measure as part of general slaughterhouse practice.

In organic production, legislation requires the separation of organic from non-organic products in all stages of production and all kinds of products (e.g. fruits and vegetables) ((EC) No 834/2007). Whereas in free-range production, nothing is specified about separation, except in the private certification standards. However, the private standards only focus on the separation of free-range meats from non-free-range in processing and packaging. This separation is considered important, especially in catering industry and restaurants, as they are listed in some of the schemes as potential client. Furthermore, vegetables that are conventionally produced[19] are mixed with free-range meats in ready-to-eat and pre-cooked meals, which could render free-range meats as a source of contamination[20].

Notably, private standards do not differ too much from the regular scope except that they provide more detailed information on production criteria. Moreover, the only criterion for microbial contaminants is that during slaughtering, the producers must comply with the hygiene requirements set by the EC. In addition, one of the standards (Freedom Food) contains a clear indication about not allowing domestic animals near the animals grazing and housing areas.

Lastly, but not least, all the EC laws, EU Member State guidelines and private third-party standards, share one similarity, namely no specification of how to manage the higher microbial load associated with free-range production.

5.2. Decision analyses

5.2.1. Partial budgeting

In general, the analysis in general shows that the NV is higher in cattle and in higher certification star-ratings. Furthermore, cattle NV is higher than pork (i.e. 50% higher than pork production) as the meat yield expected from cattle and price per kg is higher. However, the results were negative for the UK Cattle (Table 9).

[19] Have lower microbial level than free-range
[20] Have a higher microbial level that will make free-range meat a contaminant.

Moreover, for the UK (Freedom Food) the NV was also negative, for two reasons. Firstly, the revenue for conventional animal yield foregone (i.e. in the UK, higher conventional meat production price per kg) is higher than the Netherlands and Germany. Secondly, the license fees (0.3% on all profits), which is the only extra fee a farmer will incur when compared with the rest of the certification costs.

The results of calculated revenues in the partial budgeting for Netherlands and Germany are higher, because of lower animal yield foregone and the star-rating system of these countries' certification schemes. The higher amount of revenue due to the certification scheme star-rating is derived from the higher selling price per kg of meat. Which amount to 50% more as more stars are gained in both schemes for small- and large animal production.

Table 9. Partial budgeting results.

UK £		
	Cattle	Pork
Small	-2,320.30	-10,590.06
Large	-5,481.72	-9,216.65
NL * €		
	Cattle	Pork
Small	43,236.70	8,747.70
Large	83,517.90	14,539.90
NL ** €		
	Cattle	Pork
Small	117,069.64	13,535.70
Large	231,183.79	24,115.90
NL *** €		
	Cattle	Pork
Small	180,075.26	21,002.20
Large	187,250.57	22,591.76
GR €		
Pork		
	*	**
Small	12,027.63	8,302.50
Large	24,260.25	16,810

Table 9 shows the results from partial budgeting. The results illustrate the possibilities for the farmer to switch towards free-range production, with respect to budgeting for the cost of

the conversion. The outcome is represented in NV that indicates profit for the first year. In the Table, negative results represent loss; also for the UK the calculation is based on pounds sterling, whereas Euros are used for calculations from the Netherlands and Germany.

5.2.2 Decision tree and EMV

Results from the decision tree (EMV) on whether to invest in free-range certification are provided in Tables 10, 11 and 12. The free-range EMV was calculated for both beef and pork, with probability of contamination with *Salmonella, Campylobacter* and *Toxoplasma gondii*. They were also obtained from three different countries: the Netherlands (table 10), UK (Table 11) and Germany (Table 12). The results indicate whether it is profitable for a meat producer to invest in free-range certification, given the conditions of the high probability of microbial contamination.

The EMV for free-range production and certification in the Netherlands (Table 10), show that the probability of *Salmonella* and *Campylobacter* contamination are all positive for both cattle and pork. In the event of *Toxoplasma gondii* contamination the results for pork is negative, thus suggesting free-range pork production with this contaminant becomes not profitable.

Results for the UK EMV calculation of free-range production and certification (Table 11), shows that the probability of *Campylobacter* contamination of beef is higher than the *Salmonella*. In pork production, the results are negative for *Salmonella,* although in *Campylobacter* contamination is positive. Also, in the event of *Toxoplasma gondii* contamination the results for both beef and pork are negative and very costly.

In Germany, only pork EMV was calculated because the certification scheme covers the production of pork and chickens only (Table 12). The EMV in the event of *Salmonella* and *Campylobacter* contamination is positive. However, in the event of *Toxoplasma gondii* contamination*,* the EMV is much lower than conventional production.

The results show that investing in pork production poses a much higher risk, because of the high probability of contamination with *Toxoplasma gondii.*

Table 10. Results from the EMV calculation for Beter Leven free-range certification, accounting for the probability of contamination in the Netherlands.

The Netherlands				
EMV €		1 star	2 star	3 star
Salmonella				
Beef	Small	14,811.99	37,510.07	79,284.27
	Large	34,082.73	77,414.01	91,285.27
Pork	Small	-45.38	2,068.19	8,428.78
	Large	4,955.3	6,533.43	12,504.38
Campylobacter				
Beef	Small	29,557.25	78,052.74	170,140.9
	Large	61,306.09	157,282.6	220,798.2
Pork	Small	8,367.01	16,236.23	28,855.34
	Large	19,214.3	33,654.74	47,203.51
Toxoplasma gondii				
Beef	Small	7,930.86	18,590.15	36,884.51
	large	21,378.5	40,141.97	30,845.9
Pork	Small	-3,971.17	-16,561	-1,103.6
	Large	-1,698.89	-2,761.2	-3,688.55

Table 11. Results from the EMV calculation for Freedom Food free-range certification, accounting for the probability of contamination in the United Kingdom.

United Kingdom		
EMV £		
Salmonella		
Beef	Small	12,463.6
	Large	28,717.67
Pork	Small	-4,357.2
	Large	-2,239.91
Campylobacter		
Beef	Small	67,161.94
	Large	166,705.6
Pork	Small	7,263.57
	Large	16,055.97
Toxoplasma gondii		
Beef	Small	-13,062.3
	large	-35,676.7
Pork	Small	-9,780.23
	Large	-10,778

Table 12. Results from the EMV calculation for Fur Mehr Tierschuntz free-range certification, accounting for the probability of contamination in the Germany.

Germany			
EMV €		1 star	2 star
Salmonella			
Pork	Small	2,675.29	3,713.98
	Large	3,713.98	10,763.25
Campylobacter			
Pork	Small	12,051.92	22,312.47
	Large	22,312.47	46,264.31
Toxoplasma gondii			
Pork	Small	-1,700.47	-4,965.31
	large	-4,965.31	-5,803.91

The results from (Table 10, 11 and 12) EMV calculation represent the outcome for the farmer decision to transform to free-range production with the probability of contamination in *Salmonella, Campylobacter* and *Toxoplasma gondii*. Accounting for the probability of contamination in the Netherlands, United Kingdom and Germany. The amount shown in red represent loss from the high probability of product withdrawn or outbreak because of high microbial levels.

5.3. In the eventuality of an outbreak

The direct costs resulting in the case of an outbreak were derived from partial budgeting. To calculate the chance of an outbreak, the probability of contamination was multiplied by the probability of not detecting the contaminated product during inspection and the probability of no product recall from the market. The probabilities of contaminated products reaching the market during the first year were 29% for *Salmonella*, 14% for *Campylobacter* and 35% for *Toxoplasma gondii*. Therefore, a farmer who wants to invest in free-range production must first factor in an average 26% of likely contamination during the first year of production. The total cost differs from with country, and for the certification star-rating[21] in each scheme (Table 13). The total cost of an eventual outbreak was calculated from the cost of production and losses of that expected revenue from contamination products, which can be seen if cattle farms are

[21] The higher the certification star-rating, the more probability the farmer has to cover the costs.

compared with pork in amount of loss, because of high animal yield. However, the total cost is calculated without regard to loss of the farm's goodwill (i.e. loss of farmer's reputation and depreciation of label value).

Table 13. Costs associated with free-range certification in the eventuality of an outbreak.

	(Freedom Food) UK[1]	(Beter Leven) Netherlands			(Fur Mehr Tierschutz) Germany	
		*	**	***	*	**
Pigs						
small	£29,497	€27,499	€40,932	€59,601	€32,116	€51,291
big	£44,742	€34,998	€70,872	€91,746	€53,232	€91,582
Cattle						
small	£131,037	€53,811	€128,244	€268,969		
big	£311,094	€89,622	€245,489	€356,994		

* amount of stars granted by certification.

Table 13 shows an estimate cost in the eventuality of an outbreak or product withdrawal from the market. The statements are shown in Pounds Sterling for the UK and Euros for the Netherlands and Germany.

In the eventuality of outbreaks in free-range production systems, losses do not exclusively affect the individual farm, but also affect all businesses within that particular certification scheme. Consumers associate other certified businesses within the same scheme in their perceived view of free-range and this can be reflected in their buying choices[22]. This is important as all products labelled with the same certification can encounter resultant loss.

[22] Other certified business for free-range meats

6. Discussion

6.1. Legislation

The main goal in current legislation is to enhance the sustainability of food production through supporting sustainable production methods. Free-range is one of these methods. However, it is not the dominant sustainable method, as organic production is perceived as a more mature farming practice that produces a wider range of food varieties (e.g. vegetables, fruits and tea). Furthermore, organic certification is still the major 'sustainability certification' in terms of business and high profits. Therefore, legislation includes more organic specific criteria than free-range, and free-range legislation includes less details. Organic production legislation focuses on production standards to ensure correct labelling, and also mandates separation in all stages of the production chain. Thus, it can enhance traceability of products and help prevent cross-contamination. This is particularly important for restaurants and the catering business[23]. Moreover, the perception is that organic production results in the same probability of contamination as conventional products without the variation between high and low microbial levels, as seen in free-range production. This is important because conventionally produced foods of all kinds can be easily cross-contaminated[24].

Another important result is the incompatibility between certification standards with regard to domestic animals access to farms, seen also in the literature review[25] as one of the main sources of contamination (*Toxoplasma gondii*). This can be seen in both Beter Leven and Für Mehr Tierschutz certifications, whereas Freedom Food prohibits domestic animals` access to the farm. Since Freedom Food was established earlier, it reflects a higher level of practical experience as is evident from the fact that its standards are more detailed than the other two certification schemes.

Due to language limitations, not all of the information available could be included in the report. However, the main regulations were examined and analysed. This included their labelling criteria and explanation, the star-rating in relevant certification schemes and its

[23] When making ready to eat meals other ingredients are also organic with same microbial load.
[24] Conventionally produced products are grown in controlled environment with a lower exposure than free-range produced meats.
[25] Check section 3.1.3 in the literature review.

content. Most of the legislation studied did not include preventive procedures or mention the unconventional microbial risks associated with free-range.

According to the results, the EU and EU Member States food legislation cover only poultry production (i.e. free-range production main and mature business is poultry and eggs). In addition, poultry production legislation included no specific criteria for preventing or controlling risks associated with other types of meat business. The EU GFL holds the potential to covers any gaps in other legislation, but still does not address preventive measures specific to free-range production. Thus for free-range business- and certification bodies, the current legislation increases the risk of fines, as it does not include any measures to prevent or reduce contamination, but only detect the incidence of microbial infections. This does may even contribute towards accelerating disease outbreaks should they occur.

6.2 Decision simulation study analysis

6.2.1 Probability of contamination

The microbial results for probability of contamination were a key figure in determining the decision analysis associated with free-range meats. However, an important indication in the extent that the probability of contamination could reach was seen. Results for *Salmonella* and *Toxoplasma gondii* were as anticipated, but those for Campylobacter were surprising. Whilst the probability of contamination for *Campylobacter* was significant, it was the lowest of the three, and was lower than expected, especially since it is considered a major environmental contaminant (Adams and Moss 2010). As expected, *Toxoplasma gondii* was the highest of the three, and was initially established to be the main source of contamination for free-range meats[26]. In general, most of the results resemble realistic microbial prevalence from the cases examined for free-range production in the literature review. Although the contamination prevalence focused mostly on three countries, the probability still shows a similarity for each type of microbe, which supports the results. However, there are some data limitations as two of the microbe prevalence's were taken from countries close to them, namely Switzerland and Spain. Another aspect not examined was the prevalence within the certification scheme's star-

[26] Check section 2.8 in the introduction.

rating. In the certification schemes the higher the star the more outdoor interaction. Thus, the exposure to pathogens is higher. Also, some of the prevalence numbers referred to poultry meats as they are closest to the environmental exposure values[27]. Therefore, a microbial risk assessment for the specific products under analysis could have enhanced the accuracy of the results.

6.2.2 Partial budgeting

The analysis also considered partial budgeting, which was used to provide a key indication of the costs and the revenue from free-range production during the first year of operation. The NV included the costs of the conversion to free-range for most of the certifications (except Freedom Food)[28]. Also, without accounting for the risk of contamination, the total NV for pork was high, rendering it profitable only if potential fines are excluded from consideration. The added value for these results was the premium that farms with higher certification scheme star-rating can receive for their products. However, the NV is only relevant for the first year of conversion, therefore, the results of partial budgeting cannot be applied for a second year. This means that the NV will be higher in subsequent production years for all three certification schemes, as the farmer does not bear conversion costs or revenue foregone from animal yield.

One of the limitations of the simulation is the WTP. The data was taken from single examples in each country. Likewise, with iron blood check costs, the prices were taken from a single veterinary clinic in each country, except the Netherlands. Nevertheless, they were similar between Germany and Netherlands (Table 3). Another perspective is that iron blood checks are not required as long as the animals are accessing outdoor areas, since iron blood levels will be sufficient. Despite, the high NV and limitations of the data, it is still profitable with regard to the risks associated with free-range production.

[27] Has the same exposure with the environment contaminants.

[28] Because of the revenue percentage fee they require for the logo right.

6.2.3 EMV

The EMV results have a pattern that is similar to results from partial budgeting, except for *Toxoplasma gondii* in pork. These results show the same pattern regarding EMV between certifications, as farms with a higher certification scheme star-rating can achieve a higher revenue. However, the outbreak percentage was fixed at 0.5, which may not be an exact percentage. Moreover, the costs associated with the outbreak outcome included transport costs and fines, plus the total costs and revenue for the product. These costs did not incorporate possible effects on the certification goodwill or costs in the processing level (i.e. the costs incurred by stopping and disinfecting process lines). Another limitation is the fines for non-compliance with microbial legal limits in the Netherlands and Germany.

From a business perspective, it is clear that investing in free range certification is highly profitable. Moreover, it gives opportunity to enter new markets. Two of the certification schemes were very recently developed (Beter Leven and Für Mehr Tierschutz)(Bescherming 2014, Tierschutz 2014a). Especially for cattle producers, as EMV covers any risk probability costs, but also the costs for the conversion from conventional to free-range. Furthermore, the deference between the star-ratings gives an even higher EMV as selling prices, and in Beter Leven the cost of certification would be lesser. In contrast with cattle, pig producers should take in mined the negative EMV associated with *Toxoplasma gondii*. The star-rating schemes reduce the costs of risks loss, but not entirely, as the higher selling prices will decrease loss.

The EMV results indicate that there is a higher probability of contamination especially in pork. However, free-range pork products are still abundant on the market. This can be explained by the 'tip of the iceberg theory', which states that not all food borne illness is reported, and reported cases are the 'tip of the iceberg', since symptoms are usually mild, and do not require a visit to the doctor. Also, most of the meats used in pre-cooked foods and ready-to-eat meals in retail and catering industries are derived from cattle. Another factor is that consumption rate is not as high as of conventional products. Also, it is hard to change consumers' perspectives about free-range, which is that the products are considered 'natural', and is believed to offer benefits. This consumer belief could be compared with that of botanical supplements, which are also not fully regulated. Whilst some have subsequently been proven to be harmful, consumer

perception of this danger changes only slowly. Finally, a specific high risk group not evaluated with EMV results are pregnant women. *Toxoplasma gondii* infection can cause abortion. Unfortunately, no certification schemes address this issue or include any preventive measures to reduce the risk of infection for this specific group. Furthermore, the analysis did not take into account the physical properties of the various product forms e.g.: processed meats. These types are usually considered a high risk food because of the distribution of commitments within the specific production chain.

6.3 In the eventuality of an outbreak

Although the outbreak probability is fixed, the results of the EMV resemble the probability of contamination and case studies done in literature. The average probabilities that a contaminated product reaches food retail market were *Salmonella* 29.3%, *Campylobacter* 14.4% and *Toxoplasma gondii* 35%. These percentages are high, but show a realistic resemblance, as mentioned, with prevalence analysis in the literature review, especially for *Toxoplasma gondii.*

7. Conclusion and suggestions for future research

This research provides an insight into the costs and benefits associated with free-range certification and the hazards that can be associated with this production method. Free-range meats have a higher probability of contamination than conventional meat products. Such hazards can be prevented through compliance with GFL regulation ((EC) 178/2002); nevertheless, they cannot be reduced. Current free-range laws focus on label trustworthiness. However, in the eventuality of an outbreak, the revenue expected from free-range meats would be able to cover any incidental costs. Conversely, these benefits do not apply with pork producers, as the EMV is lower than cattle. Therefore, pork producers are more financially-vulnerable in case of an outbreak. Although free-range is associated with different types of risks, consumer's trustworthiness towards this method of production continues to remain strong.

The research focused on a limited number of certified beef- and pork meat products; other products, such as poultry fish and lamb were not included. These other products are

exposed to the same elements of microbial contamination as cattle and pigs. From a microbial perspective, there would appear to be a need for a specified free-range risk assessment for *Salmonella, Campylobacter and Toxoplasma gondii.* From a legal perspective, a policy option might be to include separation of free-range meats from all varieties of conventional products at all stages of the production chain. Another policy option might be to prohibit domestic animals (the main hosts for *Toxoplasma gondii* contamination, for example) from accessing farm areas. Also, legislation could be expanded to cover the production of other variety of free-range meat, as its current, specific focus is on poultry meat and eggs only. Moreover, labels could carry specific and clear warnings for the YOPI group, as consumption of free-range meats could have an enhanced impact on their health.

References

Adams, Martin R, and Maurice O Moss. 2010. *Food Microbiology*. Edited by third. Guildford RSCP Publishing.

Athanasios Krystallis, Klaus G. Grunert, Marcia D. de Barcellos, Toula Perrea, and Wim Verbeke. 2012. "Consumer attitudes towards sustainability aspects of food production: Insights from three continents." *Journal of Marketing Management* no. 28 (3-4):334-372.

Bailey, J. S., and D. E. Cosby. 2005. "Salmonella Prevalence in Free-Range and Certified Organic Chickens." *Journal of Food Protection* no. 68 (11):2451-2453.

Bee, G., G. Guex, and W. Herzog. 2004. "Free-range rearing of pigs during the winter: Adaptations in muscle fiber characteristics and effects on adipose tissue composition and meat quality traits." *Journal of Animal Science* no. 82 (4):1206-1218.

Bennett, Richard M, Kathy Christiansen, and Richard S Clifton-Hadley. 1999. "Estimating the costs associated with endemic diseases of dairy cattle." *Journal of Dairy Research* no. 66 (03):455-459.

Berger-Schoch, AE, DC Herrmann, G Schares, N Müller, D Bernet, B Gottstein, and CF Frey. 2011. "Prevalence and genotypes of< i> Toxoplasma gondii in feline faeces (oocysts) and meat from sheep, cattle and pigs in Switzerland." *Veterinary parasitology* no. 177 (3):290-297.

Bescherming, Dieren. 2014. *Beter Leven: succesverhaal* Het Verenigingsbureau van de Dierenbescherming 2014 [cited May 2014]. Available from http://www.dierenbescherming.nl/beter-leven

Beter-Leven. 2014. *Kort overzicht belangrijkste verschillen in welzijn tussen gangbare varkenshouderij en varkenshouderij met Beter Leven kenmerk van de Dierenbescherming met 1, 2 of 3 sterren*. Dieren Bescherming 2013 [cited January 2014]. Available from http://beterleven.dierenbescherming.nl/fileupload/Criteria/20111219-varkensvlees-1-ster.pdf.

Black, Robert E, Myron M Levine, Mary Lou Clements, Timothy P Hughes, and Martin J Blaser. 1988. "Experimental Campylobacter jejuni infection in humans." *Journal of infectious diseases* no. 157 (3):472-479.

Blumsack, Seth. 2014. *Expected Monetary Value and Value at Risk*. The Pennsylvania State University 2014 [cited August 2014]. Available from https://www.e-education.psu.edu/eme801/node/578.

BMEL. 2013. Bekanntmachung der Liste risikobewerteter Spender- und Empfängerorganismen für gentechnische Arbeiten. edited by Landwirtschaft und Verbraucherschutz Das Bundesministerium für Ernährung and Kommission für die Biologische Sicherheit.

Braghieri, A, C Pacelli, N Piazzolla, A Girolami, and F Napolitano. 2013. "Eating quality of beef from free-range and confined Podolian young bulls." *Journal of animal science* no. 91 (12):5885-5893.

Browen, Martyn, and Mike Stringer. 2000. *Microbiological Risk Assessment in Food Processing*. Edited by Third. New York: CRC Press LLC.

Brown, Felicity. 2009. Meat consumption per capita. *the Guardian*, 2 September

BVL. 2008. Bericht gem. Artikel 21 Abs. 2 der Verordnung (EG) Nr. 2006/2004 für die Jahre 2007/2008. Bundesamtes für Verbraucherschutz und Lebensmittelsicherheit.

Cameron, A. R. 2012. Harmonised epidemiological indicators for poultry slaughter: case studies for Salmonella and Campylobacter. edited by EN-294: AusVet Animal Health Services

Clinic, Samen Beter. 2014a. Iron Blood Check. In *Telephone interview*, edited by Majed AlMuhanna.

Clinic, The Scott Veterinary. 2014b. Iron Blood Check. In *Telephone interview*, edited by Majed AlMuhanna.

Colles, FM, KE Dingle, AJ Cody, and MCJ Maiden. 2008. "Comparison of Campylobacter populations in wild geese with those in starlings and free-range poultry on the same farm." *Applied and environmental microbiology* no. 74 (11):3583-3590.

Colles, Frances M, Noel D McCarthy, Samuel K Sheppard, Ruth Layton, and Martin CJ Maiden. 2010. "Comparison of< i> Campylobacter</i> populations isolated from a free-range broiler flock before and after slaughter." *International journal of food microbiology* no. 137 (2):259-264.

Davies, Robert H, and Mark Breslin. 2003. "Persistence of Salmonella Enteritidis Phage Type 4 in the environment and arthropod vectors on an empty free-range chicken farm." *Environmental microbiology* no. 5 (2):79-84.

De Krom, Michiel PMM, and Peter Oosterveer. 2010. "Contesting risk and responsibility: European debates on food and agricultural governance of avian influenza." *Nature and Culture* no. 5 (2):175-195.

Development, Directorate-General for Agriculture and Rural. 2009. Production Costs and Margins of Pig Fattening Farms - 2008 Report. edited by perspectives and evaluations L.3. Microeconomic analysis of EU agricultural holdings Directorate L. Economic analysis. Brussels: European commission.

Development, Directorate-general for Agriculture and Rural. 2013. EU beef farms report 2012 based on FADN data. edited by perspectives and evaluations L.3. Microeconomic analysis of EU agricultural holdings Directorate L. Economic analysis. Brussels: European Commission.

Dickinson, David L, and DeeVon Bailey. 2003. "Willingness-to-pay for information: Experimental evidence on product traceability from the USA, Canada, the UK and Japan." *Economic Research Study Paper ERI* no. 12.

EFSA, and ECDC. 2012. The European Union Summary Report on Trends and Sources of Zoonoses, Zoonotic Agents and Food-borne Outbreaks in 2012. In *Scientific Report of EFSA and ECDC*: European Food Safety Authority European Centre for Disease Prevention and Control.

Ehui, S, and B Rey. 1992. "Partial budget analysis for on-station and on-farm small ruminant production systems research: Method and data requirements."

Esteban, Jon I, Beatriz Oporto, Gorka Aduriz, Ramón A Juste, and Ana Hurtado. 2008. "A survey of food-borne pathogens in free-range poultry farms." *International journal of food microbiology* no. 123 (1):177-182.

Food, Freedom. 2014. *Licence Fee Protocol*. The Royal Society for the Prevention of Cruelty to Animals 2010a [cited January 2014]. Available from http://www.freedomfood.co.uk/media/15058/licence_fee_protocol.pdf

Food, Freedom. 2014. *new standards and guidance for the rearing of pigs*. The Royal Society for the Prevention of Cruelty to Animals 2010b [cited January 2014]. Available from http://www.freedomfood.co.uk/media/9318/pigs.pdf

Food, Freedom. 2014. *RSPCA welfare stanards for beef cattle - new standards and guidance for the rearing of calves*. The Royal Society for the Prevention of Cruelty to Animals 2010c [cited January 2014]. Available from http://www.freedomfood.co.uk/media/34782/RSPCA_welfare_standards_for_beef_cattle_2010___including_CCTV_and_calf_standards_2013.pdf.

Food, Freedom. 2014. *NSF-CMi Certification Freedom Food Scheme Schedule 1—Charges* The Royal Society for the Prevention of Cruelty to Animals 2012 [cited January 2014]. Available from http://www.freedomfood.co.uk/media/15043/charges_sheet_freedom_food.pdf

Food, Freedom. 2014. *Good welfare is good business*. The Royal Society for the Prevention of Cruelty to Animals 2014a [cited January 2014]. Available from http://www.freedomfood.co.uk/industry/benefits

Food, Freedom. 2014. *RSPCA Welfare Standards*. The Royal Society for the Prevention of Cruelty to Animals 2014b [cited January 2014]. Available from http://www.freedomfood.co.uk/industry/rspca-welfare-standards

Franklin, Marcy. 2012. Making Sense of Food Labels. *New York Times*.

Goutard, F, M Paul, S Tavorapanich, KDC Stärk, and F Roger. 2011. "Assessment of the Avian Influenza H5N1 surveillance system for backyard and free-range poultry production systems in Thailand." *Épidémiologie et Santé Animale* (59/60):422-424.

Grunert, Klaus G. 2006. "Future trends and consumer lifestyles with regard to meat consumption." *Meat Science* no. 74 (1):149-160.

Hernández, M, J Gómez-Laguna, C Tarradas, I Luque, R García-Valverde, L Reguillo, and RJ Astorga. 2013. "A serological Survey of Brucella spp., Salmonella spp., Toxoplasma gondii and Trichinella spp. in Iberian Fattening Pigs Reared in Free-Range Systems." *Transboundary and emerging diseases*.

Horst., Dierenartsenpraktijk. 2014. Iron Blood Check. In *Telephone interview*, edited by Majed AlMuhanna.

James, M Jay, J Loessner Martin, and A golden David. 2005. *Modern Food Microbiology*. Edited by Seventh. New York: Springer Sicense + Business Media.

Jones, DR, KE Anderson, and JY Guard. 2012. "Prevalence of coliforms, Salmonella, Listeria, and Campylobacter associated with eggs and the environment of conventional cage and free-range egg production." *Poultry science* no. 91 (5):1195-1202.

Kijlstra, A, BG Meerburg, and AP Bos. 2009. "Food safety in free-range and organic livestock systems: Risk management and responsibility." *Journal of Food Protection®* no. 72 (12):2629-2637.

Kijlstra, Aize, Okke A Eissen, Jan Cornelissen, Klaske Munniksma, Ineke Eijck, and Titia Kortbeek. 2004. "Toxoplasma gondii infection in animal-friendly pig production systems." *Investigative ophthalmology & visual science* no. 45 (9):3165-3169.

Landwirtschaft, BMEL Bundesministerium für Ernährung und. 2014. *BMEL Bunterstützt ein eigenständiges Tierschutzlabel*. BMEL unterstützt ein eigenständiges Tierschutzlabel 2014 [cited May 2014]. Available from http://www.bmel.de/DE/Tier/1_Tierschutz/_texte/Tierschutzlabel.html.

Lebensmittelsicherheit, Bundesamt fur Verbraucherschutz und. 2009. Berichte zum Wirtschaftlichen Verbraucherschutz 2007/2008. In *Berichte zum Wirtschaftlichen Verbraucherschutz* Dienststelle Braunschweig: Bundesamt für Verbraucherschutz und Lebensmittelsicherheit (BVL).

Leven, Beter. 2014. *Dierenwelzijnsnormen voor vleeskalveren met 1 ster*. Dieren Bescherming 2010 [cited January 2014]. Available from http://beterleven.dierenbescherming.nl/fileupload/FD_Criteria_vleeskalveren_1_ster_20101209.pdf.

Leven, Beter. 2014. *Normen voor kalverslachterij/ uitsnijderij / verwerker* Dieren bBscherming 2011 [cited January 2014]. Available from http://beterleven.dierenbescherming.nl/fileupload/FD_Criteria_kalverslachterij_uitsnijderij_verwerker_20111205.pdf.

Leven, Beter. 2014. *Kostendoorberekening Beter Leven kenmerk 2014*. Dieren Bescherming 2014 [cited January 2014]. Available from http://beterleven.dierenbescherming.nl/fileupload/Kostendoorberekening_2014.pdf.

Lewsey, David. 2002. MAVIS news. *Medicines Act Veterinary Information Service*, July, 24.

Luning, Pieternel A , and Willem J Marcelis. 2011. *Food Quality Management Technological and Managerial Principles and Practices*. Edited by Second. Wageningen Wageningen Academic Publishers.

Lusk, Jayson L, Jutta Roosen, and John A Fox. 2003. "Demand for beef from cattle administered growth hormones or fed genetically modified corn: a comparison of consumers in France, Germany, the United Kingdom, and the United States." *American Journal of Agricultural Economics* no. 85 (1):16-29.

McCullough, Norman B, and C Wesley Elsele. 1951. "Experimental human salmonellosis: I. Pathogenicity of strains of Salmonella meleagridis and Salmonella anatum obtained from spray-dried whole egg." *The Journal of infectious diseases*:278-289.

McInerney, JP, KS Howe, and JA Schepers. 1992. "A framework for the economic analysis of disease in farm livestock." *Preventive Veterinary Medicine* no. 13 (2):137-154.

Meuwissen, Miranda PM, Ivo A Van Der Lans, and Ruud BM Huirne. 2007. "Consumer preferences for pork supply chain attributes." *NJAS-Wageningen Journal of Life Sciences* no. 54 (3):293-312.

Nilzén, V, J Babol, PC Dutta, N Lundeheim, AC Enfält, and K Lundström. 2001. "Free range rearing of pigs with access to pasture grazing—effect on fatty acid composition and lipid oxidation products." *Meat Science* no. 58 (3):267-275.

NVWA. 2014. *De hoogte van de bestuurlijke boete*. De Nederlandse Voedsel- en Warenautoriteit 2014a [cited March 2014]. Available from http://www.nvwa.nl/onderwerpen/toezicht-nvwa-eten-en-drinken/dossier/bestuurlijke-boete/de-hoogte-van-de-bestuurlijke-boete.
NVWA. 2014. *Toxoplasma gondii Regelgeving*. De Nederlandse Voedsel- en Warenautoriteit 2014b [cited Februari 2014]. Available from http://www.nvwa.nl/onderwerpen/bacterien-ziekteverwekkers/dossier/toxoplasma-gondii/regelgeving.

Ressourcenschutz, Gesellschaft für. 2014. *Inspektionen und Zertifizierungen für landwirtschaftliche Öko-Betriebe*. GfRS 2011 [cited January 2014]. Available from http://www.gfrs.de/fileadmin/files/gfrs_leistungskatalog_landwirtschaft.pdf.
Rosenquist, Hanne, Louise Boysen, Anne Louise Krogh, Annette Nygaard Jensen, and Maarten Nauta. 2013. "< i> Campylobacter</i> contamination and the relative risk of illness from organic broiler meat in comparison with conventional broiler meat." *International journal of food microbiology* no. 162 (3):226-230.
Sauvegrain, SA, H Sbai, M Padilla, F Fort, and G Palma. 2012. Consumer's food sustainability perception: the case of tomato. Paper read at XII International Symposium on the Processing Tomato 971.
Shah, Nasreen. 2009. Guidance on The Contaminants in Food (England) Regulations 2009. edited by Food Safety: Contaminants. London: Food Standards Agency.
Stevenson, Angus , and Maurice Waite. 2011. *Concise Oxford English Dictionary*. Edited by Twelfth. Oxford Oxford University Press.
Tierklinik, Dr. Martin henn. 2014. Iron Blood Check. In *Telephone interview*, edited by Majed AlMuhanna.
Tierschutz, Für Mehr. 2014. *Entwicklung des Tierschutzlabels*. Deutscher Tierschutzbund 2014a [cited May 2014]. Available from http://www.tierschutzlabel.info/wissenschaft/entwicklung/
Tierschutz, Für Mehr. 2014. *Kriterienkatalog fur Eine tiergerechte Haltung und Behandlung von Mastschweinen im Rahmen des Tierschutzlabels*. Deutscher Tierschutzbund 2014b [cited January 2014]. Available from http://www.tierschutzlabel.info/fileadmin/user_upload/Dokumente/Kriterienkatalog_Mastschweine.pdf
Tierschutz, Für Mehr. 2014. *Kriterienkatalog fur Eine tiergerechte Haltung und Behandlung von Verabeitung im Rahmen des Tierschutzlabels*. Deutscher Tierschutzbund 2014c2014]. Available from http://www.tierschutzlabel.info/fileadmin/user_upload/Dokumente/Kriterienkatalog_Verarbeitung.pdf.
USDA. 2014. *"National Organic Program"* The U.S. Department of Agriculture's Agricultural Marketing Service 2014 [cited May 2014]. Available from http://www.ams.usda.gov/AMSv1.0/NOPConsumers.

van der Giessen, Joke, Manoj Fonville, Martijn Bouwknegt, Merel Langelaar, and Ant Vollema. 2007. "Seroprevalence of< i> Trichinella spiralis</i> and< i> Toxoplasma gondii</i> in pigs from different housing systems in The Netherlands." *Veterinary parasitology* no. 148 (3):371-374.
van der Meulen, Bernd. 2011. *Private Food Law book*. Edited by First. Wageningen Wageningen Academic Publishers.

van der Meulen, Bernd , and Menno van der Velde. 2011. *European Food Law Handbook*. Edited by Second. Wageningen Wageningen Academic Publishers.
Van der Wolf, PJ, ARW Elbers, HMJF Van Der Heijden, FW Van Schie, WA Hunneman, and MJM Tielen. 2001. "< i> Salmonella</i> seroprevalence at the population and herd level in pigs in The Netherlands." *Veterinary microbiology* no. 80 (2):171-184.
Voedingscentrum, Het. 2014. *Scharrelveehouderij Omschrijving* 2014 [cited March 2014]. Available from http://www.voedingscentrum.nl/encyclopedie/scharrelveehouderij.aspx.
Ware, Michael W, Swinburne AJ Augustine, David O Erisman, Mary Jean See, Larry Wymer, Samuel L Hayes, JP Dubey, and Eric N Villegas. 2010. "Determining UV inactivation of Toxoplasma gondii oocysts by using cell culture and a mouse bioassay." *Applied and environmental microbiology* no. 76 (15):5140-5147.

European Union legislation

Commission Implementing Regulation (EU) No 1174/2012 of 5 December 2012 approving a minor amendment to the specification for a name entered in the register of protected designations of origin and protected geographical indications (Abbacchio Romano (PGI)). OJ L 337/15, 11.12.2012. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R1174&rid=1
Commission Recommendation of 3 December 2013 on the reduction of the presence of dioxins, furans and PCBs in feed and food (2013/711/EU). OJ L 323/37, 4.12.2013. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013H0711&from=EN
Council Regulation (EC) No 543/2008 of 16 June 2008 laying down detailed rules for the application of Council Regulation (EC) No 1234/2007 as regards the marketing standards for poultrymeat. OJ L 157, 17.6.2008. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02008R0543-20130701&rid=2
Commission Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91. OJ L 189, 20.7.2007. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02007R0834-20130701&rid=1
Commission Regulation (EU) No 1190/2012 of 12 December 2012 concerning a Union target for the reduction of Salmonella Enteritidis and Salmonella Typhimurium in flocks of turkeys, as provided for in Regulation (EC) No 2160/2003 of the European Parliament and of the Council. OJ L340/29, 13.12.2012. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R1190&rid=2
Commission Regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs. OJ L 338, 22.12.2005. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02005R2073-20140601&rid=1Commission Implementing
Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the Food Safety Authority and laying down procedures in matters of food safety. OJ L 31/1, 1.2.2002. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:031:0001:0024:EN:PDF
Regulation (EC) No 765/2008 of the European Parliament and of the Council of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the

marketing of products and repealing Regulation (EEC) No 339/9. OJ L 218/30, 13.8.2008. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008R0765&rid=1

Regulation (EU) No 1054/2012 of 7 November 2012 approving minor amendments to the specification for a name entered in the register of protected designations of origin and protected geographical indications [Taureau de Camargue (PDO)]. OJ L 313/3, 13.11.2012. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R1054&rid=1

Regulation (EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products and repealing Council Regulations (EEC) No 922/72, (EEC) No 234/79, (EC) No 1037/2001 and (EC) No 1234/2007. OJ L 347, 20.12.2013. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02013R1308-20140101&rid=1

Appendix 1: Example of the EMV design for small cattle farm in the Netherlands.

* (cattle)							
Small							
Salmonella							
Yes (cert)				No (cert)			
P(cont)			1-P(cont)	P(cont)			1-P(cont)
0.59			0.41	0.29			0.71
P(insp)	1-P(insp)			P(insp)	1-P(insp)		
0.005	0.995			0.005	0.995		
	P(rec)	1-P(rec)			P(rec)	1-P(rec)	
	0.5	0.5			0.5	0.5	
-10574	-54385	43811	43811	-10000	-11000	0	0
EMV	**-52.87**	**-5287**	**17962.51**	**EMV**	**-50**	**-5500**	**0**
EMV yes		**14811.9867**		**EMV no**		**-1609.5**	
Campylobacter							
Yes (cert)				No (cert)			
P(cont)			1-P(cont)	P(cont)			1-P(cont)
0.29			0.71	0.15			0.85
P(insp)	1-P(insp)			P(insp)	1-P(insp)		
0.005	0.995			0.005	0.995		
	P(rec)	1-P(rec)			P(rec)	1-P(rec)	
	0.5	0.5			0.5	0.5	
-10574	-54385	43811	43811	-10000	-11000	0	0
EMV	**-52.87**	**-5287**	**31105.81**	**EMV**	**-50**	**-5500**	**0**
EMV yes		**29557.2477**		**EMV no**		**-832.5**	
Toxoplasma							
Yes (cert)				No (cert)			
P(cont)			1-P(cont)	P(cont)			1-P(cont)
0.73			0.27	0.24			0.76
P(insp)	1-P(insp)			P(insp)	1-P(insp)		
0.005	0.995			0.005	0.995		
	P(rec)	1-P(rec)			P(rec)	1-P(rec)	
	0.5	0.5			0.5	0.5	
-10574	-54385	43811	43811	-10000	-11000	0	0
EMV	**-52.87**	**-5287**	**11828.97**	**EMV**	**-50**	**-5500**	**0**
EMV yes		**7930.8649**		**EMV no**		**-1332**	

Cert certification, P probability of occurrence, 1-P probability of not occurring, (cont) contamination, (insp) inspection, (recl) product withdrawal or recall.

Appendix 2: Example of the EMV design for large cattle farm in the Netherlands.

* (cattle)							
Large							
Salmonella							
Yes (cert)				No (cert)			
P(cont)			1-P(cont)	P(cont)			1-P(cont)
0.59			0.41	0.29			0.71
P(insp)	1-P(insp)			P(insp)	1-P(insp)		
0.005	0.995			0.005	0.995		
	P(rec)	1-P(rec)		-10000	P(rec)	1-P(rec)	
	0.5	0.5			0.5	0.5	
-14104	-93726	87622	87622		-11000	0	0
EMV	**-70.52**	**-3052**	**35925.02**	**EMV**	**-50**	**-5500**	**0**
EMV yes		**34082.7332**		**EMV no**		**-1609.5**	
Campylobacter							
Yes (cert)				No (cert)			
P(cont)			1-P(cont)	P(cont)			1-P(cont)
0.29			0.71	0.15			0.85
P(insp)	1-P(insp)			P(insp)	1-P(insp)		
0.005	0.995			0.005	0.995		
	P(rec)	1-P(rec)			P(rec)	1-P(rec)	
	0.5	0.5			0.5	0.5	
-14104	-93726	87622	87622	-10000	-11000	0	0
EMV	**-70.52**	**-3052**	**62211.62**	**EMV**	**-50**	**-5500**	**0**
EMV yes		**61306.0892**		**EMV no**		**-832.5**	
Toxoplasma							
Yes (cert)				No (cert)			
P(cont)			1-P(cont)	P(cont)			1-P(cont)
0.73			0.27	0.24			0.76
P(insp)	1-P(insp)			P(insp)	1-P(insp)		
0.005	0.995			0.005	0.995		
	P(rec)	1-P(rec)			P(rec)	1-P(rec)	
	0.5	0.5			0.5	0.5	
-14104	-93726	87622	87622	-10000	-11000	0	0
EMV	**-70.52**	**-3052**	**23657.94**	**EMV**	**-50**	**-5500**	**0**
EMV yes		**21378.5004**		**EMV no**		**-1332**	

Cert certification, P probability of occurrence, 1-P probability of not occurring, (cont) contamination, (insp) inspection, (recl) product withdrawal or recall.